TRADE-OFF BETWEEN COW NUMBERS, CALF SIZE, AND SALE DATE INCORPORATING SEASONAL FACTORS AND SUPPLEMENTAL FEEDING

Russell Tronstad[1]
Trent Teegerstrom[2]
Xing Gao[3]

Rigid sale dates are sometimes adopted to take advantage of seasonal forage availability or aggregate numbers for a given sale to attract more buyers. Arizona ranchers that primarily depend on winter rains for forage typically sell their calves in the spring while regions that most heavily depend upon monsoon rains for forage (e.g., southeast Arizona) sell in the fall. Both regions sell mainly according to the time of year, irrespective of the weight of their calves and very few supplement calves to increase their calf weights. Because ranchers often question the economic trade-offs between sale calf weights, herd size, rates of gain, and feeding supplement with a spring versus fall sale date, our primary objective is to analyze these issues.

The tradeoff between sale weight and timing of sales is complicated by seasonal forage and price conditions along with dramatic variation in the price spread between light and heavy calves. Generally, lighter calves sell for a higher per pound price than heavier calves and calf prices in the spring are greater than in the fall, but exceptions to these generalities occur. Selling calves at a heavier weight generally comes with an opportunity cost of reducing the number of cows that can be maintained on the ranch or calves that can be sold. In addition, variability in seasonal rainfall and the ability to feed supplement complicates analyzing the trade-offs between rates of gain, sale weight, herd size, and the timing of calf sales.

BIOLOGICAL CONSIDERATIONS

Quantifying the future rate of gain for a calf kept on the ranch is a critical element for evaluating the profitability of selling the animal now or at a later date. This analysis defines the calf growth cycle from birth to 20 months of age and evaluates the profitability of sale weight and season (i.e., mid-May or mid-November) under non-supplement and supplement range feeding scenarios. Weight gain was estimated as a function of age, sex, rainfall, compensatory gain, and prior weight levels. Weight data was collected from the Registered Hereford herd of the San Carlos Apache Tribal Ranch, Arsenic Tubs, Arizona for the eight years of 1980, 1981, 1983 to 1986, 1988, and 1989. A birth date and calf weight at birth was recorded for each calf. In addition, weights were taken when the entire calf crop was at an average age of roughly 3, 8, 12, and 20 months of age. Weight and animal combinations are such that we have 1,368 calves and 5,862 unique calf weights. Different calving dates provide age variation around each weighing date so that we can estimate daily weight gains as a function of age.

The solid line in figure 1 shows our calf weight estimates as a function of age for a steer calf with normal rainfall and no compensatory gain effects. The dots in figure 1 represent the weight of a given animal at a specified age and year. On average, calf weights at the 12 month weighing were 8.47 lbs. less than at their 8 month weight due to weaning and poor seasonal forage conditions that typically followed weaning. At any given age, heifer calves were estimated to weigh 4.97%

Figure 1. Calf weight data and estimated growth function

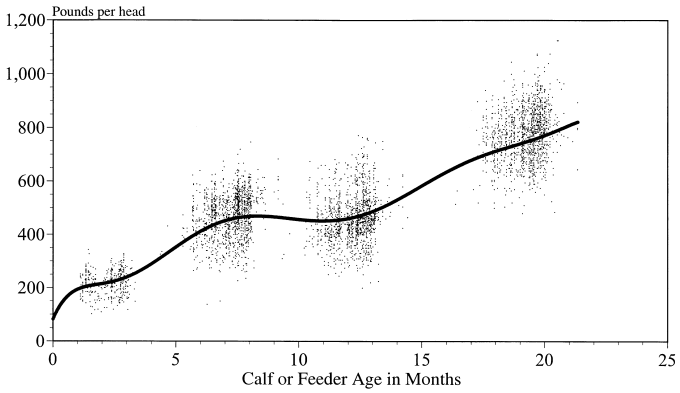
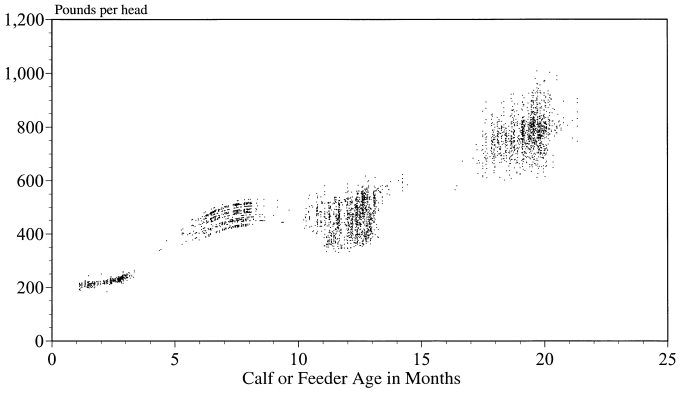


Figure 2. Calf weight estimates based on growth function, rainfall, compensatory gain, prior calf weights, and sex



less than a steer calf. Figure 2 provides weight predictions for each animal weighing. Variations from the solid line in figure 2 are due to differences in sex, cumulative rainfall from a prior weighing, prior weight from the estimated growth function, and compensatory gains.

To gain insights into the trade-off between different sale weights and dates, average real profits for two different ranching regions were simulated from 1980 through 1998 using either mid-May or mid-November sale dates for steer calves that weighed either 350, 450, 550, 650, or 750 lbs. A 350 lb. sale weight was matched with Cattle-Fax sale weight categories of 300 to 400 lb. sales and similarly for the heavier sale weights. The two regions examined have distinct seasonal forage differences. Regions that mainly depend on winter rain for forage rely on cooler season grasses and legumes like jojoba while “monsoon dependent regions” count mainly on warm season grasses for their primary forage production.

Table 1 shows the expected daily gains estimated for different sale weights and dates by region plus the equivalent cow numbers than can be maintained for each scenario. Rates of gain for the two regions were set up to mirror each other with the most favorable gains occurring prior to November and May sales for the “monsoon” and “winter” rain dependent regions, respectively. The most favorable forage conditions under supplementation assume a growth rate of 1.77 lbs./day for weights from birth to 350 lbs. and 1.75 lbs./day for weights from 450 to 750 lbs. These rates of gain were reduced by 10% for when forage is less abundant in each region prior to the animal’s sale date. To calculate the cows that could be supported on an Animal Unit Year (AUY) of forage, reductions of .5, .6, and .7 AUYs were charged for the number of days it took calves to go from 450 to 550, 550 to 650, and 650 to 750 pounds, respectively. The AUY reduction for producing calves heavier than the 450 lb. weight has the effect of reducing total cow numbers and thereby reducing the number of calves available for sale.

Birth dates and supplement requirements to meet the daily rates of gain in table 1 are described in table 2. Birth dates were calculated working backwards from the sale date and the corresponding rate of gain for each protocol. The amount of supplement required is dependent upon sale weight, sale date, and region. Respectable gains of 1.77 and 1.65 lbs. per day are viewed as attainable without feeding any supplement for 350 and 450 lb. sales in November and May for the monsoon and winter rain dependent regions, respectively. Supplemental feeding ranged from 100 to 400 lbs. per Animal Unit (AU), varying in average annual cost from $10.31 to $41.23 per

AU. The retail cost of a 50:50 corn meal and cottonseed meal mixture was charged for supplement. Because some ranchers may be able to obtain more of a wholesale than retail price for supplement, we did not charge additional labor or fuel expenses for distributing supplement to the cow herd. However, the distribution costs for supplement may be very noticeable, depending on the terrain of the ranch.

Cull cows were assumed to weigh 1,000 lbs. when they were culled, irrespective of the herd's mix or supplementation regime. In addition, a calf crop percentage of 85% per exposed cow, calf death loss after birth of 2.5%, and a culling percentage of 16% with a 4% annual death loss for cows was applied to all scenarios. The calf crop is assumed to be a 50:50 mix of steers and heifer. Thus, 40% of all heifers or 20% of all calves are retained each year to replenish the cull cows that either die or are sold. For example, a 100 AUY ranch selling 350 lb. or 450 lb. calves would expect to sell 16.0 cows, 41.4 (i.e., 100•0.85•0.975•0.5) steer calves, and 24.9 (i.e., 100•0.85•0.975•0.3) heifer calves annually.

Another expense item that varied with different sale date and weight options was the opportunity cost of money. That is, calves sold at 450 lbs. could have been sold at 350 lbs. and so forth. The opportunity cost of funds was charged at a real annual interest rate of 4%. Except for grazing expenses, cash costs for each scenario were obtained from Economic Research Service's cow-calf production costs for the west. Cash grazing costs were calculated using the grazing fees and accompanying percentages of grazing land in Arizona owned by the State (33%), Bureau of Land Management (17%), Forest Service (40%), or Private entity (9%) as reported in Mayes and Archer. Common variable and fixed cash expenses for all sale weight and date combinations are given in tables 3a. and 3b. Gao provides more detail to the cost items incorporated.

Table 1. Average daily gain (ADG, lbs./day) and equivalent cow numbers[a] (ECN)

	"Monsoon Dependent Regions"		"Winter Rain Dependent Regions"	
	No Supplemental Feeding			
Calf Weight (lbs./head)	May Sales	Nov. Sales	May Sales	Nov. Sales
	ADG ECN	ADG ECN	ADG ECN	ADG ECN
Birth to 350	1.593 (1.000)	1.770 (1.000)	1.770 (1.000)	1.593 (1.000)
350 to 450	1.485 (1.000)	1.650 (1.000)	1.650 (1.000)	1.485 (1.000)
450 to 550	0.396 (0.743)	0.440 (0.763)	0.440 (0.763)	0.396 (0.743)
550 to 650	1.530 (0.688)	1.700 (0.710)	1.700 (0.710)	1.530 (0.688)
650 to 750	0.981 (0.606)	1.090 (0.631)	1.090 (0.631)	0.981 (0.606)
	Supplemental Feeding			
450 to 550	1.575 (0.920)	1.750 (0.927)	1.750 (0.927)	1.575 (0.920)
550 to 650	1.575 (0.839)	1.750 (0.853)	1.750 (0.853)	1.575 (0.839)
650 to 750	1.575 (0.762)	1.750 (0.780)	1.750 (0.780)	1.575 (0.762)

[a] Equivalent cow numbers were obtained by reducing available Animal Unit Years for cows by 0.5, 0.6, and 0.7 for the number of days it took calves to go from 450 lbs. to 550 lbs., 550 lbs. to 650 lbs., and 650 lbs. to 750 lbs., respectively. No distinction was made for weights less than 450 lbs. since these calves always reached their weight before 8 months of age, within the normal bounds of a one-year breeding and calving cycle.

Table 2. Supplement requirements and birth dates by sale date, sale weight, and location

Calving Date			Supplement Required[a]	
Monsoon Dependent	**Winter Rainfall**			
May Sales	Nov. Sales	Sale Weight (lbs.)	Calf (lbs.)	Calf/Cow (lbs.)
Nov. 27	May 30	350	—	—
Sept. 21	Mar. 24	450	—	—
July 19	Jan. 19	550	200	0
May 17	Nov. 17	650	250	50
Mar. 14	Sept. 14	750	300	100
Nov. Sales	May Sales			
June 16	Dec. 14	350	—	—
April 16	Oct. 14	450	—	—
Feb. 18	Aug. 18	550	0	100
Dec. 23	June 22	650	0	200
Oct. 27	April 26	750	0	300

[a] 50:50 Corn & Cottonseed Meal Ration

ECONOMIC RESULTS

Calf weights were estimated as a function of age, sex, climate, 20 month compensatory gain, and prior weights, as described in equation (1). Table 4 provides the parameter estimates and corresponding statistics for this model.

Table 3a. Common real ($1999 dollars) variable and fixed cash expenses for each Animal Unit Year, 1980–1989

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Variable Cash Expenses										
Grazing Fees	62.15	56.66	46.12	36.29	35.34	34.03	30.58	28.81	32.96	35.97
Protein Supplement	23.80	20.55	19.84	17.36	18.12	15.54	15.80	15.37	17.27	17.53
Salt & Minerals	2.93	2.98	2.99	2.93	2.78	2.81	2.82	2.76	2.66	2.67
Vet & Medicine	9.91	10.02	10.42	10.31	10.39	10.14	10.14	10.03	9.95	10.29
Livestock Hauling	4.04	4.15	4.34	4.22	4.16	4.17	3.94	3.84	3.78	3.87
Custom Rates/Operation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marketing	5.49	5.54	5.81	5.75	5.77	5.80	5.76	5.71	5.86	5.94
Hired Labor	36.62	35.83	35.00	34.43	33.56	33.08	33.70	31.73	32.21	32.29
Fuel, Lube, Electricity	29.77	30.83	28.06	25.67	20.78	19.81	15.90	15.66	15.67	17.20
Machinery & Bld. Repairs	28.42	28.90	30.29	30.78	28.86	29.15	28.86	28.16	28.46	28.35
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Variable Cash Exp.	203.13	195.45	182.87	167.74	159.75	154.54	147.51	142.06	148.83	154.12
Fixed Cash Expenses										
General Farm Overhead	43.67	37.76	34.53	31.18	38.48	33.55	42.96	55.42	34.90	35.29
Taxes & Insurance	32.05	25.16	24.66	23.91	20.54	19.26	25.13	33.93	35.19	35.62
Interest	94.55	81.93	80.57	72.78	74.19	66.25	58.58	60.04	69.58	64.30
Total Fixed Cash Exp.	170.26	144.85	139.76	127.87	133.20	119.06	126.66	149.40	139.67	135.22
Total Cash Expenses	**373.39**	**340.30**	**322.63**	**295.61**	**292.95**	**273.60**	**274.17**	**291.46**	**288.50**	**289.33**

Table 3b. Common real ($1999 dollars) variable and fixed cash expenses for each Animal Unit Year, 1990–1998 [a]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	AVG.
Variable Cash Expenses										
Grazing Fees	34.04	35.31	34.16	33.04	33.82	30.47	31.36	30.08	30.47	36.40
Protein Supplement	22.93	21.93	22.47	22.01	23.46	21.83	10.04	9.78	0.00	17.66
Salt & Minerals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
Vet & Medicine	14.30	12.51	14.98	18.44	18.90	18.39	26.56	27.28	35.33	15.17
Livestock Hauling	4.21	5.27	5.08	6.02	0.00	0.00	0.00	0.00	0.00	3.22
Custom Rates/Operation	0.00	0.00	0.00	0.00	0.00	0.00	43.94	45.13	55.17	7.59
Marketing	6.75	6.39	3.36	3.78	3.87	3.77	6.14	6.31	4.59	5.39
Hired Labor	43.95	43.58	44.65	42.16	40.64	41.65	62.17	64.63	15.39	38.80
Fuel, Lube, Electricity	19.27	19.70	17.53	17.88	0.00	0.00	0.00	0.00	22.44	16.64
Machinery & Bld. Repairs	22.98	23.14	23.05	23.02	23.35	24.39	22.94	23.44	18.74	26.07
Other	4.56	4.49	4.50	4.28	0.00	0.00	0.00	0.00	0.00	0.94
Total Variable Cash Exp.	173.00	172.32	169.77	170.63	144.03	140.51	203.16	206.65	182.12	169.38
Fixed Cash Expenses										
General Farm Overhead	47.28	36.70	36.14	47.40	45.06	46.40	39.09	45.09	50.57	41.13
Taxes & Insurance	21.35	18.07	17.86	22.36	21.89	21.93	17.34	17.07	30.49	24.41
Interest	75.25	60.40	51.33	59.38	52.71	59.09	58.58	35.17	12.62	62.49
Total Fixed Cash Exp.	143.88	115.17	105.33	129.14	119.66	127.42	115.01	97.33	93.69	128.03
Total Cash Expenses	**316.88**	**287.49**	**275.10**	**299.76**	**263.70**	**267.93**	**318.16**	**303.99**	**275.81**	**297.41**

[a] Changes in USDA reporting classifications occurred from 1994 to 1998 and account for the large dollar changes in several categories from one year to the next. See the 1982–1998 Cow-Calf Production Cash Costs and Returns report for more detail on these changes.

Note that the model to estimate calf weights is constructed so that if climate, compensatory gain, and prior weight deviations are "normal," weight gain is an 8th order polynomial function of calf age in months with a constant weight percentage differential between steers and heifers.

If rainfall was above (below) the 30 year average for the months prior to their last weighing, calves would weigh more (less) than otherwise. For example, if the accumulated rainfall between the 3 and 8 month weighing was above (below) the 30 year average by 1 inch, calves would weight 11.196 lbs. more (less) than otherwise. The magnitude and statistical significance of the rainfall variable decreased as the animal increased in age. We believe that this result is because of the 20 month compensatory gain effect and the greater importance of lagged weight components as the animal increased in age. That is, these factors were able to better capture both genetic and environmental components as the calves increased in age compared to the rainfall variable.

The average and standard deviation of real returns for different sale dates and weights are given in table 4. These figures are determined using the rate of gains estimated, Cattle-Fax prices for calf and cow sales, and the opportunity cost of forage described in table 1 (i.e., reduced cow numbers for heavier calf weights). With no supplemental feeding, a sale weight of 450 lbs. for May is the most profitable alternative for both regions. Under this management plan, an average real return of $86.87/AUY for the monsoon dependent and $87.52/AUY for the winter rainfall dependent region was realized for the 19 years from 1980 to 1998. November sales of 450 lbs. are the next most profitable strategy for both regions, and this strategy has a somewhat lower standard deviation of return than the May sales of 450 lbs. It is interesting to note that cull cow sales in May rather than November account for the largest share of the $17.05 per AUY favorable revenue differential between these two seasons. Cull cow sales account for $9.39 or 55 percent of the revenue differential, while 450 lb. steer and heifer calf sales account for $5.22 and $2.44, respectively, of the favorable revenue for May sales.

Table 4. Average real return (APR) and standard deviation (SD) of returns ($ / Animal Unit Year), 1980–1998

	"Monsoon Dependent Regions"		"Winter Rain Dependent Regions"	
Sale Weight (lbs./steer)	**No Supplemental Feeding**			
	May Sales	Nov. Sales	May Sales	Nov. Sales
350	36.15 (61.78)	23.66 (57.58)	36.49 (61.85)	23.32 (57.52)
450	86.87 (67.70)	70.60 (63.90)	87.52 (67.82)	69.97 (63.79)
550	4.72 (50.84)	2.30 (50.34)	15.19 (52.67)	-7.79 (48.54)
650	1.00 (49.18)	6.91 (51.40)	13.75 (51.38)	-5.55 (49.11)
750	-20.71 (46.01)	-17.77 (63.14)	-5.08 (48.68)	-32.83 (60.20)
	Supplemental Feeding			
550	70.53 (66.10)	69.29 (64.57)	85.18 (66.97)	54.91 (63.78)
650	50.57 (63.10)	60.51 (65.41)	68.81 (64.62)	42.52 (63.97)
750	28.55 (61.55)	52.70 (84.79)	50.23 (63.70)	13.35 (79.38)

Without feeding supplement, the growth function estimated is essentially flat after reaching 7 months of age or 450 lbs. for the next 5.5 months. Thus, the opportunity cost of lower cow numbers and lower calf prices outweigh the gains from heavier sale weights for weights beyond 450 lbs. without supplement. However, heavier weights offset lower calf prices when going from 350 to 450 lb. weights carrying the same cow numbers. No opportunity cost of fewer cows is added when going from 350 to 450 lb. weights since 450 lb. calves are weaned at about 7 months of age, which allows ample time for cows to breed back in a year-round calving system.

Supplemental feeding is able to remove the long flat period for range calves from 7 to 12.5 months of age. Given the supplement requirements and weight gains described in table 2, supplementation has a considerable impact on returns when selling heavier calves. For example, supplementation for May

Table 5. Average real return (ARR) and standard deviation (SD) of returns ($ / Animal Unit Year) for extra grass year scenarios, 1980–1998

Sale Weight (lbs./steer)	"Monsoon Dependent Regions"				"Winter Rain Dependent Regions"			
	Supplemental Gains at No Supplement Cost							
	May Sales		Nov. Sales		May Sales		Nov. Sales	
	ARR	SD	ARR	SD	ARR	SD	ARR	SD
550	91.42	(66.31)	79.63	(64.63)	95.63	(67.08)	75.59	(63.87)
650	81.96	(63.46)	81.22	(65.44)	89.75	(64.87)	73.62	(63.99)
750	70.47	(62.07)	83.82	(84.03)	81.69	(64.10)	54.90	(78.34)
	Non-Supplemental Gains with No AUY Reduction							
550	116.09	(70.86)	101.04	(68.81)	118.08	(71.23)	99.10	(68.46)
650	147.05	(75.36)	139.61	(77.01)	149.42	(75.80)	137.29	(76.59)
750	178.59	(82.20)	161.28	(103.80)	181.64	(82.75)	158.28	(103.42)

sales and 550 lb. calves increased the average revenues per AUY by $65.81 and $69.99 for the monsoon and winter rainfall dependent regions, respectively. The $85.18 return associated with supplemental feeding and 550 lb. May sales for the Winter rainfall dependent regions almost attains the $87.52 return for 450 lb. May sales and no supplemental feeding for this region.

Table 5 illustrates what the return to different sale weights and dates would be if a rancher had "extra grass" so that supplemental gains were obtainable without feeding supplement or no reduction in AUYs was charged for selling calves at heavier weights. Even when supplemental gains are available at no extra feed cost, 550 lb. sales are the most profitable except for November sales in the monsoon dependent region. However, the difference between 550 and 750 lb. sales for this scenario is rather modest at $4.19 per AUY. In general, the opportunity cost associated with foregone calf numbers and lower prices does not outweigh the benefit of heavier calf weights, even when supplemental gains are imposed with no added feed cost. But if no AUY reduction is charged for producing heavier calves, the heaviest calf weight of 750 lbs. yields the highest return with May sales still somewhat preferred over November sales for both regions.

CONCLUSIONS

We found that the benefit of higher sale weights was not enough to overcome lower calf prices and fewer calf and cull cow sales for calf weights above 450 lbs. While feeding supplement was never the optimal strategy, supplemental feeding increased average returns by $45 to $70 per AUY for sale weights above 550 lbs. May sales were found to be more profitable than November sales, even with discounted rates of gain. More favorable market conditions for May than November sales are the main reason why May sales were often more profitable than November sales. It is also interesting to note that cull cow sales account for the largest share of the favorable revenue differential between these two months. Cull cow sales accounted for 55 percent of the favorable revenue differential, while 450 lb. steer and heifer calf sales accounted for 31 and 14 percent, respectively, of the favorable revenue for May sales in the mainly monsoon dependent rainfall region.

It is important to note that a more flexible sale date, weight combination, and supplemental feeding strategy could have generated more net return than the "fixed strategies" above. In addition, fertility was assumed to be high enough so that no increase in fertility was associated with feeding supplement. An increase in fertility from feeding supplement would most likely make a supplemental feeding regime as one of the most profitable strategies. But high labor and distribution costs to remote and difficult to access range sites would also make supplemental feeding less attractive than what we have expensed in our analysis. In addition, a strategy that could take advantage of market opportunities for buying replacements when they are cheap or feeding calves to a heavier weight when corn prices are high and forage is available would probably outperform the best "fixed strategy" of always producing and selling 450 lb. calves in May.

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[1]Associate Extension Specialist, Agricultural and Resource Economics, The University of Arizona
[2]Research Specialist, Agricultural and Resource Economics, The University of Arizona
[3] Former graduate student, Agricultural and Resource Economics, The University of Arizona

FROM:

Arizona Ranchers' Management Guide
Russell Tronstad, George Ruyle, and Jim Sprinkle, Editors.
Arizona Cooperative Extension