Economic Evaluation of Fire-based Improvement Systems for Macartney Rose

L. GAROIAN, J.R. CONNER, AND C.J. SCIFRES

Abstract

Integration of prescribed burns into management systems with herbicide and mechanical controls is proposed as an economically efficient means of improving the productivity of Macartney rose infested rangeland. Roller crushing followed by prescribed burns produce the highest rate of return (15%) and the lowest maximum investment. However, because of the great regrowth potential of the brush, this low-intensity system is also associated with the greatest risk. Systems which utilize initial mechanical controls followed by aerial application of 2,4,5-T+ picloram and maintenance treatments of prescribed burning and/or individual-plant treatments with herbicides are less risky but more capital intensive. Internal rates of return for the more intensive treatments range from 11.2 to 11.7%. Fire-based systems increase the rate of return by as much as 13.8% over systems with the same initial treatment but without prescribed burning.

Macartney rose (*Rosa bracteata* Wendl.) occurs on approximately 201,000 ha of highly productive grazing lands in eastcentral Texas and on the Coastal Prairie (Hoffman et al. 1964). This troublesome species occupied less than 17,000 ha in 1948 (Hoffman 1966). Recommended chemical treatment of Macartney rose during the early 1960's and until the mid 1970's was multiple, successive annual applications of 2,4-D [(2,4-dichlorophenoxy)acetic acid], with the rate and time of application dictated by growth form of Macartney rose. However, a generalized treatment schedule usually consisted of 2.2 kg/ha of 2,4-D (amine formulation for spring applications and low volatile ester for fall treatments) broadcast applied the first year followed by 1.1 to 2.2 kg/ha of 2,4-D the next year (Scifres 1980). As many as five successive, annual applications of 2,4-D were used in some cases (Hoffman 1966).

Multiple 2,4-D applications have become increasingly expensive, are not always highly effective, remove desirable forbs from the grassland, and pose repeated potential for spray drift to susceptible crops. Therefore, research was initiated in 1970 to evaluate several herbicides which might improve control, especially with fall applications (Scifres 1975a). Research also investigated the potential for replacement of herbicide application with prescribed burning (Scifres 1975b, Gordon and Scifres 1977) which led to the development of several Integrated Brush Management Systems (IBMS) for improvement of Macartney rose-dominated Coastal Prairie (Scifres 1975b, 1980, 1981).

Prescribed burning, subsequent to an initial treatment to reduce the cover of live brush and/or prepare the fuel, is a component of the more effective Macartney rose management systems (Scifres 1981). Use of prescribed burning has become more widely accepted among producers for range improvement, especially during the past 10 years (Scifres 1980, Wright and Bailey 1982).

Authors are research associate, Department of Agricultural Economics; professor, Department of Agricultural Economics and Range Science; and Thomas M. O'Connor professor, Department of Range Science, Texas Agricultural Experiment Station, Texas A&M University, College Station, 77843.

Approved as TA-18225 by the Director, Texas Agricultural Experiment Station.
Received for publication February 3, 1983.

Economic considerations are critical to developing a range improvement program to meet specific land management objectives. Therefore, the objective of this research is to quantify the economic performance of previously developed schemes, non-fire and fire based systems, for improvement of Macartney rose-dominated Coastal Prairie.

Procedures

Specific systems evaluated have been applied under both research and operational conditions since 1971. Most of the treatment sequences were originally proposed by Scifres (1975b).

Response curves were developed based on research results (Gordon and Scifres 1977, Hoffman 1966, Hoffman et al. 1968, Scifres 1975b) and verified by interviews with producers having experience with the specific system or treatment. Published data were used to estimate carrying capacities of cattle based on herbage production following treatment (Whitson et al. 1979) for the first 10 years of the planning profiles. These data were verified and changes in weaning percentages and weaning weights obtained by producer interview (P.H. Welder, pers. comm.). Estimates of carrying capacity change for some treatments were also published by other workers (Hoffman 1966). Production responses for the remaining 10 years of the planning periods were projected based on perpetuation of treatment effects established earlier in the profiles.

Assumptions underlying development of the response curves were:

1. All sites infested with Macartney rose will respond, on a relative basis, to the systems selected as will the Blackland site (primarily Victoria clay [fine, montmorillonitic, hyperthermic Ucid Pellustert]) from which the data base was formed.
2. Other management practices (grazing system, parasite control, etc.) are not limitations to production change from brush management, nor will there be synergisms between brush management and livestock management (this assumption presumably resulted in conservative estimates).
3. Planning horizon of 20 years depends on systems equilibrating after 10 years, i.e., allows perpetuation of range improvement by practices applied after year 10.
4. Systems will cause no change in other products, such as wildlife.
5. Systems will not change ratio of breeding males to females.
6. Annual rainfall will follow annual average for past 20 years (94 cm).
7. System selection is constrained by past vegetation management practices such that 2 brush growth types, disturbed and undisturbed, must be considered separately.

Response curves were developed as discussed by Whitson and Scifres (1980) for 2 growth forms, disturbed (control attempted within last 3 years) and undisturbed stands, because of the influence on response of Macartney rose to treatments such as herbicide sprays (Hoffman et al. 1964), and because of the stage of secondary succession normally associated with infestations of the 2 growth forms. Stands of undisturbed Macartney rose may develop canopy covers of 75% or greater with some plants to 5 m tall (Scifres 1975b). Whereas previous disturbance usually allows establishment of perennial native grasses in the proximity of the brush plants, the area beneath undisturbed Macartney rose plants is bare and herbaceous cover is established by secondary succession (Gordon and Scifres 1977).

Economic evaluation of the systems was determined by utilizing multi-year partial budgeting techniques (Whitson and Scifres 1980, 1981). Annual costs and returns in constant 1982 dollars, were calculated for systems based on a 202-ha pasture. Annual costs included specific brush treatments, livestock investment costs and additional variable costs. Returns were additional pounds of beef sold, reduced management costs and livestock disinvestment.

Economic comparisons are based on cash flows, internal rates of return and net present values. Determination of net present values requires that annual costs and returns be discounted to the present. The discount rate reflects time preference for money and risk under the assumption of constant price levels. While the risk associated with each system is unknown, a risk premium is included in the 10% discount rate used in this analysis. This discount rate maintains that a rancher must obtain a 10% rate of return on investment before net present value will be positive.

Difficulties existed with using net present value and internal rate of return as indicators of economic performance (Workman 1981). Differences in treatment lives[1] and cost may have resulted in contradictory selections of treatments. Response curves for fire based systems were developed for a 20-year period. Responses for previously recommended treatments and treatments without fire-based maintenance had treatment lives of less than 20 years. Initial and subsequent maintenance treatments were repeated to extend the project lives to 20 years. Responses for repeated treatment sequences were assumed the same as initial sequence responses. Normalization of initial and followup treatment costs were not attempted. Since selection of treatments was influenced by factors in addition to net present value and internal rate of return, the possibility of contradictory selections was not considered critical.

The systems developed have residual economic benefits beyond the 20-year period generated from maintenance or repetition of treatments. These benefits include increased stocking rates, weaning weights, and calving percentages above initial levels. Economic evaluation suggests that a value be placed on this productive potential. Estimates of productive potential are based on the assumption that maintenance or repetition of treatments will be continued indefinitely. An annual average benefit for treatments from 20 years to infinity is obtained and discounted to year 20. This "salvage value" is included in the analysis of year 20 and discounted to the present. This procedure accounts for the increased productive potential created by continuation of the systems.

Systems Evaluated

Systems and treatments evaluated for undisturbed, dense stands (average 75% canopy cover, 2,000 plants/ha) were:

1. Aerial spray with 2.2 kg/ha 2,4-D ester in fall of year 0 and 1.1 kg/ha 2,4-D amine formulation in years 1 and 2 (Hoffman et al. 1964, 1968; Hoffman 1966; McCully et al. 1959).
2. Rake and stack Macartney rose and burn stacks in year 0 (Scifres 1975).
3. Rake, stack, and burn stacks in year 0; aerially spray with 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] + picloram (4-amino-3,4,5-trichloropicolinic acid) (1:1) at 1.1 kg/ha in year 3; prescribed burning during winters of years 5, 8, 16, and 19; and individually spray with 1.1 kg 2,4,5-T + picloram (1:1) in 172 liters water containing 0.5% (v/v) commercial surfactant in year 12. Costs of individual-plant treatments were calculated as required to reduce (a) light, scattered stands, and (b) moderate stands to less than 125 small (0.3 m tall) plants/ha.
4. Rake, stack, and burn stacks in year 0 followed by aerial spray with 2,4,5-T + picloram at 1.1 kg/ha in year 3.
5. Rake, stack, and burn stacks in year 0; aerially spray with 2,4,5-T + picloram at 1.1 kg/ha in year 3; and prescribed burn during winters of years, 5, 8, 11, 14, and 17 (Scifres 1975b).
6. Compact Macartney rose fuel by roller chopping (crushing) in the fall of the year 0 and prescribed burn in the winters of years 1, 4, 7, 10, 14, and 18 (P.H. Welder, pers. comm.).

Systems and treatments evaluated for disturbed, dense stands (average 50% canopy cover, 1,500 plants/ha, average 0.5 to 1.5 m tall) of Macartney rose were:

1. Aerial application of 2,4,5-T + picloram (1:1) at 1.1 kg/ha in the fall (September-October) of year 0 with no subsequent treatment (Scifres 1975a, 1975b).
2. Aerial spray with 2,4,5-T + picloram in the fall of year 0 followed by prescribed burning using the fire plan for tallgrass prairie (Wright and Bailey 1982) during the winters of years 2, 5, 8, 11, 14, 17, and 20 (Scifres 1975b, Gordon and Scifres 1977).

Economic Responses from Systems

Physical results obtained from adaption of the systems were improved forage quality improved botanical composition of herbage stands and increased forage production. Economic benefits occur from utilization of forage in a cow-calf operation. Benefits include increased stocking rates, calving percentages, weaning weights, and reduced management costs.

Increased forage production was utilized by purchasing livestock. Decreases of forage because of decreased range condition (reinfestation of brush) or deferments resulted in livestock being sold at the purchase price.

Production Parameters for Undisturbed Stands

Pretreatment stocking rates, calving percentages, and weaning weights for undisturbed stands of Macartney rose-infested land were 11.3 ha/animal unit (AU), 65%, and 176.9 kg, respectively. Changes in production parameters for non-fire based systems were cyclic. Initial improvement of production parameters following treatment and later deterioration, because of brush reestablishment, created symmetric responses. Treatments were reinitiated when production parameters had returned to pretreatment levels. Average stocking rates, calving percentages and weaning weights ranged from 6.8 to 8.5 ha/AU, 67 to 68% and 181.4 to 184.3 kg, respectively.

Production parameters for fire-based systems increased and stabilized at these higher levels. Stabilization of systems was characterized by cyclic stocking rates. Cyclic behavior was the result of reestablishment of Macartney rose between prescribed burns. Raking, stacking, burning of stacks, and aerial spray, followed by a succession of prescribed burns, allowed stocking rates to increase to 2.0 ha/AU by year 12.[2] Stocking rates stabilized in 3-year cycles of 2.0 ha/AU, 2.4. ha/AU and 4.2 ha/AU starting in year 12. Calving percentages increased steadily and stabilized at 78% by year 10. Weaning weights increased to 204.1 kg by year 14, and maintained an average of 203.3 kg.

Integrating spraying of individual plants with raking, stacking, burning of stacks, aerial spray, and prescribed burns increase maintained production parameters. Stocking rates increase to 2.0 ha/AU in year 11, remained constant, and sustain 3-year cycles, beginning in year 15 of 2.0 ha/AU, 3.0 ha/AU, and 2.0 ha/AU. Calving percentages are identical to the system without individual-plant treatments, but weaning weights are 5.3 kg greater by year 17.

Roller crushing, followed by prescribed burning, generates lower

[1]Treatment life refers to the number of years a treatment or series of treatments induces production above pretreatment levels.

[2]Fluctuations in stocking rates did occur due to deferments associated with prescribed burns.

sustained production parameters than the other fire-based systems. Stocking rates fluctuate before increasing to 3.2 ha/AU in year 11 and stabilize in 4-year cycles of 4.0 ha/AU, 6.1 ha/AU, 3.2 ha/AU, and 3.2 ha/AU beginning in year 13. Calving percentages and weaning weights gradually increase to maintained levels of 76% and 204.1 kg in years 17 and 18, respectively.

Production Parameters for Disturbed Stands

Initial stocking rates, calving percentages, and weaning weights on pastures with previously disturbed stands were 8.1 ha/AU, 65%, and 183.7 kg, respectively. Aerial application of 2,4,5-T + picloram (1:1) at 1.1 kg/ha without prescribed burning produced long cyclic responses characteristic of non-fire based systems. Stocking rates increased to 3.2 ha/AU in year 3, remained there for another year, and returned to pretreatment level in year 8. Calving percentages increased gradually to 70% in year 4, remained constant for 4 years before declining to 68% in year 8. Weaning weights were 188.2 kg in year 2, increased to 195.0 kg in year 4, and began to decline in year 7. Spraying was repeated in year 8 with the same production responses.

Prescribed burns subsequent to aerial application of 2,4,5-T + picloram enhanced initial treatment. Stocking rates averaged 4.1 ha/AU for the first 8 years, before stabilizing in 3-year cycles of 2.0 ha/AU, 2.0 ha/AU, and 3.6 ha/AU. Calving percentages and weaning weights increased to 78% and 208.6 kg in years 8 and 10, respectively, before stabilizing.

Beef Production

Changes in production parameters are directly related to changes in beef production. Systems used to improve undisturbed stands result in 20-year average increases of 5.4 to 49.2 kg/ha (Table 1). Production levels for non-fire based systems increase beef production by an average of only 9.6 kg/ha/yr.

Fire-based systems with initial treatment by raking, stacking, and burning stacks produced an average 17.3 kg/ha additional beef per year during an 8-year establishment period. Subsequent treatment by aerial spraying and prescribed burning produced an average of 47.4 kg/ha additional beef during the next 6 years, before stabilizing with an average annual increase of 48.4 kg/ha. Followup treatments of aerial spraying, individual plant treatments, and prescribed burning resulted in large increases after establishment. During the prestabilization period, annual beef production increased by 66.6 kg/ha and stabilized at an average 59.6 kg/ha/yr by year 17.

Roller crushing resulted in approximately half the increases obtained from the other fire-based systems. Beef production increased by 9.8 kg/ha/yr during the early adjustment period. Increased beef production averaged 26.6 kg/ha between years 9 and 16 and stabilized at an average 28.7 kg/ha/yr.

The non-fire based system used to control disturbed stands produced an average annual increase of only 13.5 kg/ha/yr over a 20-year period. Continuation of the system would result in increased beef production of 12.8 kg/ha per year. The fire-based system produced 32.1 kg/ha/yr additional beef during the first 9 years. The system stabilized in year 10, with an average increase in beef production of 51.8 kg/ha/yr.

Returns

Increased returns from implementation of a system are the product of additional beef produced and the selling price of beef. The price used in this study, $1.54/kg, is the real average price of beef for the past 20 years. It is assumed that this price will prevail for the future.

Another benefit is reduced management costs of $3.09/ha, based on estimates from Whitson et al. (1979) as the result of labor savings in livestock handling and management following brush control. Labor savings result when stocking rates increase to 10.2 ha/AU in response to reduction of Macartney rose stands.

Costs

Costs associated with the development of a system to control Macartney rose are initial treatment costs, followup treatment costs and livestock investment, indirect deferment, and additional variable costs. Initial treatment costs occur in year 0 and include aerial

Table 1. Additional beef production (kg/ha/year) resulting from the application of selected treatment systems for improvement of Macartney rose-dominated Coastal Prairie.

	Undisturbed stands						Disturbed stands	
Year	Multiple sprays	Rake, stack, burn stacks	Rake, stack burn stacks spray, burning	Rake, stack, burn stacks, spray, burning, ind. spray, burning	Rake, stack burn stacks, spray, burning	Roller chop, burning	Aerial spray	Aerial spray, burning
1	1.7	2.6	2.6	2.6	2.6	0	3.6	3.6
2	3.5	8.7	8.7	8.7	8.7	5.4	11.1	2.7
3	9.7	10.4	10.4	10.4	10.4	7.2	23.9	23.9
4	20.8	9.3	20.3	20.3	20.3	1.2	26.2	50.3
5	30.2	3.8	21.6	10.5	10.5	6.0	18.5	14.2
6	23.1	2.4	21.6	28.9	28.9	19.8	12.7	56.2
7	16.1	1.2	17.0	34.5	34.5	9.8	5.5	58.5
8	9.6	0	9.8	22.6	22.6	28.9	.9	17.0
9	2.7	2.6	5.6	48.7	48.7	21.9	3.6	62.3
10	.3	8.7	3.4	50.8	50.8	17.4	11.1	67.2
11	1.7	10.4	1.2	64.8	40.1	31.7	23.9	29.1
12	3.5	9.3	.1	66.5	66.5	33.8	26.2	63.1
13	9.7	3.8	2.6	66.5	52.0	25.1	18.5	63.1
14	20.8	2.4	8.7	66.5	26.1	13.7	12.7	29.1
15	30.2	1.2	10.4	67.3	66.5	34.6	5.5	63.1
16	23.1	0	20.3	41.8	52.7	34.6	.9	63.1
17	16.1	2.6	21.6	68.2	26.1	26.4	3.6	29.1
18	9.6	8.7	21.6	68.2	66.5	14.7	11.1	63.1
19	2.7	10.4	17.0	42.4	52.7	36.9	23.9	63.1
20	.3	9.3	9.8	68.2	26.1	36.9	26.2	29.1
21 to ∞	11.8	4.8	10.2	59.6	48.4	28.7	12.8	51.8
20-yr avg	11.8	5.4	11.7	42.9	35.7	20.3	13.5	42.5

application of 2,4-D; aerial application of 2,4,5-T + picloram; raking, stacking, and burning of stacks; and roller chopping (Table 2). Roller chopping is the least expensive initial treatment costing \$19.77/ha. Application of 2,4-D and 2,4,5-T + picloram cost \$35.21/ha and \$50.65/ha, respectively. Raking, stacking, and burning the stacks is the most expensive initial treatment, costing \$70.42/ha.

Individual-plant sprays are the most costly followup treatments estimated at \$55.97/ha for light stands and \$101.02/ha for moderate stands. In general, aerial application of herbicides for maintenance of improvement, costs the same as initial treatments. The second aerial application of 2,4-D amine is less expensive than the first treatment because less herbicide is applied. Prescribed burning is the least expensive maintenance procedure available costing \$11.12/ha for the initial burns and \$2.47/ha for subsequent burns.

Utilization of increased forage production following brush treatment requires investment in livestock. Livestock investment costs are \$699.55/cow unit (CU)[3] (Texas Agricultural Experiment Station, 1982). Annual variable cost associated with raising additional livestock is \$102.76/CU (Texas Agricultural Experiment Station, 1982). Decreased use of the hypothetical pasture because of deferments results in livestock being sold for the purchase price. Deferments average 4 months for prescribed burning, and 2 months for aerial herbicide application; and raking, stacking, and burning of stacks.

Results and Discussion

Roller chopping of undisturbed Macartney rose, primarily to crush and compact the coarse fuel, followed the subsequent winter by prescribed burning, produced the highest internal rate of return, highest net present value, and required the least maximum invest-

[3]A cow unit as used refers to cow, 0.15 replacement, .05 bull, and 0.2 horses.

Table 2. Initial and maintenance treatment costs associated with selected systems for improvement of Macartney rose-dominated Coastal Prairie.

Initial treatment	Maintenance treatment	Years of maintenance	Costs (\$/ha) Initial	Costs (\$/ha) Maintenance
	Undisturbed stands			
Aerial spray, 2,4-D ester (2.2 gk/ha)	Aerial spray, 2,4-D amine (1.1 kg/ha)	1 & 2	35.21	25.33
Rake, stack, burn stacks		—	70.42	—
Rake, stack, burn stacks	Aerial spray, 2,4,5-T + picloram (1.1 kg/ha)	3	70.42	50.65
Rake, stack, burn stacks	Aerial spray, 2,4,5-T + picloram (1.1 kg/ha)	3	70.42	50.65
	First burn[1] and subsequent burn	5 & 8	—	13.59
	Individual-plant herbicide treatments	12		
	Light stands			55.97
	Moderate stands			101.02
	First burn and subsequent burn	16 & 19		13.59
Rake, stack, burn stacks	Aerial spray 2,4,5-T + picloram (1.1 kg/ha)	3	70.42	50.65
	First burn	5		11.12
	Subsequent burns	8, 11, 14, 17, 20		2.47
Roller crushing	First burn	1	11.12	
	Subsequent burns	4, 7, 10, 14, 18		2.47
	Disturbed stands			
Aerial spray 2,4,5-T + picloram (1.1 kg/ha)			50.65	
Aerial spray 2,4,5-T + picloram (1.1 kg/ha)	First burn	2	50.65	11.12
	Subsequent burns	5, 8, 11, 14, 17, 20		2.47

[1]Refers to burns that require initial construction of fire lanes.

Table 3. Maximum investment in selected treatment sequences for improvement of Macartney rose-dominated rangeland and expected annual rates of return on the investments, present values of treatments at the end of the planning profiles, years to breakeven on the investments, and 20-year net cash flows on the Coastal Prairie.

Treatment/treatment sequence	Maximum investment (\$)/h	Annual rate of return (%)	Present value \$/ha (10%)	Breakeven[a] (yr)	20-year net cash flow (\$/ha)
		Undisturbed stands			
Multiple aerial spray (2,4-D)	202.85	5.0	-51.96	8 & 18	130.52
Rake, stack, burn stacks	164.29	-30.1	-95.72	—[b]	-132.36
Rake, stack, burn stacks-aerial spray (2,4,5-T + picloram)	210.39	-2.3	-103.51	—[b]	-40.44
Rake, stack, burn stacks-aerial spray-prescribed burn	232.81	11.5	33.89	15	761.34
Rake, stack, burn stacks-aerial spray-prescribed burn-individual-plant treatment (light stand)-prescribed burn	232.81	11.7	44.18	14	923.57
Rake, stack, burn stacks-aerial spray-prescribed burn-individual-plant treatments moderate stand)-prescribed burn	232.81	11.2	29.82	15	878.52
Roller crush fuel-prescribed burn	138.33	15.0	61.33	12	566.88
		Disturbed stands			
Aerial spray (2,4,5-T + picloram)	161.40	6.3	-28.16	6 & 13	104.68
Aerial spray-prescribed burn	292.56	16.1	140.06	10	1,024.62

[a]Based on average price for steer and heifer calves of \$1.54/kg and a 10% discount rate.
[b]Did not breakeven.

ment[4] (Table 3). However, there is a relatively high degree of risk associated with this treatment since roller chopping, if not followed promptly by burning, may actually increase the Macartney rose stand density. Canes severed from the parent plant may be pressed into the soil surface, especially if the soil is damp, and take root (Hoffman et al. 1964). Also, roller chopping kills relatively few, if any, of the Macartney rose plants (Scifres 1980). Therefore, the pescribed burns must be applied regularly (at about 3-year intervals) to prevent the Macartney rose infestation from nullifying the positive effects of previous treatments (Gordon and Scifres 1977).

Because of the regrowth potential of Macartney rose, simple top removal by raking and stacking did not generate positive rates of return (Table 3). Forage response to such treatments is short-lived, with production usually not increased for more than 4 or 5 years, depending on rainfall. Herbaceous response to removal of undisturbed Macartney rose requires that secondary succession reinstate the cover on the bare areas beneath the brush canopies. Application of aerial sprays of 2,4,5-T + picloram (1:1) at 1.1 kg/ha increased the life of the raking and stacking. However, response was not adequate to result in a positive annual rate of return, indicating that the additional range improvement did not compensate for the increased investment.

Multiple aerial sprays of 2,4-D resulted in an annual rate of return of 5.0% with a breakeven period of 8 years (Table 3). However, net present value was $-51.95/ha.

In addition to the roller crushing-prescribed burning treatment sequences, the mechanical (rake-stack)-herbicide-burn system resulted in positive net present values. The internal rate of return for the mechanical-herbicide burn system without individual-plant herbicide treatments was 11.5%. Use of individual-plant treatments, an extremely intensive management input, resulted in higher internal rates of returns for light stands and lower for moderate stands, compared to the same system without individual-plant treatments (Table 3).

Investment capital not limiting, intensive manipulation systems, by virtue of maintaining a relatively high level of productivity, are well adapted to Coastal Prairie ecosystems. The more intensive management systems resulted in the greatest 20-year net cash flows ($878.51 to $923.56/ha) but required 14 to 15 years to pay back the investment.

Maximum investment was increased by $22.42/ha (10.7%) when prescribed burning followed the mechanical-herbicide sequence. However, the internal rate of return was increased to 11.5% when prescribed burning was employed, compared to -2.3% without burning, and the present value was increased from $-103.51 to $33.89/ha. The 20-year net cash flow was increased from $-40.44 to $761.34/ha, a 20-fold improvement, attributable to use of prescribed fire.

Prescribed burning following herbicide application to disturbed Macartney rose stands increased the internal rate of return from 6.3 to 16.1%, and the present value of treatment from $-28.16 to $140.07/ha. Although maximum investment was increased from $161.40 to $292.56/ha, the 20-year net cash flow was increased from $104.07 to $1,024.62/ha. These changes are attributable to prescribed burns.

[4]Refers to the maximum amount invested, including costs of additional livestock, at any given time in the planning profile.

Management Implications

These analyses indicate that selection of an appropriate sequence of treatments which includes prescribed burning may result in positive economic effects whereas the standard multiple herbicide applications or mechanical-herbicide treatments may result in negative rates of return, present values, and/or 20-year net cash flows. Prescribed burning at 3 to 5-year intervals increases the effective life of range improvement with a relatively small increase in investment.

However, as each additional treatment is incorporated into the improvement systems, management must become progressively more intensive to maintain level of improvement. Moreover, because of rapid regrowth potential of Macartney rose, the prescribed burns must be applied in a timely fashion. Otherwise, a preparatory treatment, mechanical or herbicide, may have to be employed to reduce the brush cover so that burning may be applied most effectively.

These analyses did not consider Macartney rose removal in a pattern to improve or maintain wildlife habitat. All treatment sequences described are amenable to patterned application, and habitat requirements of wildlife such as white-tailed deer *(Odecoilius virginiana)* should be considered in the development of improvement systems (Whitson et al. 1977).

Literature Cited

Gordon, R.A., and C.J. Scifres. 1977. Burning for improvement of Macartney rose-infestd Coastal Prairie. Texas Agr. Exp. Sta. Bull. 1183.

Hoffman, G.O., R.H. Haas, and B.E. Jeter. 1964. Macartney rose control in Texas. Texas Agr. Exp. Ser. Misc. Pub. 745.

Hoffman, G.O. 1966. Chemical control of Macartney rose and unpalatable weed pays. Down to Earth 22:8-11.

Hoffman, G.O., L.A. Wilson, and J.M. Sprott. 1968. On the run. . . Macartney rose. Tex. Agr. Prog. 14:16-18.

McCully, W.G., G.O. Hoffman, and B.E. Jeter. 1959. Possibility of controlling Macartney rose. Tex. Agr. Exp. Sta. Prog. Rep. 2093.

Scifres, C.J. 1975a. Fall application of herbicides improves Macartney rose-infested coastal prairie rangelands. J. Range Manage. 6:483-486.

Scifres, C.J. 1975b. Systems for improving Macartney rose infested coastal prairie rangeland. Tex. Agr. Exp. Sta. Misc. Pub. 1225.

Scifres, C.J. 1980. Brush Management. Principles and practices for Texas and the southwest. Texas A&M Univ. Press, College Station.

Scifres, C.J. 1981. Integrated brush management systems (IBMS) for rangeland: Concepts and application. Internat'l Stockmen's School, Beef Cattle Sci. Handbk. 18:74-79.

Texas Agricultural Extension Service. 1982. Texas Enterprise Budgets, Texas Coastal Bend Region. Texas Agr. Ext. Service. B-1241 (L 18).

Whitson, R.E., S.L. Beasom, and C.J. Scifres. 1977. Economic evaluation of cattle and white-tailed deer response to aerial spraying of mixed brush. J. Range Manage. 30:214-217.

Whitson, R.E., W.T. Hamilton, and C.J. Scifres. 1979. Techniques and considerations for economic analysis of brush control alternatives. Tex. Agr. Exp. Sta. Dep. Tech. Rep. Range Sci. 79-1.

Whitson, R.E., and C.J. Scifres. 1980. Economic comparisons of alternatives for improving honey mesquite-infested rangeland. Tex. Agr. Exp. Sta. Bull. 1307.

Whitson, R.E., and C.J. Scifres. 1981. Economic comparison of honey mesquite control methods with special reference to the Texas Rolling Plains. J. Range Manage. 34:412-415.

Workman, John P. 1981. Disagreement among investment criteria—A Solution to the Problem. J. Range Manage. 34:319-24.

Wright, H.A., and A.W. Bailey. 1982. Fire Ecology. United States and Southern Canada. John Wiley and Sons, New York.