WHAT IS AN A.U.M.?

George Ruyle and Phil Ogden[1]

Livestock grazing is one of the most widespread and important uses of Arizona rangelands. Ruminant animals provide food and fiber from renewable plant resources. This method of harvesting solar energy requires relatively low inputs of petroleum products for agricultural production. But range livestock must be managed properly to insure the long-term sustainability of the resource base. Proper grazing management depends in part on determining correct livestock numbers per area of land, known as the stocking rate. Stocking rate is often expressed as animal units per section or animal unit months per acre.

Federal and state livestock grazing permits generally are expressed in terms of animal units per area or total animal unit months (AUMs). One AUM is the amount of forage required by an animal unit (AU) for one month, or the tenure of one AU for a one-month period. If one AU grazes on an area of rangeland for six months, that tenure is equal to six AUs for one month or six AUMs. In general, the number of animal units, multiplied by the number of months they are on the range equals the number of AUMs used.

But how much forage is in one animal unit month? An animal unit is defined as a mature (1,000-pound) cow or the equivalent, based on an average consumption rate of 26 pounds of forage dry matter per day (Society for Range Management Glossary). That makes an AUM equal to 31 days x 26 pounds per day or about 800 pounds of air-dried forage. More conservative or liberal values are also used, for example 600 to 1,000 pounds of forage per AUM are common values.

Flexible management plans often allow for changes in the kind and class of livestock to be grazed on a particular area. To convert cow/calf AUMs to yearling, sheep or some other category, animal unit conversion factors are used. Animal unit conversion factors are numerical figures expressing the forage requirements of particular kinds or classes of animals relative to the standard animal unit, described above. They can be calculated by dividing the new animal's daily or monthly forage requirements by the standard animal unit value. However, these forage requirement values are variable and often unknown.

Another way to calculate the AU conversion factor is on the basis of metabolic body size (MBS), a relationship between animal weight and surface area. Metabolic body size is an expression relating energy metabolism to body weight, which has a relationship to body surface. The numerical expression for metabolic body size is $Wkg^{.75}$ where Wkg equals the weight of the animal in kilograms (1 kilogram = 2.2 pounds) and the exponent .75 has been derived through research. Metabolic body size conversions can be used when changing kind or class of livestock simply by dividing the average MBS of the current livestock by the average MBS of the new livestock. Then multiply that fraction by the current stocking rate for the adjustment.

For example, if you are now grazing five hundred 1,000-pound cows on an area and want to convert to 600-pound steers, completing the following steps will calculate the conversion factor and the number of steers you should run.

1. convert pounds to kilograms

   1,000 lbs x 0.45 kg/lbs = 450 kg
   600 lbs x 0.45 kg/lbs = 270 kg

2. take these values to the .75 power

   $450^{.75} = 98$

   $270^{.75} = 67$

3. divide the current (cow) weights by the new (steer) weights 98/67 = 1.5 = the conversion factor

4. multiply the cow herd size by the conversion factor 500 cows x 1.5 = 750 steers

To simplify matters, many people prefer the straight conversion by weight alone. In the above example, this would be 1,000/600 = 1.67. So the conversion would be 500 x 1.67 or 835 steers for 500 cows. On large-scale rangeland operations, weight conversions are usually adequate. Common conversion factors, based on metabolic body sizes are listed in Table 1.

CAUTION! Forage requirement values and conversion factors should only be used as a starting point when calculating and/or adjusting stocking rates. There are many variables that alter the animal unit requirement and change these basic relationships.

Standard conversion ratios should be modified locally to account for the type of range. For example, a proportionally larger number of sheep or yearling steers can be grazed on rough, poorly watered rangeland than standard conversion ratios would indicate. The vegetation mix may also alter this relationship.

Forage quality differences should also be considered. Seasonal changes in forage quality may increase or decrease the amount of forage animals must consume to meet maintenance

Table 1. Approximate Numbers of Individual Animals (Conversion Factor) per Standard Animal Unit Calculated by Using the Ratio of Metabolic Weights (wt. kg 0.75).

Species	Average Weight lb.	kg.	0.75 kg.	Ratio	Conversion Factor
Cow	1,000	450	98	1.00	1.0
Horse	1,100	495	105	0.93	0.9
Elk	600	270	67	1.46	1.5
Mule Deer	125	56	21	4.67	4.5
Sheep	120	54	20	4.90	5.0
Pronghorn Antelope	90	41	16	6.13	6.0

requirements. Animal needs also change over the year. Animal demands are much greater during lactation, a rule of thumb is a 33% increase in protein and a 50% increase in energy requirements.

Forage requirements are not uniform over various sized animals. Small animals consume more per unit of weight than larger animals. Metabolic weight conversions can be used where necessary to reduce this error.

Finally, there is little or no research information on forage wastage whether by trampling, covering with feces or by other means. However, there does appear to be a positive relationship between grazing pressure (the animal-to-forage ratio) and efficiency of forage harvesting by the grazing livestock.

In general, a value of 26 pounds of forage per day per animal unit seems to be a reasonable starting point for management purposes. Local values may be modified by the U.S. Forest Service, Bureau of Land Management or Soil Conservation Service procedures. But these values should be used only as a guide. Stocking rates should be continually monitored through range trend analysis.

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FROM:

Arizona Ranchers' Management Guide
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POISONOUS PLANTS ON ARIZONA RANGELANDS

George Ruyle[1]

Poisonous plants can be grouped according to their primary type of poison. The better understood types of poisoning include:

1. alkaloids;
2. glycosides
3. organic acids;
4. resins;
5. phytotoxins; and
6. various minerals.

Additionally, poisonous plants are lumped into a miscellaneous category attributed to unknown poisons.

ALKALOIDS

Alkaloids are complex compounds containing Nitrogen (N) that form salts with acids. In most cases poisonous alkaloids produce a strong physiological reaction in animals, primarily through the nervous system. These poisons may produce violent acute or chronic reactions. Alkaloids are found in a wide variety of plants, including ***desert tobacco***. Nicotine is the poisonous principle in this plant and although it is unpalatable to livestock a lethal dose is about 2% of the animal's weight and poisonings do occur.

Astragalus or ***locoweed*** is another plant containing poisonous alkaloids which cause the typical loco poisoning. This is a complex genera; nearly 100 different species occur in Arizona. Locos are toxic in all stages of growth, even when dry. Consumption of loco by cattle, depending on the species, can cause immediate death or chronic poisoning leading to general unthriftyness and eventual death.

Senecio or ***threadleaf groundsel*** also poisons animals with a number of alkaloids. Cattle and horses are sensitive to senecio poisoning while sheep and goats are not. Often, a vitamin A-fortified supplement will cut down consumption of the plant.

GLYCOSIDES

Toxic glycosides yield a number of compounds. Hydrocyanic acid is the most common. Animals poisoned by HCN die of asphyxiation because HCN blocks the release of oxygen from red blood cells to tissue cells. Cattle are most susceptible and upon absorption of toxic amounts of HCN death follows in a few minutes to an hour or so.

Important hydrocyanic-acid producing plants in Arizona include ***Johnsongrass***. Danger from HCN poisoning in Johnsongrass is greatest when plants have been exposed to drought or have been frosted. Periods of rapid plant growth can also cause problems.

ORGANIC ACIDS

Oxalic acid is the most common poison in the organic acid group. This acid often produces colic, depression, coma and eventually death due to kidney failure. High calcium diets seems to prevent oxalic acid poisoning. ***Greasewood*** and ***Russian thistle*** contain oxalic acid. Losses are greatest in sheep and problems occur mainly when the diet is almost exclusively made up of these plants.

Many of the oaks including ***Gambel oak*** contain a related organic acid—

tannic acid which is also poisonous, but probably creates the most economic losses through reducing general herd productivity.

RESINS

Resins and resinoids affect both nerve and muscular tissues. The symptoms of resin poisoning are varied. The ***milkweeds*** are good examples of poisonous plants containing toxic resins.

Whorled milkweed contains toxic glycosides and resins which are partially retained in the plant after it is dry. This makes milkweed poisonous at all stages of growth, even after maturity, and when put up in hay. Whorled milkweed leaves are long and narrow and occur in whorls around the stem.

MINERALS

A number of minerals cause poisoning in livestock through plant consumption. In Arizona, probably only nitrogen and selenium are of real concern.

NITRATES

High nitrate levels in plants commonly poison livestock on both range and cropland. Losses most frequently occur during drought, after heavy application of N fertilizer and on soils high in N. Horses are less likely than ruminants to be poisoned by plants high in nitrate. Cattle are more frequently poisoned than other animals. Death is relatively rapid once enough plant material with high nitrate content is consumed.

Species that may accumulate toxic concentrations of nitrate are numerous and include ***carelessweed*** or ***pigweed***, and ***Russian thistle***. ***Filaree***, which is a valuable forage plant, occasionally develops high concentration of nitrates during the flush period of growth.

SELENIUM

Plants growing on soils containing over 2 ppm of selenium may accumulate toxic levels of this element. Consumption of these plants by livestock can produce either acute or chronic poisoning.

Plants that accumulate selenium are of two type-species Obligate species are those plants which require selenium for growth and therefore are indicators of selenium-bearing soils. Facultative selenium absorbers are plants that will accumulate selenium but are not limited to growing in soils containing selenium..

Some species of ***locoweed*** are obligate indicator plants meaning they require soils high in selenium. Secondary selenium absorbers include the ***asters*** and the ***saltbushes***.

Again, consumption of plants containing toxic amounts of selenium produce either acute or chronic poisoning. The acute form is rare however.

Chronic selenium intoxication occurs in one or two forms, blind staggers or alkalai disease. Blind staggers is caused by selenium consumption while grazing plants containing less than 200 ppm of selenium for one or two weeks. Alkalai disease develops after consumption of usually cultivated plants containing 5 to 40 ppm of selenium for periods of up to a month or longer.

MISCELLANEOUS POISONOUS PRINCIPLES

Numerous other toxic substances have been and are being discovered in plants. Tremetol, an alcohol found in

burroweed is an example of a miscellaneous poison. All parts of the burroweed plant is poisonous. These plants may also cause milk sickness in humans and calves from drinking the milk of cows grazing them.

GRASS TETANY

Grass tetany or grass staggers is a nutritional disease resulting from low blood magnesium levels and can be an important cause of losses among grazing cattle and sheep. The most common occurrence is during the first two weeks of spring green-up. Grass tetany generally affects the mature cow and is most common in the ten-week period after calving.

The immediate cause of grass tetany in animals on spring pasture is the rapid decrease in serum magnesium (MG), although the reasons for this decline are not clearly understood. Tetany can be prevented by providing additional magnesium like dolomitic limestone or magnesium oxide. Treatment of affected animals by injection of magnesium salts can prevent death loss.

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GRAZING CELL MANAGEMENT

Russell Gum[1] and George Ruyle[2]

INTRODUCTION

Management of a grazing cell requires careful planning and continuous monitoring. Both the planning and monitoring activities can be made easier by the use of computer spreadsheets to assist in calculations and data organization. Two useful spreadsheets are the growing season planning spreadsheet and the dormant season planning spreadsheet. The use of both of these spreadsheets are described below.

GROWING SEASON PLANNING

The growing season planning spreadsheet (see Table 1) assists in making the calculations to determine to the guidelines for rotation of animals through a cell during the season the forage is growing. To use the spreadsheet simply fill in the items in the spreadsheet, which are displayed in the gray cells. Each of these items is discussed below.

NUMBER OF PADDOCKS 14

If you have a different number of paddocks than the example program you will have to modify the spreadsheet by adding or deleting rows. If you do this you must change the formulas in D26 and D27 to reflect the correct number of paddocks. If you insert rows be sure to copy the formulas in row 24 to the new rows.

MINIMUM REST DESIRED 30
MAXIMUM REST DESIRED 45

Minimum rest desired is the least number of days you must rest a paddock when the plants are growing rapidly. Maximum rest desired is the most number of days you should rest a paddock when the plants are growing rapidly. Thirty and 45 days are reasonable values for many southwestern ranches. If plant growth is extremely rapid 20 to 50 days might be more reasonable. Since the spreadsheet assumes that you start in paddock 1 and proceed in numerical order, be sure to enter the paddock data accordingly.

RELATIVE QUALITY

The next step is to make an assessment of the forage available per acre in each paddock relative to one another. For new cells a simple procedure is to assume an equal quality of one for each paddock. If you have information about differences in production per acre among paddocks relative quality values can be assigned. This information is normally collected and refined as you operate a cell and keep records on its performance. To calculate the total forage available in a paddock the size of the paddock in acres is required by the spreadsheet. The following table might represent the data input for a typical cell.

PADDOCK	*SIZE ACRES*	*RELATIVE QUALITY*
1	500	0.5
2	300	2
3	200	1.2
4	300	2
5	500	0.3
6	600	0.7
7	500	1
8	200	0.3
9	300	3
10	400	1.5
11	500	0.6
12	200	0.8
13	300	1
14	500	2

At this point all of the required data has been entered into the spreadsheet and the results should appear as in the Table 1.

Use the minimum and maximum grazing periods for each paddock in the cell as guidelines for animal rotation. Continue this procedure throughout the growing season. Modifications may need to be made in the relative quality ratings of the paddocks based on observations of forage availability immediately after the animals are removed from a paddock. As modifications are made new guidelines will be calculated by the spreadsheet and should be used in determining animal rotations.

DORMANT SEASON PLANNING

The dormant season planning spreadsheet (see Table 2 and 3) assists in making the calculations to determine to guidelines for rotation of animals through a cell during the season the forage is not growing. To use the spreadsheet simply fill in the items in the spreadsheet, which are displayed in the gray cells. Each of these items is discussed below.

STARTING DATE 10/1/88

The starting date is simply the beginning date for the dormant season.

NUMBER OF PADDOCKS 14

Table 1

	A	B	C	D	E	F
1	ACTIVE GROWING SEASON					
2						
3						
4	NUMBER OF PADDOCKS		**14**			
5	MINIMUM REST DESIRED		**20**			
6	MAXIMUM REST DESIRED		**30**			
7						
8				STANDARD	MIMIMUM	MAXIMUM
9	PADDOCK	SIZE	RELATIVE	ACRES OF	GRAZING	GRAZING
10		ACRES	QUALITY	FORAGE	PERIOD	PERIOD
11	**1**	**500**	**0.5**	250	0.9	1.3
12	**2**	**300**	**2**	600	2.1	3.2
13	**3**	**200**	**1.2**	240	0.9	1.3
14	**4**	**300**	**2**	600	2.1	3.2
15	**5**	**500**	**0.3**	150	0.5	0.8
16	**6**	**600**	**0.7**	420	1.5	2.2
17	**7**	**500**	**1**	500	1.8	2.7
18	**8**	**200**	**0.3**	60	0.2	0.3
19	**9**	**300**	**3**	900	3.2	4.8
20	**10**	**400**	**1.5**	600	2.1	3.2
21	**11**	**500**	**0.6**	300	1.1	1.6
22	**12**	**200**	**0.8**	160	0.6	0.9
23	**13**	**300**	**1**	300	1.1	1.6
24	**14**	**500**	**2**	1000	3.5	5.3
25						
26	TOTAL FORAGE AVAILABLE (STANDARD ACRES)			6080		
27	AVERAGE PADDOCK RATING (STANDARD ACRES)			434		
28	AVERAGE MINIMUM GRAZING PERIOD			1.54		
29	AVERAGE MAXIMUM GRAZING PERIOD			2.31		

Table 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	DORMANT SEASON													
2														
3														
4	NUMBER OF PADDOCKS			14										
5	MINIMUM REST DESIRED			90										
6	MAXIMUM REST DESIRED			120	Rotation Guidelines									
7	ADA FOR RELATIVE QUALITY = 1			20.00										
8					MIMIMUM	MAXIMUM		MAX.				MAX.		
9	PADDOCK	SIZE	RELATIVE	INITIAL AD	GRAZING	GRAZING	STARTING	DAYS	NUMBER	AD	STARTING	DAYS	NUMBER	AD
10		ACRES	QUALITY	AVAILABLE	PERIOD	PERIOD	DATE	GRAZED	OF AD	REMAINING	DATE	GRAZED	OF AD	REMAINING
11	1	500	0.5	5000	3.99	5.31	1/1/88	5	1674	67%	5/9/88	5	2491	17%
12	2	300	2	12000	9.56	12.75	1/6/88	13	4018	67%	5/14/88	13	5979	17%
13	3	200	1.2	4800	3.83	5.10	1/19/88	5	1607	67%	5/27/88	5	2391	17%
14	4	300	2	12000	9.56	12.75	1/24/88	13	4018	67%	6/1/88	13	5979	17%
15	5	500	0.3	3000	2.39	3.19	2/5/88	3	1178	61%	6/14/88	3	1495	11%
16	6	600	0.7	8400	6.70	8.93	2/9/88	9	3299	61%	6/17/88	9	4185	11%
17	7	500	1	10000	7.97	10.63	2/18/88	11	3928	61%	6/26/88	11	4982	11%
18	8	200	0.3	1200	0.96	1.28	2/28/88	1	471	61%	7/6/88	1	632	8%
19	9	300	3	18000	14.35	19.13	2/29/88	19	7070	61%	7/8/88	19	9484	8%
20	10	400	1.5	12000	9.56	12.75	3/20/88	13	4714	61%	7/27/88	13	6323	8%
21	11	500	0.6	6000	4.78	6.38	4/1/88	6	2989	50%	8/9/88	6	1961	17%
22	12	200	0.8	3200	2.55	3.40	4/8/88	3	1594	50%	8/15/88	3	1046	17%
23	13	300	1	6000	4.78	6.38	4/11/88	6	2989	50%	8/18/88	6	1961	17%
24	14	500	2	20000	15.94	21.26	4/17/88	21	9964	50%	8/25/88	21	6538	17%
25														
26	TOTAL FORAGE AVAILABLE			121600	ADS									
27	AVERAGE PADDOCK RATING			8686	ADS									
28	AVERAGE MINIMUM GRAZING PERIOD			6.92	days									
29	AVERAGE MAXIMUM GRAZING PERIOD			9.23	days									

TABLE 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
30	STOCK TABLE													
31			JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
32	YEARLINGS													
33		STEERS												
34		HEIFERS	60	60	60	60	60	60	60	60	60	60	60	60
35														
36	COWS													
37		BRED HEIFERS	40	40	40	40	40	40	40	40	40	40	40	40
38		COWS	200	200	200	200	200	200	200	200	200	200	200	200
39														
40	BULLS								15					
41														
42	NUTRIENT REQUIREMENTS PER COW													
43	CALVE IN		IN											
44		%	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
45	JAN	0	1.60	1.60	1.60	1.60	0.95	0.95	0.95	0.98	0.98	0.98	1.20	1.20
46	FEB	0	1.20	1.60	1.60	1.60	1.60	0.95	0.95	0.95	0.98	0.98	0.98	1.20
47	MAR	0	1.20	1.20	1.60	1.60	1.60	1.60	0.95	0.95	0.95	0.98	0.98	0.98
48	APRIL	100	0.98	1.20	1.20	1.60	1.60	1.60	1.60	0.95	0.95	0.95	0.98	0.98
49	MAY	0	0.98	0.98	1.20	1.20	1.60	1.60	1.60	1.60	0.95	0.95	0.95	0.98
50	JUNE	0	0.98	0.98	0.98	1.20	1.20	1.60	1.60	1.60	1.60	0.95	0.95	0.95
51	JULY	0	0.95	0.98	0.98	0.98	1.20	1.20	1.60	1.60	1.60	1.60	0.95	0.95
52	AUG	0	0.95	0.95	0.98	0.98	0.98	1.20	1.20	1.60	1.60	1.60	1.60	0.95
53	SEPT	0	0.95	0.95	0.95	0.98	0.98	0.98	1.20	1.20	1.60	1.60	1.60	1.60
54	OCT	0	1.60	0.95	0.95	0.95	0.98	0.98	0.98	1.20	1.20	1.60	1.60	1.60
55	NOV	0	1.60	1.60	0.95	0.95	0.95	0.98	0.98	0.98	1.20	1.20	1.60	1.60
56	DEC	0	1.60	1.60	1.60	0.95	0.95	0.95	0.98	0.98	0.98	1.20	1.20	1.60
57														
58	AD YEARLINGS													
59		STEERS	0	0	0	0	0	0	0	0	0	0	0	0
60		HEIFERS	72	72	72	72	72	72	72	72	72	72	72	72
61	AD COWS													
62		BRED HEIFERS	47	58	58	77	77	77	77	46	46	46	47	47
63		COWS	196	240	240	320	320	320	320	190	190	190	196	196
64														
65	AD BULLS		0	0	0	0	0	0	27	0	0	0	0	0
66	TOTAL		315	370	370	469	469	469	496	308	308	308	315	315

If you have a different number of paddocks than the example program you will have to modify the spreadsheet by adding or deleting rows. If you do this, you must change the formulas in D26 and D27 to reflect the correct number of paddocks. If you insert rows be sure to copy the formulas in row 24 to the new rows.

MINIMUM REST DESIRED 90
MAXIMUM REST DESIRED 120

Minimum rest desired is the minimum number of days you must rest a paddock during the dormant season when forage plants are growing slowly or growth has halted. Maximum rest desired is the maximum you would want to rest a paddock during the dormant season. Values of 90 and 120 days are reasonable for many southwestern ranches.

ADA FOR RELATIVE QUALITY = 120.00

ADA is animal days per acre and refers to the quantity of forage that can be harvested by an animal from one acre of a paddock. If there is enough forage in a paddock for 20 animals to eat for a day on one acre or for 1 animal to eat for 20 days on one acre then the ADA for that paddock is equal to 20. We recommend the following procedure to estimate ADA's.

Select the paddock which is average for your cell. This paddock will become a standard and be assigned a relative quality value of 1.

Estimate how many square yards it would take to feed one cow for one day in this paddock. This would require about 20 pounds of edible forage on a dry weight basis. Then convert the square yard value into acre units by dividing it into 4840 (the number of square yards in an acre). For example, you might estimate that it would take an area 25 yards by 25 yards or 625 square yards to provide enough forage for one cow to eat for one day. Dividing 4840 by 625 results in an ADA value of 7.74. An average value for southeastern Arizona ranches would be around 10 to 12.

RELATIVE QUALITY

The next step is to make an assessment of the forage available per acre in each paddock relative to one another. Since the spreadsheet assumes that you start in paddock 1 and proceed in numerical order be sure to enter the paddock data accordingly. Rate each other paddock compared to the standard. For example a paddock with twice as much forage per acre (one which would only require 312.5 square yards i.e., about 18 by 18 yards to feed one cow for a day) would be rated as having a relative quality of 2. Table 2 shows what a typical rating might look like.

To calculate the total forage available in a paddock the size of the paddock in acres is required by the spreadsheet. Again, Table 2 might represent the data input for a typical cell. Continue to monitor the paddocks as you move your animals. If the relative quality measures do not reflect the forage availability of the cell revise them to be more realistic and rerun the spreadsheet.

STOCK TABLE

In order to calculate the correct ADA requirements for your herd, the number and type of animals grazing the cell need to be entered into the stock table. The results might look like Table 2, which follows. The stock table simply keeps track of the number of animals in the herd each month.

Since cows have different nutritional requirements depending on what stage of the pregnancy cycle they are in it is necessary to input the calving dates into the spreadsheet. The month when the cows are expected to calve needs to be known in order to keep track of the increased nutrient requirements of the cows during critical periods. For example, the final trimester of pregnancy, lactation and breeding periods require increased emphasis on cow nutrition. A typical situation might be as in Table 3, which follows.

ANALYSIS OF RESULTS FROM SPREADSHEET

The results of the spreadsheet are displayed in Table 2. The first thing to check for is whether the moves planned by the spreadsheet and the initial levels of forage will result in enough forage available to last through the expected dormant season with appropriate considerations for drought reserve. If the projected plan meets these requirements the the guidelines can be used to plan the rotation of animals through the paddocks. As you make your moves, be sure to monitor the forage

conditions and modify and rerun the spreadsheet when conditions change.

CONCLUSIONS

The use of the spreadsheets described above can reduce the drudgery of making the calculations necessary for management of a grazing cell. In addition they can be used to evaluate quickly many what if questions. What if I add 20 cows? What if the dormant seasons is two months longer than usual?

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RANGE MANAGEMENT TERMS/DEFINITIONS

Bill Frost[1] and George Ruyle[2]

Allotment — Area of federal lands designated for the grazing use of a prescribed number and kind of livestock under a specific plan of management.

Allowable Use — The degree of utilization considered desirable and attainable on various parts of a ranch or allotment considering the present nature and condition of the resource, management objectives and level of management.

Animal Impact — The sum total of the direct physical influences animals have on the land: trampling, dunging, urinating, salivating, rubbing, digging, etc.

Animal Unit — One mature (1,000 lb.) cow or the equivalent based upon average daily forage allowance of 26 lbs. dry matter per day under range conditions. This allows for forage trampled or used by other animals.

Animal Unit Month. — (1) Amount of forage required by an animal-unit for one month. (2) Tenure of one animal-unit for a period of one month.

Annual Plant — A plant that completes its life cycle and dies in one year or less.

Annual Range — Range on which the principal forage plants are self-perpetuating, annual, herbaceous species.

Apparent Trend — An interpretation of trend based on observation and professional judgment at a single point in time (see Trend).

Available Forage — That portion of the forage production that is accessible for use by a specified kind or class of grazing animal.

Available Soil Moisture — Water in the soil that is accessible to plants for growth and development.

Bare Ground — All soil surface not covered by vegetation, rock or litter.

Basal Area — Cross sectional area of the stem or stems of a plant or of all plants in a stand. Herbaceous and small woody plants are measured at or near the ground level; larger woody plants are measured at breast or other designated height. (s*ynonym - basal cover*)

Base Property — See Commensurate Property.

Biennial — A plant that lives for two years, producing vegetative growth the first year and usually blooming, fruiting, and dying in the second year. Usually grouped with annuals.

Biomass — The total amount of living plants and animals above and below ground in an area at a given time.

Biome — A major biotic unit consisting of plant and animal communities having similarities in form and environmental conditions, such as the desert, chaparral or grassland biomes.

Brittle Environments — Characterized by unreliable precipitation (regardless of amount), poor distribution of precipitation through the year as a whole, high rate of oxidation and physical decay (weathering) in old plant and animal material, very slow successional development from bare and smooth soil surfaces and, with a lack of adequate physical disturbance for years, the plant communities become simpler, less diversified and less stable. A continuous scale exists from nonbrittle to brittle environments.

Browse — Leaf and twig growth of shrubs, woody vines, and trees available for use by animals. Also, to search for or consume browse.

Bunchgrasses — Grasses that reproduce by seed and/or tillering and grow in tufts.

Canopy Cover — The percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. It may exceed 100%. (*synonym - crown canopy*)

Carrying Capacity — The average number of livestock and/or wildlife which may be sustained on a management unit compatible with management objectives for the unit. In addition to site characteristics, it is a function of management goals and management intensity.

Climax Community — The final or stable biotic community in a successional series; it is self-perpetuating and in equilibrium with the physical habitat. The assumed end point in secondary succession. Determined primarily by climate but also influenced by soil, topographic, vegetative, fire and animal factors.

Commensurability — Capacity of a grazing permittee's base ranch property to support permitted livestock during the period such livestock are off public land.

Commensurate Property — Land or controlled livestock water which qualifies a person for a grazing privilege, permit, or preference on other land, either public or private.

Community — A general term for an assemblage of plants and/or animals living together and interacting among themselves in a specific location.

Community Type — An aggregation of all plant communities with similar structure and floristic composition.

Comparison Area — An area with a documented history and/or condition that is used as a standard for comparison.

Continuous Grazing — Grazing an area without rest periods or rotation.

Cool-Season Plant — A plant which generally makes the major portion of its growth during the winter and spring and sets seed in the late spring or early summer.

Cover, Total — Percentage of ground area covered by aerial parts of live plants, litter, gravel and rocks.

Cover, Total Vegetative — Percentage of ground area covered by live aerial parts of plants.

Critical Area — An area which must be treated with special consideration due to inherent site factors, size, location, condition, values or significant potential conflicts among users.

Decreasers — Plant species of the assumed original or climax vegetation that decrease in relative amount with continued overuse. In grass communities, they are usually the taller, more palatable grasses on the site.

Deferment — Delay or discontinuance of livestock grazing on an area for an adequate period of time to provide seed production, establishment of new plants, or restoration of vigor of existing plants. Generally defined as delay of grazing until the seed of the key forage species is mature.

Deferred-Rotation Grazing — Moving grazing animals to various parts of a range in succeeding years or seasons to provide for seed production, plant vigor, and for seedling growth.

Density — Number of individuals or stems per unit area.

Desired Plant Community — Of the several plant communities that may occupy a site, the one that has been identified through a management plant to best meet the plan's objectives for the site. As a minimum, it must protect the site.

Dual Use — Use of range by two kinds of livestock within the same grazing year or season.

Dominant — Plant species or species groups, which by means of their number, coverage, or size, have considerable influence or control upon the conditions of existence of associated species. Also, those individual animals which, by their aggressive behavior or otherwise, determine the behavior of one or more animals resulting in the establishment of a social hierarchy.

Ecological Site — A kind of land with a specific potential natural community and specific physical site characteristics, differing from other kinds of land in its ability to produce vegetation and to respond to management.

Ecological Status — The present state of vegetation and soil protection of an ecological site in relation to the potential natural community for the site. Vegetation status is the expression for the relative degree to which the kinds, proportion and amounts of plants in a community resemble that of the potential natural community. Soil status is a measure of the present vegetation and litter cover relative to the amount of cover needed on the site to prevent accelerated erosion.

Ecosystem — A complete interacting system of organisms (i.e. community) considered together with its environment.

Ecotone — A transition area of vegetation between two communities, having characteristics of both kinds of neighboring vegetation as well as characteristics of its own.

Foliar Cover — The percentage of ground covered by the vertical projection of the aerial portion of plants. Small openings in the canopy and intra-specific overlap are excluded. Foliar cover is always less than canopy cover.

Forage — Browse and herbage which is available to and may provide food for grazing animals or be harvested for feeding. Also, to search for or consume forage.

Forage Production — Weight of forage produced within a designated period of time on a given area.

Forb — Herbaceous plant, usually with broad net-veined leaves. In general, any herbaceous plant other than those in the grass, sedge or brush families.

Forestland (Forest) — Land on which the vegetation is dominated by trees. Lands shall be classified forestland if the trees now present will provide 25% or greater canopy cover at maturity.

Frequency — The ratio of the number of sample units that contain a particular species and the total number of sample units.

Grasses — Plants of the *Gramineae* family. Usually herbaceous plants with narrow, parallel-veined, two-ranked leaves.

Grassland — Lands on which the vegetation is dominated by grasses, grasslike plants, and/or forbs.

Grasslike Plants — Plants of the *Cyperaceae* and *Juncaceae* families. Usually herbaceous plants with slender, usually solid, round or three-angled stems and parallel-veined, often three-ranked leaves.

Grazing Capacity — Same as carrying capacity.

Grazing Management — The manipulation of grazing and browsing animals to accomplish a desired result.

Ground Cover — The percentage of material, other than bare ground, covering the land surface. It may include live and standing dead vegetation, litter, cobble, gravel, stones and bedrock.

Habitat Type — The collective area which one plant association occupies or will come to occupy as succession advances. The habitat type is defined and described on the basis of vegetation and its associated environment. Habitat type is similar in concept to ecological, site depending on how specifically plant associations are defined. Habitat is commonly misused to refer to classification of vegetation or wildlife habitat rather than a land classification.

Herbage — The above-ground material of any herbaceous plant.

Half-Shrub — A perennial plant with a woody base whose annually produced stems die back to the woody base each year.

Herb — Any plant that is not woody above ground, such as forbs and most grasses.

Herd Effect — The impact on soil and vegetation produced by a large herd of animals in an excited state. Generally produced by concentration with excitement such as at supplements or other attractants, and then applied to areas of the range where required.

High-Intensity/Low-Frequency Grazing — Heavy, short-duration grazing in which all livestock in a set of several range units or pastures graze one pasture at a time. The animals are left in a pasture until the desired degree of use is obtained and then are moved to another pasture.

Historical Climax — The plant community considered to best typify the potential plant community of an ecological site prior to the advent of European man. May no longer be one of the potential plant communities for the site.

Increasers — For a given plant community, those species that increase in amount as a result of a

specific abiotic/biotic influence or management practice.

Indicator Species — (1) Species that signify the presence of certain environmental conditions, seral stages or previous treatments. (2) One or more plant species selected to determine the level of grazing use.

Introduced Species — Species not a part of the original fauna or flora of an area.

Invaders — Plant species absent, or present in very small amounts, in undisturbed portions of original vegetation on a specific range site which invade following disturbance or continued overuse.

Key Area — A relatively small portion of a range selected because of its location, use or grazing value as a monitoring point for grazing use. It is assumed that key areas, when properly selected, reflect the overall acceptability of current management over the range and serve as an indicative sample of range conditions, trend or degree of use.

Key Species — Forage species whose use serves as an indicator to the degree of use of associated species. Those species which must, because of their importance, be considered in the management program.

Leaf Area Index — Sum of total leaf area expressed as a percentage of ground surface. Leaf area index may exceed 100%.

Litter — The uppermost layer of organic debris on the soil surface; essentially the freshly fallen or slightly decomposed vegetal material.

Mulch — A layer of dead plant material on the soil surface, or an artificial layer of material such as paper or plastic on the soil surface. Also, the cultural practice of placing rock, straw, asphalt, plastic or other material on the soil surface as a surface cover.

Native Species — One which is part of the original fauna or flora of the area in question.

Nonbrittle Environments — Totally nonbrittle environments are characterized by reliable precipitation regardless of amount, good precipitation distribution through the year as a whole, a high rate of biological decay in old plant and animal material, speedy successional community development from smooth and sloped surfaces, and the development of complex and relatively stable communities with a lack of disturbance over many years. A continuous scale exists from nonbrittle to brittle environments.

Overgrazing — Grazing during active growth which is both severe and frequent. Generally results in reducing vegetation production and ultimately in death of the plant.

Overrest — Rest of any perennial plant that is so prolonged that accumulating old material hampers growth and/or kills the plant.

Palatability — The relish an animal shows for a particular plant as forage. This varies with succulence, fiber content, nutrient and chemical content, and morphological features such as spines or thorns. Palatability and preference are sometimes incorrectly used interchangeably.

Perennial Plant — One with a life cycle of three or more years.

Pioneer Species — A plant or animal capable of establishing itself in a bare or barren area and initiating an ecological cycle.

Plant Association — A kind of climax plant community consisting of stands with essentially the same dominant species in corresponding layers.

Plant Community — An assemblage of plants occurring together at any point in time, thus denoting no particular ecological status.

Plant Community Type — See Community Type.

Plant Succession — Vegetation change.

Poisonous Plant — One containing or producing substances that cause animal sickness, death or deviation from a normal state of health.

Potential Natural Community — See Potential Natural Vegetation.

Potential Natural Vegetation — An historical term defined as the stable vegetation community which could occupy a site under current climatic conditions without further influence by man. Often used interchangeably with Potential Natural Community.

Potential Plant Community — One of usually several plant communities that may become established on an ecological site under the present environmental conditions, either with or without interference by man.

Preference — Relative consumption of one plant over another by a specific class of animals when given free choice at a particular time and place.

Proper Use — Degree and time of use of current year's growth which, if continued, will achieve management objectives and maintain or improve the long term productivity of the site. Proper use varies with time and systems of grazing. (syn*onym - proper utilization*)

Range — Includes rangelands and forest lands that support a cover of herbaceous or shrubby vegetation suitable for grazing by livestock or game.

Range Condition — A generic term relating to present status of a unit of range in terms of specific values or potentials. Specific values or potentials must be stated. Also defined as the present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site.

Range Condition Class — One of a series of arbitrary categories used to classify range condition as that term has been variously defined.

Range Condition Trend — Direction of change, whether stable, toward (upward) or away (downward) from the site's potential.

Range Degradation — The process that leads to an irreversible reduction in capability of an ecological site to produce vegetation.

Range Improvement — Any activity or program on or relating to rangelands which is designed to improve production of forage, change vegetation composition, control patterns of use, provide water, stabilize soil and water conditions, or provide habitat for wildlife and livestock.

Range Inventory — The systematic acquisition and analysis of resource information needed for planning and for management of rangeland.

Range Site — Synonymous with ecological site when applied to rangeland.

Range Type — An historical term which refers to, and only to, the 18 standard range vegetation types recognized by the 1937 Task Force (Interagency Range Survey Committee).

Resource Value Rating (RVR) — The value of vegetation present on an ecological site for a particular use or benefit. RVR's may be established for each plant community capable of being produced on an ecological site, including exotic or cultivated species.

Rest — Prolonged non-disturbance to soils and plant community.

Rest-Rotation Grazing — A system in which one part of the range is ungrazed for an entire grazing year or longer, while other parts are grazed for a portion, or perhaps all, of a growing season.

Retrogression — An historical term used to mean succession in reverse.

Rotation Grazing — A system in which animals are moved from one range unit or pasture to another on a scheduled basis.

Serial Community — The relatively transitory communities which develop under ecological succession (s*ynonym - seral stage*).

Serial Stage — See seral community.

Sere — The whole series of communities which develop in a given situation during ecological succession.

Short Duration Grazing — Grazing system involving many pastures where animals are in each pasture for a short period of time. Pastures are grazed several times during each year. (*Synonyms - rapid-rotation, time control and cell grazing*)

Shrub — A plant with persistent, woody stems and relatively low growth. Generally produces several basal shoots (stems) and many branches.

Site Conservation Rating — An assessment of the protection afforded a site by the current vegetation against loss of potential.

Site Conservation Threshold — The kind, amount and/or pattern of vegetation needed as a minimum on a given site to prevent accelerated erosion.

Sodgrasses — Those that reproduce by stolons and/ or rhizomes and form a dense turf.

Species Composition — Proportions of various plant species in relation to the total on a given area. Proportions may be expressed in percentages based on weight, cover, density, etc.

Standing Crop — The total amount or number of living things or of one kind of living thing in an area at a given time.

Stocking Rate — The number of specified kinds and classes of animals utilizing a unit of land for a specific time period. May be expressed as animals per acre, section or the reciprocal (land area/animal).

Succession — Process of vegetational development whereby an area becomes successively occupied

by different plant communities of higher ecological order.

Tree — A large woody perennial plant, usually single stemmed, that has a definite crown shape and characteristically reaches a mature height of more than 10 feet.

Trend — The direction of change in ecological status or resource value rating observed over time. Trend in ecological status should be described as toward or away from the potential natural community, or as not apparent. Trend in a resource value rating should be described as up, down or not apparent. Trends in resource value ratings for several uses on the same site at a given time may be in different directions, and there is no necessary correlation between trends in resource value ratings and trend in ecological statues.

Usable Forage — That portion of the forage that can be grazed without damage to the basic resources; may vary with season of use, species and associated species.

Use, Utilization — Proportion of current year's forage production consumed by grazing animals. May refer to the use of a pasture or individual species.

Vegetation Management Status — The relative degree to which the kinds, proportions, and amounts of vegetation in the present plant community resemble the desired plant community chosen for an ecological site.

Vegetation Type — A kind of existing plant community with distinguishable characteristics described in terms of present vegetation that dominates the aspect or physiognomy of the area. Examples include sagebrush, creosotebush, mesquite, shortgrass, tallgrass, etc.

Vigor — Relates to the relative robustness of a plant in comparison to other individuals of the same species. Reflected primarily by the size of a plant and its parts in relation to its age and the environment in which it is growing.

Warm-Season Plant — One that makes most of its growth during the spring and summer and sets seed in the late summer or early fall. It is normally dormant in winter.

Weed — Any unwanted or undesirable plant, whether grass, forb, shrub or tree.

Wolf Plants — Individual plants of generally coarse, moderately-palatable species that when ungrazed become stemmy and remain ungrazed year after year.

Glossary of Acronyms Commonly used in Federal Land Planning Documents

AMP - Allotment Management Plan — Contains action program needed to manage the range resource for livestock grazing with consideration to soil, watershed, wildlife, recreation, timber, and other resources on lands within a range allotment.

AUM - Animal Unit Month — Quantity of forage required by one mature cow, or equivalent, for one month. Tenure of one animal-unit for a period of one month.

CE - Categorical Exclusion — The act of excluding an Environmental Analysis from being documented in an Environmental Assessment or Environmental Impact Statement because no significant environmental effects were predicted.

C&T - Condition and Trend — Refers to range condition and trend.
Condition - Current developmental stage of the range in relation to the potential or climax stage of which the area is naturally capable, either in terms of species composition or productivity.
Trend - Direction of change whether stable, toward (upward) or away (downward) from the site's potential.

CYL - Cattle Year Long — One animal grazing for an entire year.

DM - Decision Memo — A decision document that is prepared when projects are categorically excluded from preparation of an Environmental Assessment or Environmental Impact Statement. A Decision Memo documents the rationale for the project and the project's exclusion from documentation.

DN - Decision Notice — The decision document that accompanies an Environmental Assessment and Finding of No Significant Impact documenting the rationale for the decision.

EA - Environmental Assessment — A report that documents the analysis and the determination of whether or not to prepare and environmental impact statement.

EIS - Environmental Impact Statement — A document or set of documents prepared for projects having significant environmental effects that disclose the effects of the project and alternatives.

FONSI - Finding of No Significant Impact — A brief document that accompanies an Environmental Assessment in which the determination was that an Environmental Impact Statement would not be prepared because the environmental effects of the project are not significant.

FSM - Forest Service Manual — The manual used by Forest Service employees which contains the regulations, policies, and direction for Forest Service activities.

ICO's - Issues, Concerns, and Opportunities — ICO's are what projects will resolve or capitalize on. Commonly called "issues".

IDT - Interdisciplinary Team — A group of people including the project leader, are primarily responsible for the project design and analysis. Also known as Project ID Team.

IRM - Integrated Resource Management — The Integrated Resource Management Process is the Region 3 standardized format for tying Forest Plan Implementation and National Environmental Policy Act and other legal requirements together.

A land management philosophy which recognizes that all natural resources are connected through an intricate series of interrelationships. An interdisciplinary approach to project design is used to define resource relationships and integrate procedural requirements.

LAC - Level of Acceptable Change — A system of planning recreation in wilderness.

LO - Line Officer — The person with decision authority on the project, i.e., District Ranger, Forest Supervisor, Regional Forester, or Chief.

LMP - Land Management Plan — Defines long-term direction for managing the Tonto National Forest. Purpose is to provide for multiple use and sustained yield of goods and services from the Forest in a way that maximizes long term net public benefits in an environmentally sound manner.

NEPA - National Environmental Policy Act of 1969 — A Congressional Act which established a national policy for the environment, and provided for the establishment of the Council on Environmental Quality (CEQ).

NFMA - National Forest Management Act of 1976 — Requires each National Forest to prepare a Forest Land Management Plan. All subsequent management actions must be directed at effective implementation of the Plan.

NI - Natural Increase — Livestock offspring which are held over (past Jan. lst) to take advantage of winter and spring annuals in the desert ecosystem.

NOI - Notice of Intent — A notification published in the Federal Register to inform the public that an Environmental Impact Statement will be prepared for a project.

PIL - Project Initiation Letter — The letter from the District Ranger to the project leader to start the IRM process on the project.

PR - Project Record — The file of all products of the analysis phases.

PRIA - Public Rangelands Improvement Act of 1978 — A Congressional act which established a national policy for Forest Service and permittee roles in allotment management.

PU - Production-Utilization Surveys — A document which provides information on forage availability for: 1) determining estimated grazing capacity (allowable forage harvest) by livestock and wildlife; 2) analyzing opportunities to improve management technique; 3) correcting grazing problems; 4) establishing correct grazing management; and 5) locating needed range improvements.

RATM - Resource Access Travel Management — A management plan being developed to determine access to resources through the current Forest systems roads, i.e., which roads will remain open and which roads should be closed.

RBF - Range Betterment Funds — The portion of the funds collected through grazing fees which comeback to the Forest and District where they were collected for use on range improvements.

ROD - Record of Decision — The record of decision documents the rationale for selecting the project alternative, developed in the preparation of the Environmental Impact Statement, which will be implemented.

RPA - Forest and Rangeland Renewable Resources Planning Act of 1974 — Requires the preparation of a program for the management of all acres of land administered by the Forest Service.

SO - Supervisor's Office — Office where the Forest Supervisor and his/her staff are located.

SRP - Salt River Project — Organization formed to manage the water along the Salt River for Phoenix area farmers.

T&E - Threatened and Endangered Species — Threatened and endangered species of plants and animals that are listed by the US Fish and Wildlife Service and must be protected under the terms of the Endangered Species Act.

TES - Terrestrial Ecosystem Survey — Survey used in making land management decisions through integration of soils, vegetation and climate data.

VQO - Visual Quality Objective — The desired level of excellence based on physical and sociological characteristics of an area.

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FROM:

Arizona Ranchers' Management Guide
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MONITORING RANGELAND BROWSE VEGETATION

George Ruyle[1] and Bill Frost [2]

Rangeland vegetation monitoring is a useful tool to detect changes in plant communities induced by management practices and/or natural processes. Information obtained through vegetation monitoring can be used to determine if management goals are being met and to adjust management practices if needed.

There are many attributes of plant communities that may be monitored, but not all of these are useful to interpret or feasible to measure. The appropriateness of a particular attribute depends upon the vegetation type (e.g. shrubs or grasses) and the management goals for which the data will be interpreted.

Some of the important measurable attributes of shrub communities are:

1. **density** - the number of individual plants per unit area.

2. **cover** - an expression of the soil surface which is overhung (covered) by either the plant crown and shoot (canopy) or encountered by basal stems (basal cover).

3. **age and form class** - age classes consisting of seedling, young, sprout, mature and decadent (25% or greater dead wood) and the degree of hedging (form class) describing the availability of the shrub to browsing animals and the degree of hedging the plant has received.

There are a variety of other plant attributes such as height, stem diameter, leader length, and biomass, but for shrub dominated rangeland, density, canopy cover and age and form class are those which can be measured and interpreted for analysis for resource managers. Belt transects are used to determine density and age and form class, and line-intercept data are collected to estimate canopy cover.

Belt transects are merely two-dimensional, very long rectangular plots. The line-intercept method is based on the principle of reducing the belt-transect with dimensions of length and width to a line with only one dimension; length.

DENSITY & AGE AND FORM CLASS

Determining plant density is accomplished by counting the number of individuals in a known area. Density counts should be kept by species, and by age and form class within species. The age classes give a representation of the diversity present in the shrub community and the form classes represent the amount of use the shrubs are receiving. The age and form class designations are:

Age Classes

S - seedling
Y - young
Sp - sprout
M - mature
D - decadent

Form Classes

1 - All available, little/no hedging
2 - All available, moderately hedged
3 - All available, closely hedged
4 - Largely available, little/no hedging
5 - Largely available, moderately hedged
6 - Largely available, closely hedged
7 - Mostly unavailable
8 - Unavailable

These data can be collected, for example, by establishing a 100 foot transect and recording the plants present (species, age and form class) along a belt 6 feet on either side of the 100 foot tape (12 foot width total). The results can easily be converted to plants per acre on either a species, age and form class, or age and form class within species basis. The length of the transect and width of belt will vary depending upon the shrub community to be measured. Where shrubs are numerous, smaller transects and belts may be used whereas sparse shrub communities will require larger sampling units. As a general rule, 20 to 30 individual shrubs of the target species should be contained within the belt transect.

PLANT COVER

Usually cover is defined as the vertical projection of the crown or shoot area of a plant to the ground surface expressed as a fraction or a percent of a reference area (canopy cover). Cover may also apply to the basal area in relation to ground surface (basal cover). The basal area is the area outline of a plant near the soil surface.

Cover as a measure of plant distribution is often considered as being of greater ecological significance than density, largely because cover gives a better measure of plant biomass than does the numbers of individuals. Also very important is the relationship of plant cover to the potential for soil erosion.

A fast and efficient way to estimate shrub canopy cover over large areas of rangeland is with the line-intercept method. As mentioned earlier, the line-intercept method is based on the belt transect, a long, rectangular quadrat, which has two dimensions and reducing it to one dimension; length. This line consists of a tape laid out on the ground on the center of the belt transect and the plant crowns that overlap or intercept the line are recorded by species. The beginning and end of where the canopy overhangs the tape is recorded and later converted to percent cover. Where plant canopy gaps occur within individual shrubs, rounding out canopy edges and filling in interval gaps is recommended (Figure 1). The line-intercept is most useful where cover assessment of a large area is required.

These methods may be modified based on attributes of specific plant communities and objectives for the analysis. But for general estimates of shrub numbers and cover some form of belt and line intercept transects are efficient and reliable sampling methods.

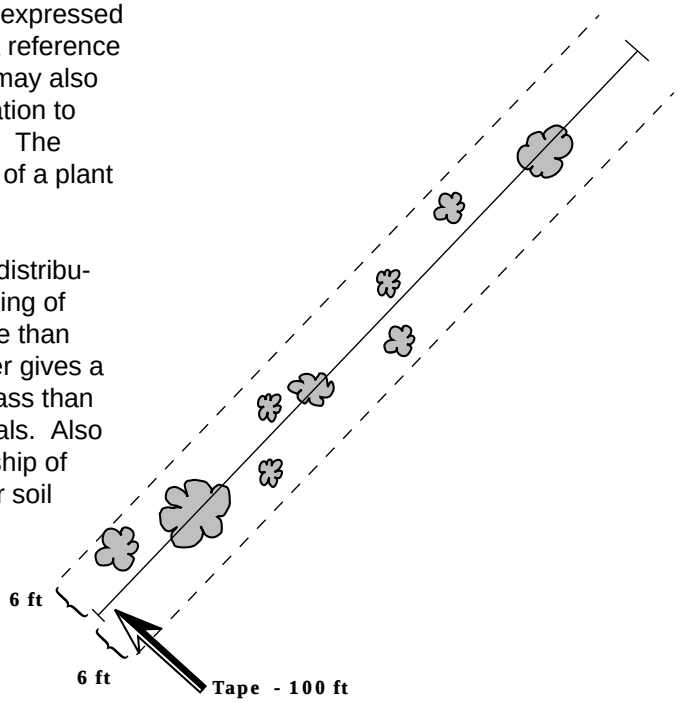

Figure 1. Where gaps occur within plant canopies along the tape, visual projections of edges and gaps are required.

THE BASIC PROCEDURES

1. Select monitoring location.
2. Establish rain gauge.
3. Establish transect end points with permanent stakes.
4. Establish photo point (take picture)
5. To read transect:

   a. record positions along tape where shrub canopies intercept line.

   b. walk along tape holding a 12 ft pole horizontally to transect so 6 ft project on each side of line. Count and record the number of shrubs in each species of interest in one of the age and form classes. The length of pole may be variable, depending on the shrub community to be measured. Sampling poles can be made of PVC segments to fit together into various lengths.

EQUIPMENT

1. 100 ft or 30 m tape (longer if vegetation is very sparse)
2. stakes for transect end points
3. springs for each end of tape (optional)
4. photo ID placard
5. metal fence post
6. PVC pipe, capped to serve as rain gauge (add inch or so of oil to limit evaporation)
7. 12 ft pole (or other chosen length)
8. data forms (example in figure 3).

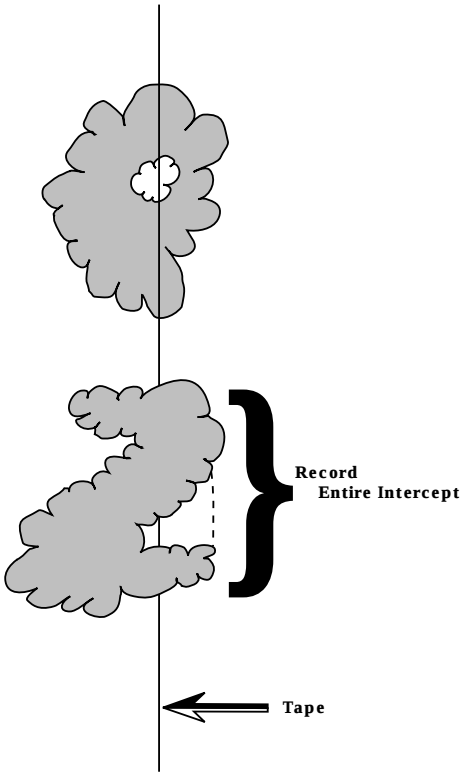

Figure 2. Diagram of line-intercept and belt transect indicating shrub cover and density. Dotted line represents imaginary boundaries created by moving pole down center line.

Figure 3. Example of a data form used to record density, cover and growth form data.

Line Intercept Transect

Location:									**Transect No.** **Length:**		**Examiner**	**Date**		
Species			**Species**			**Species**			**Species**			**Species**		
Actual Intercept	Total Inches	Age & Form Class	Actual Intercept	Total Inches	Age & Form Class	Actual Intercept	Total Inches	Age & For Class	Actual Intercept	Total Inches	Age & Form Class	Actual Intercept	Total Inches	Age & Form Class
Total														

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INTENSIVELY MANAGED ROTATIONAL GRAZING SYSTEMS FOR IRRIGATED PASTURE

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Harvest of forage from irrigated pastures can be distinct, at a given time and a determined amount. A simplified analogy between the hay grower and rotational grazing systems may be made. The manager of a grazing system determines when and how much plant material is harvested. The manager uses livestock instead of equipment to make the harvest.

Just as the hay grower must understand plant growth principles, the manager of grazing livestock must understand pasture growth principles. These must be balanced with knowledge of and performance goals for the livestock. The objective of the grazing management plan is to quickly and uniformly harvest the desired amount of plant material. Plans, however, should be considered as guidelines and remain flexible.

A practical intensively grazed pasture system consists of a number of pastures or paddocks. Pastures are grazed for one to four days, with some period of rest between grazing. A uniform harvest with minimum selectivity and repeated defoliation is encouraged when pastures are properly stocked and short grazing periods are used. The manager determines the number of livestock per paddock, the amount of time spent grazing on each paddock and the amount of time (rest) between grazings. That is, livestock are managed to conduct a timely, uniform and prompt harvest of pasture much like a swather for making hay.

Intensive grazing systems can be one of the most cost effective management activities for pastures. However, to be successful, plant varieties, composition, fertility, and water management must be considered.

STOCKING RATES, GRAZING INTENSITY AND DURATION

Uniform removal of plant material from pasture is encouraged by using a relatively "high" density or number of livestock per unit area (acre) of pasture. Picture a mass of cattle moving through a pasture, cutting (grazing) as they move. Typically, the ideal number of livestock will remove the desired amount of pasture in at least 3-4 days of grazing. When livestock are left to graze a pasture for greater than 3-4 days, regrazing of plants previously bitten will occur. The result is areas of overgrazing, which selectively discourages desirable plants while encouraging undesirable plants.

Grazing should remove a portion of the plant while leaving some leaves to capture sunlight for the plant to use in growing new leaves. The new leaves or regrowth will be removed in subsequent grazing after an adequate period of time for regrowth. Typical recommendations are to leave about 2-4 inches of plant leaves for the plant to use in regrowing. Therefore the amount of material available for grazing is all of the plant taller than about 2-4 inches (Figure 1).

Figure 1. Grazing should harvest plant material leaving 2-4 inches. The residual serves as the basis for regrowth of new plant material for subsequent grazing.

It would be much simpler to plan rotational grazing systems, if an accurate and rapid method existed for estimating the total amount of plant

material to be removed by grazing. A device marketed as a "Pasture Probe"[1] is adequate for making gross estimations. With experience, which the Pasture Probe can accelerate, growers can visually estimate amounts of plant material for grazing. In the Spring, improved pastures of fescue or orchard grass with some clover can typically be grazed when about 12 inches or taller.

The number of cattle per acre is best estimated as a weight relationship rather than number of head. For cows and calves the combined weight of cow and calf should be used (1). For example, about 15,000 (typical range is 15,000 to 25,000) pounds of livestock per acre are generally satisfactory when the duration of grazing is about 3 days. For cattle weighing 600 pound each, then 25 individuals (15,000 divided by 600) per acre would probably be satisfactory. If a paddock consisted of 5 acres then a total of 125 cattle (25 X 5), each weighing 600 pounds would be grazed for 3 days. Similarly if the cattle were cows with calves and their combined weight was 1350 pounds each (ex. cows 1100 plus 250 pound calves), then each acre might be grazed with 11-12 cows with their calves (15,000 divided by 1350). If the calves had been born in the Fall and weighed perhaps 400 pounds by the start of the grazing season we would use 1500 (1100 plus 400) pounds as the weight of an individual unit (pair). Thus, only about 10 pairs with larger Fall born calves might be grazed on each acre.

These examples are illustrated in Table 1 and your plans can be started in the space provided. This table provides information on management of one pasture or paddock that will be grazed for only 3 days at one time, we next need to consider additional paddocks for the entire grazing system.

There is no "correct" number of paddocks in a grazing system. For practical reasons eight paddocks is a reasonable compromise: fewer paddocks will result in overgrazing or inadequate rest between grazings, while more paddocks can increase performance of the pasture system, but requires considerably greater labor with smaller incremental returns.

Eight paddocks, when used with a rotational grazing scheme of 3 days of grazing on each paddock, results in rest periods of 21 days. This meets minimum typical rest recommendations of 21 to 30 days. Typically in the Spring the rancher is anxious to start cattle on pasture as early as possible, but pasture may be a little shorter than desired. Grazing plans can be adjusted slightly by

Table 1. The number of livestock for a single pasture or paddock of a grazing system (collection of pastures used in a rotational grazing plan) can be based on the desired weight of beef per acre rather than the number of head. Typical weight per acre is from 15,000 to 25,000 pounds of beef per acre (column E). The "density" or number of livestock to be grazed in a single pasture is calculated in column F.

A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Total Acres Available	**Number of Pastures (Paddocks)**	**Size in Acres of a Single Pasture or Paddock (A ÷ B)**	**Weight of Individual "Unit" Pair, Steer, etc.**	**Desired Weight Per Acre**	**Total Number of "Units" (D's) on 1 Acre (E ÷ D)**	**Total Number of "Units" (D's) for a Single Pasture or Paddock (F x C)**	**Total Number of "Units" (D's) for all Land Available (G)**
40	8	5	600	15,000	25	125	125
40	8	5	600	25,000	41-42	205-210	205-210
40	8	5	1100	15,000	13-14	65-70	65-70
40	8	5	1100 + 400	15,000	10	50	50
Your Values							

[1]Design Electronics, Palmerston, New Zealand. Available for demonstration purposes from some Cooperative Extension offices.

leaving the cattle for only 2 days in the first paddocks. This will provide enough forage for the cattle and not overgraze the pasture. Then with rapid Spring growth, pastures grazed later will have more than enough forage for 4 days of grazing. The combination of grazing for 2, 3 or 4 days, depending on forage availability will result in adequate rest to return to the first paddock with at least 21 days of rest.

Due to hotter weather after about the Fourth of July, pastures typically regrow less rapidly. The grazing manager has several alternatives for adjustment to this change in plant growth.

1. Reduce the number of livestock, adjusting for specific pasture growth conditions.
2. Stock slightly low (for the Spring period) from the beginning, but adequate for the hotter, summer season. Some "extra" feed may build up on the pasture to permit extending grazing periods to 4 days after the Fourth of July. This would result in rest periods of 28 days.
3. Provide supplemental feed.
4. Stock adequately for the summer season and during rapid Spring growth do not graze or reduce grazing to create an extra "buffer" paddock. This can be grazed during periods of slow plant growth. This "buffer" paddock might be hayed in June and allowed to regroup for a later grazing period.

Option 1 can be very effective in increasing total carrying capacity but requires more flexibility. Many managers select option 2.

FLEXIBILITY AND ADJUSTMENTS

Intensive grazing management plans should be flexible. The following are observations from some managers useful for making beneficial adjustments. If hard, dry cow patties seem to be accumulating, it is frequently a symptom of low stocking density. More livestock per acre will tend to break up or reduce the occurrence of cow paddies. Another alternative to reduce manure accumulation is irrigating immediately after grazing. This is not always feasible.

Another symptom of low stock density is the appearance of pastures that are "getting ahead" of the cattle. Forage is still tall after the planned three (3) days of grazing, or the plants are beginning to mature as evidenced by developing seed heads. Solutions are to increase livestock density, increase grazing duration on the pasture or mechanically cutting the excess. The excess, if practical, might be baled. Increasing grazing duration is only a temporary solution since the result is more days of growth on the next pasture which will result in even more excess forage when it is grazed. If the excess is great enough a hay cutting might be taken instead of grazing that pasture.

FACILITIES

Pastures of approximately the same size work much better than unequal sized pastures when used in a rotational system. Sometimes instead of thinking how to divide pastures into eight units (or whatever number are planned), one needs to consider what existing pastures can be grazed together to make eight units. Frequently 3-4 existing pastures can be easily split into two or perhaps three pastures each, making a total of 8 units.

Figure 2 shows a typical layout. Two water troughs provide drinking water for all 8 pastures. Perimeter fencing can be barbed wire or newer style high tensile smooth wire fence. Smooth wire fence may be built to provide for electrification. It should be four strands with alternating charged and non charged (grounded) wire. Interior

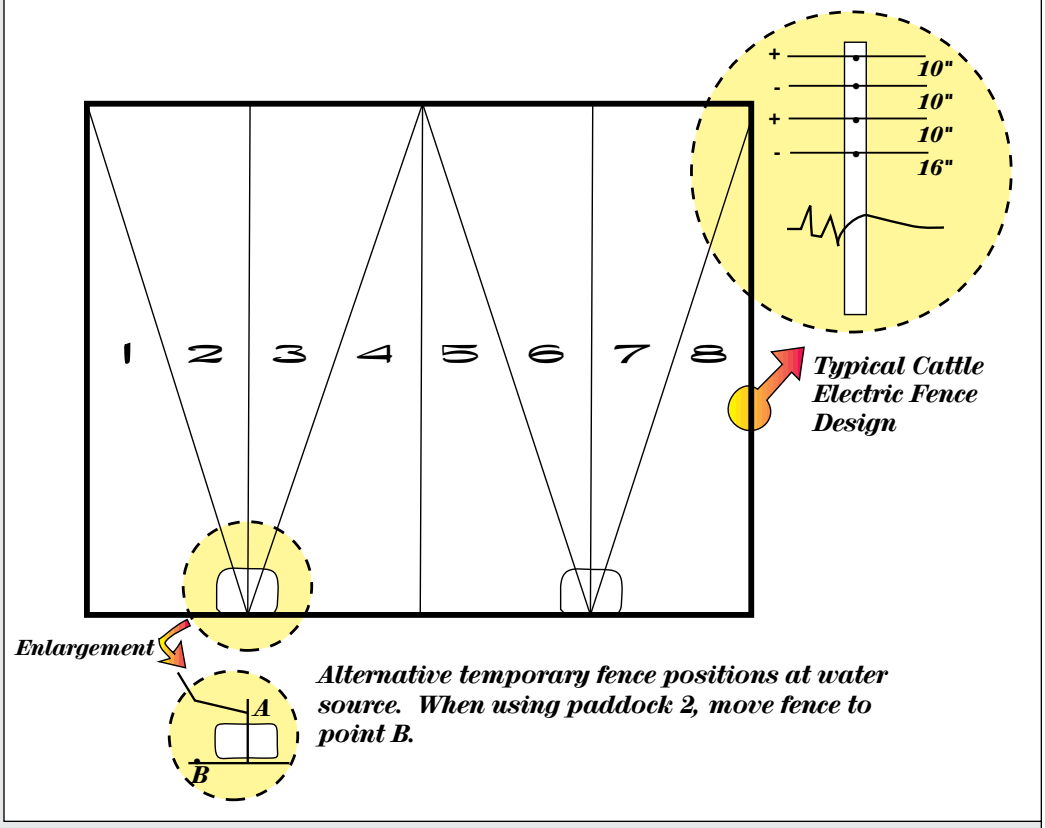

Figure 2. Aerial view of paddocks showing possible fencing arrangement and alternatives. Inset details electrification pattern for electric fence.

fencing can be multiple strands of smooth wire, or a single strand of smooth wire or woven plastic/metal wire, commonly marketed as Polywire or the equivalent. Limited experience suggests the wider Polytape is more visible, but may be less resistant to deterioration than Polywire.

Chargers should be high voltage (about 5,000) but low amperage - "New Zealand" type. These are very resistant to grounding out. The most important aspect of the energizer is adequate and proper grounding. If the fence does not work, always check the ground first.

Fence posts can be wooden or metal T posts with insulators, or nonconducting posts such as plastic or special nonconducting wood, such as ironwood. Single wire interior fencing can use short, plastic tred-in posts that are easily moved. In addition, they are short and flexible enough for wheel lines to move over them.

A wide variety of fence "posts" are now available for specific installations such as pivoting types for center pivot irrigation systems, and tumble wheels, which facilitate moving.

When livestock drinking water is shared by numerous pastures, as shown in Figure 2, sacrifice areas or areas of heavier use occur near the water. In the illustration in Figure 2 for paddocks 5, 6, 7 and 8, this sacrifice area is minimized. The design does not require additional water development. However, due to the small portion of the water trough available, adequate flow to quickly fill the tank should be available. The inset illustrates for paddocks 1 and 2 an alternative arrangement that increases trough space but suffers from a larger sacrifice area. A single trough is shared by paddocks 1 and 2 with the fence being moved to permit fuller use of the trough. The manager would have to weigh these various consequences for each application.

IRRIGATION

Besides drinking water, irrigating intensively grazed pasture systems is the second major difficulty. Fencing and grazing management strategies should be designed with existing irrigation systems in mind. With rapid cattle rotation and typically more fencing, irrigation can be difficult.

Irrigation systems should be designed and operated to provide adequate amounts of water in a timely manner. Amounts required can be closely estimated by using evapotranspiration (ET) information. ET data estimates the amount of water used or lost through evaporation from soil and transpiration of plants. Historical data from many locations is available and current season data may be available through your land grant university or local Cooperative Extension office. Adequate irrigation will insure water is not a limiting factor in crop production and resultant grazing potential.

Rotational grazing can be accomplish with either sprinkler or flood irrigation. It is usually not recommended to irrigate while cattle are on a pasture. However if this has been a historical and acceptable practice, it could be continued with rotational grazing.

Wheel line sprinklers usually cannot be used when the lines are perpendicular to fences creating physical barriers to cattle movement throughout the paddocks. Wheel lines parallel to fences can be moved over fencing and are compatible with rotational grazing. Center pivot irrigation systems with their high supply lines can be used in conjunction with break over (pivoting) fence posts.

Regardless of irrigation system, many growers attempt to irrigate immediately after grazing. This may facilitate regrowth and certainly appears to reduce or eliminate any fecal deposits. The critical factor is to design the grazing system to work in conjunction with the irrigation system: during the growing season provide irrigation to satisfy crop needs, thereby avoiding water as the limiting resource.

CATTLE SELECTION AND MANAGEMENT

No specific breed restrictions apply to intensive grazing systems. Breeds with Brahma influence can be used successfully, although extra care to avoid their agitation maybe important. As with set stocking, steers and heifers are typically not grazed together; however, from the grazing response standpoint this is not a problem. Similarly large differences in animal weights should be avoided, but no more so than with other grazing management schemes.

Some grazing managers have found whistling or making some distinctive sound when moving cattle leads to a “learned” response. Cattle will be trained to move when the sound is repeated.

Ideally cattle should be trained to an electric fence before putting them on pasture. The only reason for this is to avoid the possible labor involved in gathering cattle if they should break a fence. An ideal time to train cattle is when cattle are confined in a well enclosed area. A short strip of electric fence can be constructed, perhaps across a corner of a familiar corral, and a small amount of hay placed on the ground on the opposite side of the electric fence. As the cattle smell the hay they will get acquainted with the electric fence. This will not harm cattle and they will learn about electric fences in a controlled and safe manner.

The manager of intensively grazed cattle needs to decide who is making the decisions, the cattle or the manager. If an individual animal is causing significant problems, will management bend to the whims of that individual or

will the manager put that problem somewhere else and get going with the program?

ANIMAL HEALTH

Several considerations should be taken to maintain acceptable animal health levels when planning rotational grazing systems. When livestock are managed to more completely utilize pasture, the potential for grazing of harmful plants occurs. As management encourages more complete utilization livestock may consume plants previously avoided.

Potentially increased density of livestock per unit area may also increase the risk of internal parasitism and transfer of contagious diseases. However, specific animal behavior with any grazing system may result in time periods or areas of high livestock concentration, that are conducive to disease transmission. Preventative measures should be adopted.

ECONOMICS

Rotational grazing management plans which include length of grazing, rest periods and other factors ultimately impact stocking rates and economics. Considerable evidence indicates as stocking rates increase, such as may occur with more intensive rotational grazing, daily gain of individual cattle decrease. This response has been described as linear (see Figure 3). By definition this response to increased stocking rates when converted to gain per area is curvilinear (Figure 3). These trends are theoretical representations in the graph and specific values and relationships vary.

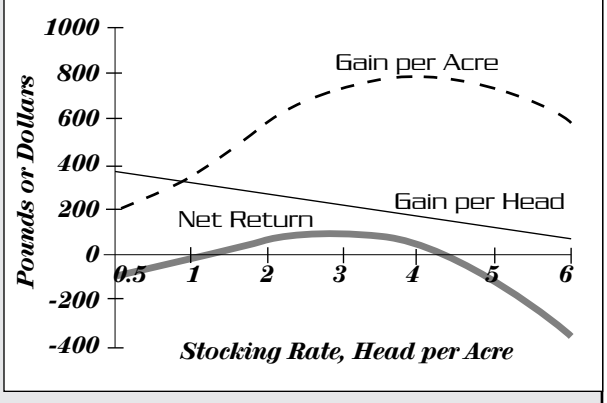

Figure 3. Theoretical responses to stocking rate.

It is noteworthy to recognize that gain per acre does decrease when stocking levels go beyond some high stocking level. Also illustrated on the graph is the relationship between stocking rate and net returns. This is again a curvilinear response. With traditional stocking rates and economics, net return per acre peaks at lower stocking levels than gain per area. However, this may vary with changes in economics.

Record keeping should permit evaluation of performance for both livestock and pastures. Data collected should permit calculation of amount of livestock gain per acre, daily gains per head, stocking rates, and net returns. Supplemental feeds or additional hay production should also be included.

An example worksheet illustrates the types of information and calculations useful for either planning or evaluating grazing systems.[2] It is important to understand differences in evaluating alternatives on a per head or per acre basis. Livestock performance has traditionally been evaluated on a per head or individual basis. Grazing systems should also include monitoring and evaluating of land based values.

The computer program facilitates the comparison of alternative grazing strategies. It provides both a per head and per acre value for data. Additionally, the computer program provides some measure of risk and allows consideration of alternatives to alter or reduce risk.

[2] The computer program for IBM and compatible computers is available from Dan Drake, University of California, Cooperative Extension, 1655 So. Main, Yreka, CA 96097; (916) 842-2711.

SUMMARY

Rotational pasture grazing systems can significantly increase carrying capacity or production of beef per acre compared to continuous or less managed systems. Rotational systems utilizing livestock for grazing can be implemented to mimic hay harvest with equipment: leading to timely, uniform and planned harvest of pasture plants. Successful plans will incorporate both plant and livestock concepts to achieve desired personal, economic and environmental goals.

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141 Stocker Cattle Profit or Loss and Risk Calculator — by
142 Version 9.25.91 — Daniel J. Drake
143.
144 Name: Intermountain Example, Typical Stocker Cattle
145 Date: 11/11/92

		INFO SUPP-LIED	CALCULATIONS Pessi-mistic	Opti-mistic	
146					
147 Comments:					
148					
149 **GENERAL INPUTS AND ASSUMPTIONS**					
150					
151 Size of pasture, acres	:	40			
152 Number of cattle	:	80			
153 Days on feed, total	:	150			
154 Purchase weight, lbs.	:	500			
155 Expected purchase price, $/cwt	:	90			
156 Purchase price variability, %	:	10	99.00	81.00	
157 Expected selling price, $/cwt	:	83			
158 Selling price variability, %	:	15	70.55	95.45	
159 Daily gain, lbs/head	:	1.67			
160 Gain variability, %	:	10	1.50	1.84	
161.					
162 **PASTURE INPUTS**			**Per Head**	**Per Acre**	**Total**
163					
164 Rent $/head/month	:	9	45.00	90.00	3600.00
165 Land, taxes, other $/acre	:	0	0.00	0.00	0.00
166 Land, taxes, other Total $	:	800	10.00	20.00	800.00
167 Irrigation Costs					
168 Water costs, $/acre foot	:	18	20.25	40.50	1620.00
169 Water amount, acre feet/acre	:	2.25			
170 Fertilizer Costs					
171 Amount, lbs/acre	:	300			
172 Cost, $/ton	:	125	9.38	18.75	750.00
173 Spread charge, $/acre	:	5	2.50	5.00	200.00
174 Labor cost, $/month	:	200	12.50	25.00	1000.00
175.					
176 **MANAGEMENT INPUTS**					
177 Vet & Medicine, $/head	:	5	5.00	10.00	400.00
178 Supplement					
179 Lbs./head/day	:	0.25			
180 Cost, $/ton	:	398	7.46	14.93	597.00
181 Days fed, all = 150	:	150			
182 Death loss, %	:	1	4.55	9.10	364.00
183 Yardage, $/head/day	:	0.05	7.50	15.00	600.00
184 Transportation, $/head	:	1	1.00	2.00	80.00
185 Brand insp., Beef pro., $/head	:	1.9	1.90	3.80	152.00
186 Insurance, Misc. $/head	:	0	0.00	0.00	0.00
187 Comm., % of buy cost	:	0.75	3.38	6.75	270.00
188 Comm., % of sell income	:	3	18.69	37.37	1495.00
189 FINANCIAL INPUTS					
190 Equity, $/head	:	75	75.00	150.00	6000.00
191 Cattle interest rate, %	:	12	18.49	36.99	1479.45
192 Op. Capital interest, %	:	11.25	3.44	6.88	275.37
193 CME Livestock Options					
194 Put Option strike price, $/cwt	:	0			
195 Option Cost cents/lb	:	1.2	0.00	0.00	0.00
196 Basis	:	-2.25			
197 Number of contracts 44,000# each	:	0			
198 Commission, total $	:	0	0.00	0.00	0.00
199 Critical Profit (1), $ total	:	30000			
200 Critical Profit (2), $ total	:	-2000			
201.					
202.					
203.					

204	RESULTS		
205 **EXPECTED**	**Per**	**Per**	
206	**Head**	**Acre**	**Total**
207 Cattle cost, total	450.00	900.00	36000.00
208 Cattle equity, $	75.00	150.00	6000.00
209 Cattle interest, $	18.49	36.99	1479.45
210 Pasture cost	99.63	199.25	7970.00
211 Management cost	71.41	142.82	5712.82
212 Pasture & Management Cost	171.04	342.07	13682.82
213 Pasture, Manage. & Cattle Cost	621.04	1242.07	49682.82
214 Gain over total period, lbs.	250.50	501.00	20040.00
215 Total cost per lb. gain	0.68	1.37	
216 Selling weight, lbs	750.50	1501.00	60040.00
217 Total dollar receipts	622.92	1245.83	49833.20
218 Total receipt minus cattle cost	172.92	345.83	13833.20
219 Profit or loss	1.88	3.76	150.38
220 Breakeven sell price, $/cwt (cost of prod.)	82.75		
221 Return on equity, %	2.51		
222 Breakeven buy price, $/cwt	90.38		

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USING SALT FOR LIVESTOCK

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The elements of common salt, sodium and chlorine, are essential for animal life. They are part of several functions in maintaining osmotic pressure in body cells which is vital to the transfer of nutrients and waste products across the cell membrane. Salt is a major component of fluid blood, which contains about 0.17% of both sodium and chlorine. Experiments have shown conclusively that extended deprivation of salt (up to one year) will cause a marked breakdown in animal production.

Livestock have shown that they are fairly capable of regulating their own intake of salt if given a reliable source of it. Under range conditions about 20 pounds per head per year has been recommended, with most available during the active growing season to assist the animal with the faster metabolism of succulent feeds.

Overdoses of salt are relatively rare, as sodium chloride is readily excreted in the urine; however it is possible to induce rumen acidosis when using salt to limit feed supplement rations, especially if a generous source of drinking water is not available.

SALT AS A MANAGEMENT TOOL

Efforts by ranchers throughout the Southwest to improve the productivity of the range have shown that a tremendous advantage lies in using salt as a tool, as well as a mineral supplement. Almost anywhere a "salting ground" can be found, the effects of continuous attraction of livestock and wildlife are obvious. These usually bare, trampled areas are often blamed on the effect of salt on the soil, rather than the result of many years of daily trampling, loafing and nearby continuous grazing. In fact, a growing number of Arizona ranchers are realizing the benefits from using salt to attract the impact of the cattle herds' feet into areas that need the short-term disturbance.

TIME

As long as the salt source remains, animals will be attracted to it. Many ranches place large, hard salt blocks in the same place year after year to be sure that the stock will be able to find it. However, while grass is growing the recovery time from grazing effects is critical. To the plant, removal of its leaves by biting or trampling has a similar effect in that either way, it will have to draw on root reserves to replace the lost leaves. If animals are still in the vicinity when the new leaves are regenerating and before root reserves are replenished, that plant will be overgrazed.

In Arizona, during summer grass growth, the plant needs a minimum of roughly 30 days to recover from loss of its leaves. From this it is easy to realize that if the salt source still attracts animals within that recovery period, the local vegetation will suffer. The biggest single benefit of salt on rangeland is that by moving it around with plant recovery time in mind, plants in any one area can be effectively grazed, but protected from overgrazing. **Never leave a salt source in one spot longer than the time it takes for the first nearby desired plants to begin regrowth.**

AMOUNT

The statement above will make some stockmen imagine the unacceptable amount of work it would take to find, pick up and move one or several large salt blocks every few days. That is a management choice, but unnecessary. The easiest way to move salt while controlling time is to place only enough salt, that it will be completely consumed in a day or two. Then, the next salt should be placed somewhere else. Depending on the time of year and size of the herd, as well as the amount that wildlife consume, some experimentation will quickly show how much salt is needed.

LOCATION

There are literally an infinite number of locations on Arizona rangelands where the brief placement of salt will be a positive management tool. A cursory glance through the pasture inventory will show many locations that are far away, on steep hillsides, in dense brush or suffering from rodent dens where the concentrated short-term effect of the herd chasing salt can be a beneficial event. We are seeing a growing number of examples of small, soft salt blocks placed at the bottom and on the sides of actively eroding gullies, where the efforts of the animals to reach the salt for a few days has rounded over the eroding banks, filled in the bottom and stirred enough seed into the soil that vegetation has been able to stabilize the erosion. **The least desirable location for salt on rangeland is close to the water source.** This is because the water is already a long-term attractant which tends to concentrate the time of animal use for too long, and salt will only increase the animal pressure. Some ranchers in southeast Arizona deliberately place their salt as far from the water point as the pasture will allow, so as to get their animals exposed to as much of the forage as possible.

EFFECTIVE USES

Salt is a powerful attraction to animals of every description. As such, it gives the land manager a valuable way to use animal impact for the improvement of the land and vegetation. By moving salt sources frequently, herds are persuaded to go into and utilize areas they never use, and just as importantly are attracted away from areas already impacted to allow vegetation to fully recover. As “bait”, salt will help:

- Break down standing (dead) litter
- Control grazing time in any one location
- Concentrate livestock use within a pasture
- Attract heavy animal impact into areas needing disturbance, such as dense mesquite, blackbrush, manzanita thickets
- Attract wild stock out of hiding, allow them to associate salt provider with familiarity
- Bring effective forage use into areas neglected for long periods

MANAGEMENT

All of the effects listed above require the active, thoughtful management of the rancher and/or land manager. By developing a careful, detailed plan of the land, vegetation and animal life and their various needs, the manager can make the lowly salt block one of the most effective resource improvement tools in the inventory.

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STRATEGIES FOR MANAGING GRAZING ALLOTMENTS ON PUBLIC LANDS

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Most ranches in Arizona are dependent, in one way or another, on federal and/or state grazing permits. The U.S. Forest Service (U.S.F.S.), Bureau of Land Management (B.L.M.) and the Arizona State Lands Department (A.S.L.D.) administer 28.6 million acres in Arizona that are grazed by livestock. Public and state land grazing permits and leases account for over 85 percent of the state's grazing land outside of Indian reservations. Approximately 63 percent of the beef cows raised in Arizona graze at least part of the year on public lands.

Public land grazing allotments are increasingly under the scrutiny of the regulatory agency involved and the general public, primarily through the vigilance of individuals from various environmental organizations. Restrictions imposed by legislation have also increased, influencing ranchers' flexibility to manage livestock on these allotments. Often, grazing permits are reduced where conflicts have arisen over real or perceived resource damage.

Generally, these conflicts can be mitigated through an organized approach to grazing allotment management planning. This effort may be initiated by the permittee and requires the same level of attention that other aspects of the ranching business demand.

We have identified six general areas that provide ranchers a process to improve range management and their ability to reduce and/or mitigate public land management conflicts. Many of the suggestions or scenarios discussed are obvious or common-sense approaches. Nonetheless, allotments targeted for administrative action often lack many of these characteristics.

1. MAINTAIN OPEN LINES OF COMMUNICATION WITH THE AGENCY PERSONNEL ASSOCIATED WITH YOUR GRAZING ALLOTMENT

Communication with the land management agencies is essential. To communicate you need to speak the same language. Increased attention to multiple range resources is often warranted in addition to discussions about livestock. Interest in soils, vegetation, wildlife and watershed values may be a common ground for further discussions. Learn what range condition means and how grazing influences range trend. Grazing can have both positive and negative effects on plants and management can have a direct bearing on these processes. Application of range management principles can directly influence permitted livestock numbers.

Listen carefully to what the agency people and others think are the problems on your allotment. Often these perceptions can be resolved with little change to management, but they have to be identified before they can be addressed. Future management strategies can be developed to cope with current and developing conflicts as perceived by agency personnel and others.

2. GATHER AND ORGANIZE AVAILABLE INFORMATION

Organizing and studying key information will enable you to become the expert on all aspects of your grazing allotment. These documents and data provide the framework for future planning and management decisions as well as a foundation for defending your actions. A place to begin is by requesting copies of your allotment files from the respective agencies. These files contain much outdated and obscure information, however, and a better approach might be to go to the office and look at the files, then request copies of specific documents. Usually these are easily obtained, but in the unlikely event that there is resistance to your request you can also invoke the Freedom of Information Act. Under this Act, there are strict deadlines and requests will elicit prompt responses although it is not a very friendly approach.

Agency maps will also be available and should be obtained. There will likely be a number of different kinds of maps, each focused on specific types of information. Maps should delineate specific land status and locate all range improvements. Soils and vegetation type maps are also often available. Other maps might report range condition and trend as well as grazing utilization levels on a periodic basis. Maps such as these are key to allotment management and should be updated periodically or developed if they are not available. Many agency maps will be out of date but will nonetheless be provided to any permittee.

Although they are not critical, aerial photos may be available and are very useful. These may have vegetation types delineated. They may also show locations of study plots. Data from any study plots that may exist for an allotment should be located and reviewed. These may include transect records and photos from permanent range trend plots or fenced exclosures. Dates of data collection should be clearly indicated.

A documented history of ownership and stocking records for the allotment should also be obtained where available. Records of past livestock use, both permitted and actual, along with any reductions or increases in permitted numbers are useful for future management and to show a history of beneficial resource use in a legal sense.

Additional records on the history of the ranch may include related deeds that reference range rights, water rights, permits or other documents. The more complete the record of range use the better.

Documentation of water rights is a complicated topic not to be addressed here. Suffice it to say that water rights should be properly filed in your name and the chain of title is brought to current ownership. The Arizona Cattle Grower's Association can help with these procedures.

Finally, all range improvements should be recorded and mapped. Kinds of improvements, locations, and dates built and/or maintained should be recorded. Records of the expense of the improvements should also be kept. Agency records of costs, private contributions and other improvement related data are only kept for a limited number of years so it is helpful for permittees to maintain permanent records.

3. DESIGN AND IMPLEMENT A MONITORING PLAN TO DOCUMENT VEGETATION CHANGES OVER TIME

Vegetation changes on rangeland grazing allotments are due to a com-

plex interaction of events that include environmental and management factors. Natural fluctuations in climate, plant population cycles, fires, insect manifestations and grazing animals are some of the major influences on vegetation changes. Many procedures are available to keep track of these changes.

Specific objectives for the use of the vegetation monitoring data will determine the kinds of data to collect and are not discussed in detail here. Certain procedures, however, are useful to design and implement vegetation monitoring in most situations. The first decision is the location of study areas. These are usually located according to key areas and critical areas. Key areas are representative of conditions over most of the allotment and should be located on soils or sites of major importance to forage production. Critical areas need not be extensive but are important to monitor for specific resource values or because they may be more sensitive to grazing damage than is typical. Additionally sites expected to show changes due to management should be monitored. Historical study plots should also be considered for a renewed monitoring effort.

Transects can be established at each selected area depending upon the sampling design. A typical layout for monitoring range trend might consist of 10 transects, running perpendicular to a baseline. Data for plant frequency, density and ground cover or other attributes may be collected by locating a series of quadrats along each transect. Forage utilization data should also be collected at these sampling areas.

Establishing a photographic record of vegetation changes is also important. Photographs repeated over the years display vivid evidence of vegetation changes. Specific details on vegetation monitoring are available in other publications.

Again, communication with management agency people is important. They will usually accept a rancher's data, but need to know what monitoring is being done and may desire to be actively involved in the data collection.

4. LOCATE AND STUDY PROBLEM AREAS

Any allotment management plan will probably have one or more of the following goals.

a. To maintain or increase the proportion of certain plant species by regulating the intensity, frequency and/or season of grazing on those plants. Specific goals might be to increase the proportion of cool season grasses or forbs or simply increase the diversity of plant species present, or improve ground cover on an allotment.

b. To prevent accelerated erosion or allow present erosion to heal.

c. To avoid excessive conflict between livestock and other uses, such as wildlife, riparian zones, etc. This has become a primary motivating force for public land grazing management.

Any part of the allotment where these goals are not being met can be identified as a problem area. Problem areas will primarily center around plant species composition, soil protection and critical wildlife habitat. You can identify problem areas through analysis of agency maps plus your own knowledge of the allotment.

Study agency maps of range condition and/or utilization in addition to whatever study plot data which are available. Look for areas in poor range condition and areas of heavy utilization (in excess of 50%). These are likely to be

areas identified as problems. Keep in mind that condition reflects management in the past. Trend should indicate what is happening under current management and should be related to current utilization patterns.

Problem areas that are visible to the traveling public can create a bad impression of the entire allotment. These areas should be identified and consideration given to their improvement. Most allotments will contain only localized overgrazing or heavy use.

Several common scenarios that may need attention are listed below.

a. Condition is poor, trend is down or stable and utilization is high. This is sure to be a problem area and your objective should be to reduce use in such an area, perhaps initially providing for growing season rest.

b. Condition is poor but current utilization is low. This may be due to heavy stocking for prolonged periods in the past which has been changed by reducing livestock numbers and/or the timing of use. In this case trend should be up and the objective should be to keep it improving. If you have no evidence that there was ever heavy stocking in the area, or if the trend is not upward, then the "poor condition" is probably due to invasion of brush or trees or to a naturally poor site potential. Present procedures may not adequately distinguish between poor condition caused by overgrazing and lack of forage or ground cover caused by poor soil, low precipitation or brush invasion. In these cases it is important to document that these areas of poor condition are not due to improper grazing management.

c. There may be areas of fair to good condition which are currently receiving heavy use. Trend on these areas will go down if excessive use continues without any timing considerations. Changes in management or new improvements such as fences or water development may cause such a situation. The objective in these situations should be to lighten use or change the timing of grazing by altering season of use or shortening grazing periods and providing adequate rest periods in order to maintain good range condition.

d. Other problem areas are those which are especially important for wildlife (critical browse areas or antelope kidding grounds for example), heavily grazed areas along streambanks or near campgrounds, and where active gullies are present.

5. EVALUATE ALTERNATIVES FOR MANAGEMENT

Once you have identified, from available maps, data and your own observations, where your real problems of poor condition and overuse are, you can start looking for ways to alleviate the pressure on these areas. Since no two allotments are alike in either problems or opportunities, there are no formulas for how to do this. The key is your ability to identify where the problems are and your imagination in looking for feasible changes in management to reduce the problems.

An important step is to watch utilization patterns carefully. Keep in mind that annual plants, plants that live for only one growing season, contribute little, if any, to most ratings of range condition or utilization. Therefore, look carefully at the condition and use on palatable perennial grasses and browse.

Identify areas which are not getting much use. If there are not any such areas or there is no feasible way to get use on them, a reduction in numbers may be necessary and beneficial to both range and livestock conditions. However, on many allotments the problem is not so much one of too many cattle but of the timing and distribution of grazing. Often allotments show overuse of some areas and under use of others.

The main objective is to reduce use in problem areas and increase it in areas of light use unless there are specific reasons to do otherwise. One or more of the following strategies to improve grazing distribution or management may work.

a. Move salt and supplemental feeding locations to areas with light use or, at least, move these locations frequently and keep them away from water.

b. New waters can be developed to serve lightly or unused areas. Care should be taken not to overstock these new grazing areas.

c. Herding may also keep cattle distributed. Riding can change natural grazing patterns and introduce animals to new waters and salting areas.

d. New or relocated fences or drift fences can keep cattle off of problem areas. These may also be necessary before grazing management can be effectively implemented.

e. Controlled burning or other brush control measures and/or reseeding also may improve the condition of problem areas or provide enough extra forage to take pressure off problem areas.

f. Finally, grazing management can change the timing of grazing by changing the frequency or season of use. Some type of rotational movement of cattle may give grazed plants a chance to recover and speed improvement of concentration areas. A workable system must be designed to meet the needs of both vegetation and livestock management. Remember that when trying to improve beat-out or critical areas, all livestock must be removed during the recovery periods. Leaving a few bulls or horses may be enough to prevent any positive response on these areas.

   Grazing management need not be complicated or require a lot of new water development and fences. Herding, controlling access to available water and relying on natural behavioral instincts of your livestock may be enough to get started.

6. KNOW YOUR LEGAL RIGHTS, RESPONSIBILITIES AND APPEALS PROCEDURES

Grazing permits carry with them both legal rights and responsibilities. Read your permit and understand the requirements. Access and wildlife regulations should also be known and followed, as failure to do so may invalidate grazing privileges.

Where management and communication fail, understand how to use the appeals process. There are a number of alternatives available depending upon the agency and level of your dissatisfaction. You can challenge agency decisions without a lawyer using procedures by the agencies and

their parent agencies; the U.S. Forest Service and the U.S. Department of Agriculture; the Bureau of Land Management and the U.S. Department of Interior.

For example, for BLM decisions there are two different kinds of administrative remedies: protests and appeals. A protest is a formal request for reconsideration by a BLM official of any proposed or final decision. An appeal is a formal request for review of final BLM decisions by either an Administrative Law Judge (ALJ) or the Interior Board of Land Appeals (IBLA). The Interior Department has established the IBLA and ALJs to review disputed agency decisions. Certain decisions can only be appealed to ALJs or IBLA while others can only be protested.

The kinds of decisions than can be appealed in the National Forest System are called planned actions. These are written decisions governing plans, projects, and activities to be carried out on the National Forest System that result from analysis, documentation and other requirements of the National Environmental Policy Act and the National Forest Management Act. To appeal a decision a person must file a written notice of appeal with the next higher line officer and simultaneously send a copy of the notice of the appeal to the Deciding Officer (the line officer whose decision is being questioned). Decisions subject and not subject to appeal are listed under 36 C.F.R. Part 217 of the Federal Register, Vol. 54, No. 13, as are definitions, time limitations and details for filing appeals of Forest Service decisions.

Many unfavorable agency decisions can be forestalled using the recommendations set forth in this paper. It all begins with open and honest communication, setting reasonable resource objectives and then monitoring progress. As responsible land stewards it is up to you to take the lead in communication with land management agency personnel, stressing proper resource management, documenting results and creating a positive image with the non-ranching public.

WORKING OUT SOLUTIONS

If management changes are warranted and the allotment is not scheduled for a new Allotment Management Plan, request general planning guidelines from the appropriate range management personnel and use these to write your own proposals. Further technical assistance can be obtained from the Natural Resources Conservation Service, Cooperative Extension, private consultants and other sources.

Before formal appeals, always consider further communication and consensus. Often, an informal meeting with the Forest Supervisor, BLM District Manager or State Land representative will solve the problem.

Methods exist to organize people and efforts to solve range management or other natural resource management issues. These consensus-building procedures have a number of similarities. The appropriate interests must be identified and must have the opportunity to be involved in the process. Allotment management plans are increasingly developed in conjunction with interested groups and individuals in addition to the permitee and the appropriate agency personnel. The Forest Service has formalized this process with their Integrated Resource Management procedures.

In any process, goals and objectives must be agreed to, while considering available resources and land potentials. Management recommendations should then be tied to stated goals and monitoring methods developed to determine whether or not goals are being reached. Finally, there should be procedures that allow corrections to the plan when needed.

Arizona has a memorandum of understanding to participate in the Coordinated Resource Management (CRM) procedure, signed by an executive group comprised of members from the U.S. Forest Service and Bureau of Land Management, Arizona State Land Department and Game and Fish Departments, and The University of Arizona Cooperative Extension. Coordinated Resource Management is often used to identify goals and priorities for planning, managing and monitoring grazing allotments, especially where more than one public agency is involved. Participation in the CRM process begins at the field group level and is a means to provide not only technical expertise but maintain communication among interested parties. The organization of a CRM group can facilitate the development of an allotment management plan.

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USING REPEAT COLOR PHOTOGRAPHY AS A TOOL TO MONITOR RANGELANDS

Larry D. Howery[1] and Peter Sundt [2]

"Boy, you should have seen this place 10 or 15 years ago. Things sure look better now! Cover has improved. There are more desirable plant species. Wildlife habitat is better than it used to be."

Do these comments sound familiar? Unfortunately, often times there are no data to back them up. When it comes to convincing folks that your management practices have improved the range, you have to pretend for a moment that you are from Missouri, which is known as the "Show Me" state. It is especially important to show people that what you say is true when your critics weren't around 10–15 years ago to see the changes you have seen. A series of photographs taken at the same spot through the years can vividly demonstrate change on the range. This article provides an introduction to repeat color photography and explains how it can be used as an important part of a comprehensive rangeland monitoring program.

BACKGROUND

Why use repeat color photography?

Repeat color photography is a simple and relatively quick way to monitor rangelands. A properly located photo station can reveal changes over space and time in important rangeland attributes like plant growth, species composition, total plant cover, litter, spatial arrangement of plants, and soil erosion (i.e., all aspects that can be related to grazing management practices).

Are there permanent photo stations on public land grazing allotments?

If you are a Bureau of Land Management or United States Forest Service livestock grazing permittee, it is likely that photo stations have already been installed in permanent monitoring sites (called key areas) on your allotment. Ask your range management specialist for a map that depicts the location of key areas and the types of monitoring activities conducted at these sites in the past. Some key areas will have photo stations established on them, while others may not.

Should I establish new photo stations? If so, where and how many?

If permanent photo stations have not been installed on your allotment you can set them up yourself, but involve your local rangeland management professional. Let resource managers know that you are serious about learning how grazing management, weather, or other factors (e.g., rodents, insects, fire) may be influencing rangeland attributes. They will help you locate photo stations in "key areas" which are locations that are typical and representative of larger areas. In grazing studies, key areas are chosen as a sample, a barometer of sorts, of the average grazing impacts in a pasture or vegetation type. Below are a few points to consider when establishing new key areas where photos will be taken.

- As is true of all forms of rangeland monitoring, photography requires clear objectives and careful selection of places to monitor. In most rangeland monitoring studies, the objective is to detect changes in rangeland attributes due to grazing, fire, weather, and other environmental variables. An inventory of range sites, vegetation

types, and utilization patterns helps determine where and how many key areas should be located.

- Generally speaking, the more variable the rangeland the more key areas are needed. One key area is probably adequate to monitor an irrigated pasture on flat terrain, but a typical Arizona ranch may need several key areas to adequately represent the different types of country and variation in grazing pressure.

- Remember that key areas are intended to represent typical grazing activities for a larger area. Consequently, don't locate key areas where livestock never graze (e.g., more than a mile or two from water, steep slopes), or where livestock normally congregate (e.g., within 1/4-mile from watering points, fence lines, or at pasture corners). *Note: If your objective is to monitor an "environmentally sensitive area" (e.g., riparian area, endangered species, wildlife habitat), the area monitored is commonly referred to as a* ***critical area*** *rather than a key area.*

- Spurious conclusions may result if a change occurs in a key area because of local events (like a fire or flood), but not in the larger area the site was chosen to represent. For this reason, it's helpful to have more than one key area per pasture or vegetation type so that you can be confident a change is general rather than due to local conditions.

- On the other hand, it is pointless to establish a key area if you don't have time to monitor it. Begin by establishing a few key areas within the highest priority areas of the ranch, and add more as time and your increasing experience allow. The important thing is to get started! As you gain experience, you may want to augment your photos with other more intensive rangeland monitoring techniques (e.g., frequency, dry-weight rank, cover).

What is the difference between a photo-plot and a photo-point?

- ***Photo-plots***, are close-up photos taken of a relatively small, permanently-marked plot on the ground within a key area. Photo-plots are useful if your objective is to intensively monitor changes in individual plant species populations or in soil cover.

- ***Photo-points*** are established to show a general landscape view of a key area. Their objective is to detect changes in major vegetation types, such as the degree of shrub encroachment, across landscapes.

- Both of these monitoring methods are tools that can be used to show how rangeland attributes may change due to management and/or environmental factors.

PHOTO-PLOTS

What is the objective of using photo-plots?

To intensively monitor the changes in size and number of key plant species, and to monitor changes in soil attributes like cover, pedestalling, and rilling.

What size photo-plot should I use?

Photo-plots conventionally vary in size from 1 x 1-meter, to 3 x 3-feet, to 5 x 5-feet (see Illustrations 1–3). You will need a step ladder to ensure a high enough angle to photograph the 5 x 5-feet size. However, the latest interagency monitoring manual recommends using the 1 m^2 size where new studies are being established (Interagency Technical Reference, 1996).

Where should I establish photo-plots?

As discussed earlier, photo-plots should be located in key areas. Each photo-plot is a small sample of the key area. It should include plant species of principal interest, such as key forage species. If soil erosion is of concern photo-plots can be located in a rilled or gullied area. Because of the small area being monitored (i.e., the plot) it may be necessary to have several different photo-plots located within a key area to avoid making wrong conclusions based on too little information.

What materials do I need to establish a photo-plot?

1. Frame made of PVC pipe, steel rods, or similar material to delineate the photo-plot.

   Note: You can also use 2, 6-feet wooden carpenter rulers folded at right angles at the 3-feet marks to mark 3 x 3-feet photo-plots.

2. Four rods to divide the 3 x 3-feet and 1 x 1-meter photo-plots into 9 square segments (optional, see Illustration 1).

Illustration 1. Photo plot frame (3 x 3-feet).[3]

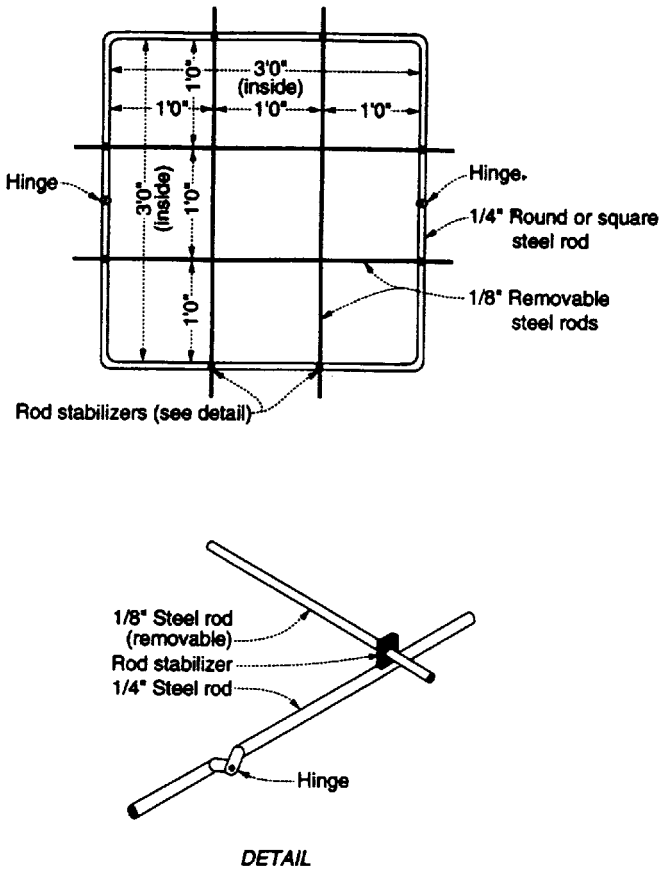
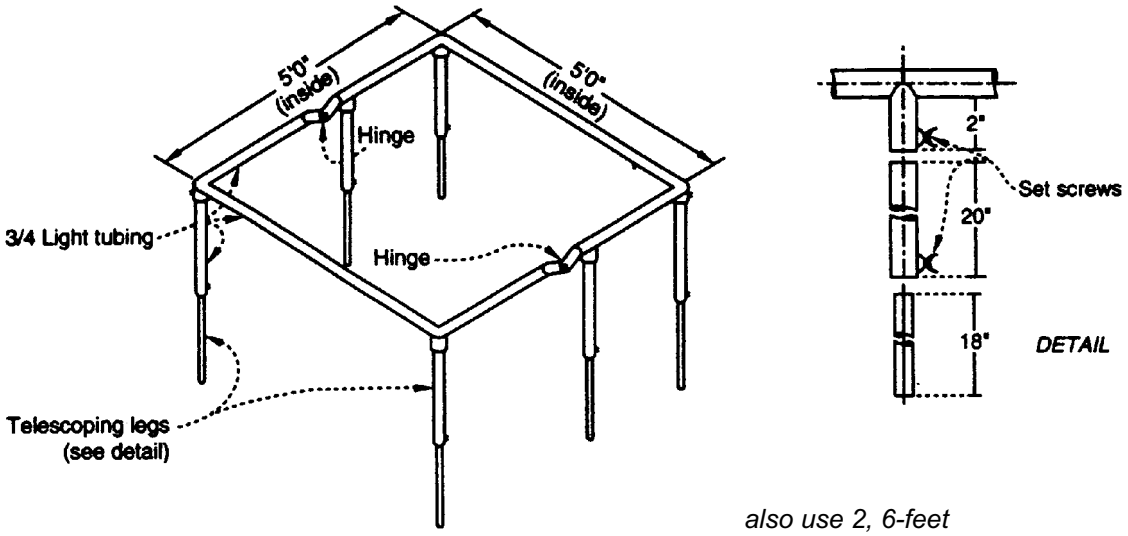
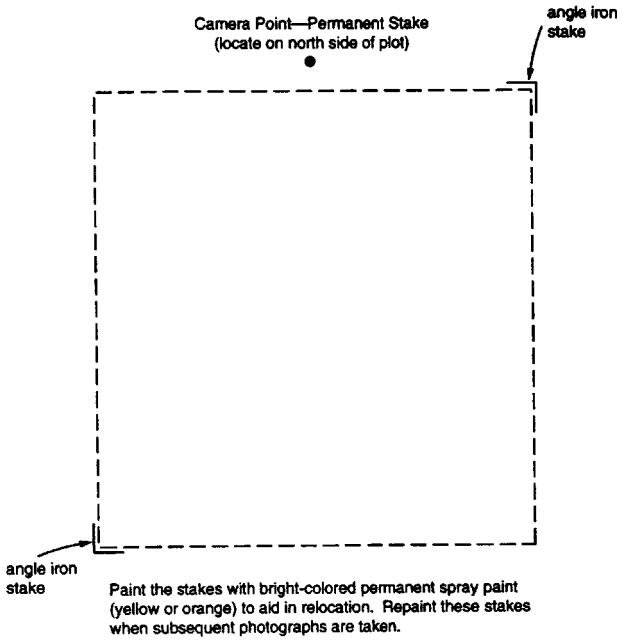


Illustration 2. Photo plot frame (5 x 5-feet).[3]



also use 2, 6-feet

Illustration 3. Permanent photo plot location (3 x 3-feet, 5 x 5-feet, or 1 x 1 meter).[3]



3. Small step ladder (for 5 x 5-feet photo-plots only).

4. Half-inch angle iron stakes (rebar or PVC pipe will also suffice) at least 16-inches long (you will need 3 stakes/photo-plot).

   Note: You may want to use PVC pipe to make stakes. Metal stakes can cause flat tires and injure animal hooves.

5. Hammer.

6. Photo identification form (see Illustration 4), or chalk board.

   Note: Pastel-colored paper (e.g., gray or light green) works better than white paper because white paper can reflect light rendering the labeled form unreadable.

7. Study location and documentation form (to record relocation information and other important data, see Illustration 5).

8. Two clip boards for holding forms.

9. Broad felt tip pen with waterproof ink.

10. Pencil.

11. Compass.

12. Map or aerial photo of the study site.

13. Bright colored spray paint (yellow or orange).

14. Camera with a 28-mm wide angle lens and color film.

15. Steel t-post or some other device to serve as a roadside marker (commonly called a “witness post”).

16. Post driver.

How do I establish a photo-plot?

1. Place photo-plot frame on the ground area you intend to photograph. Align the plot frame so the sides are aligned with the cardinal directions (i.e., north, south, east, and west). Drive 2 stakes into the ground at the diagonal corners of the frame, and 1 stake just outside the midpoint of the north side of the frame (Illustration 3).

2. Label the photo identification form with waterproof felt tip pen to include date, photo-plot number, resource area (if on public land), allotment, and pasture. Be sure to write large and legibly. Place the photo identification form flat on the ground immediately outside of the photo-plot frame.

3. Stand with your toes touching the stake on the north side of the photo-plot. Take your photo making sure the plot frame and photo identification form are included in the photo. *Note: Taking photos from the north side helps reduce shadowing across the plot.*

Illustration 4. Photo identification form.[3]

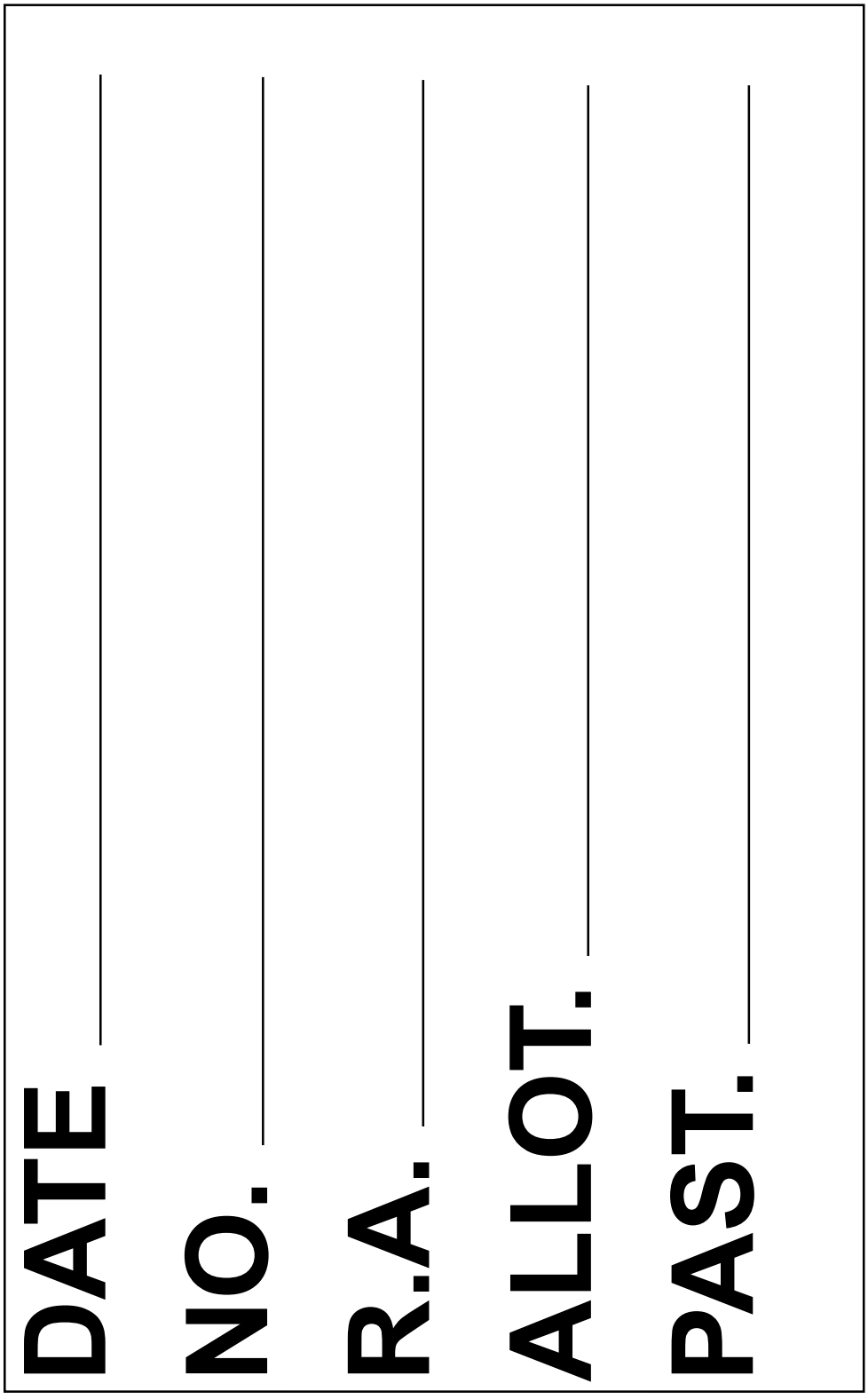


Illustration 5. Study location and documentation data form.[3]

Page ____ of ____

Study Location & Documentation Data

Study Method					Study Number	
Allotment Name & Number				Pasture		
District			Resource Area			
Ecological Site			Plant Community			
Date Established	Established by (Name)			Map Reference		
Elevation	Slope	Exposure		Aerial Photo Reference		
Township Range Section 1/4 1/4 1/4						
Location				Scale: ____ inches equals one mile		
Key Species 1 2 3						
Distance and bearing between reference post or reference point and the transect location stake, beginning of transect, or plot						
Distance and bearing between location stake and bearing stake						
Transect Bearing	Vertical Distance Between Ground & Aligned Tape					
Length of Transect	Plot/Frame Size					
Sampling Interval	Total Number of Samples					

Notes (Description of study location, diagram of transect/plot layout, description of photo points, etc. If more space is needed, use reverse side or another page.)

Note: Depending on the study method, fill in the blocks that apply when a study is established. This documentation enables the examiners to conduct follow-up studies in a consistant manner to provide comparable data for analysis, interpretation, and evaluation.

4. Take a few “landscape photos” in different directions from the photo-plot (see next section) to show the surrounding landscape. This will help you relocate the photo-plot in the future, particularly if the witness post (see below) is removed.

5. Place the steel t-post (commonly called a “witness post”) in a visible location from the photo-plot just off the road or trail.

6. Record on the study location and documentation form all information that will help you relocate the photo-plot in the future, including:

    - Compass bearing and distance of photo-plot from the witness post.

    - Sketch of prominent physical features of the key area (roads, trees, fencelines, rock outcrops, streams). Be specific because it may be a year or more before you return to the plot.

    - Record any observations you deem appropriate to the general area (e.g., actual use, animal concentration, wildlife sign/use, rodent sign/use, insect infestation, flood, fire, rainfall, water availability, open gates, vandalism).

    - Record mileage to key area from prominent physical features (e.g., road intersections, other key areas).

    - Jot down your rationale for locating the photo-plot in this particular area. *Note: Photo-points (or landscape view photos, see next section) can also be taken at each photo-plot location to aid relocation.*

7. Spray-paint stakes with bright-colored spray paint.

8. Organize your photos and forms in a 3-ring binder by date and photo-plot identification number.

PHOTO-POINTS

What is the objective of using photo-points?

To monitor how rangeland vegetation may change across space and/or time (e.g., grasses to shrubs, or vice versa). The landscape view is especially useful for detecting brush encroachment into grasslands, and for monitoring the spatial arrangement of trees and shrubs.

Where can I establish photo-points?

Photo-points can be established in upland areas to document changes in dominant plant life forms (e.g., grasses to shrubs, or vice versa). In hilly or mountainous country, it helps to locate photo-points so that views can be shot across narrow valleys and hill slopes. These views spread out vertically and aid in plant identification. Often a station can be located to allow a 360 degree panorama of a key area.

Photo-points are also commonly used in riparian areas to document changes in streamside attributes (e.g., bank cover, erosion, stream width, changes in number and size of trees and shrubs). The number of photo-points established depends on your objectives and the size of the riparian area, but a minimum of three (i.e., upstream, downstream, and across-stream) are usually recommended at each photo station.

What materials do I need to establish a photo-point?

You will need item numbers 4–16 listed in the earlier section, “What materials do I need to establish a photo-plot.” You will only need one, 1/2-inch angle iron stake (rebar or PVC pipe) at least 16-inches long for each photo-point.

How do I establish a photo-point?

1. Drive the stake into the ground and spray paint the top to mark the permanent photo-point (i.e., point where you will stand each time to take photos).

2. Label the photo identification form as explained for photo-plots. Have someone hold the photo identification form while you take the photo or prop it against a rock or tree, making sure that it is readable in your camera's view finder.

3. Take picture to include the photo identification form as well as prominent reference points (e.g., stream, fence post, fence line, prominent trees and/or rock outcrops, road) in the foreground and background.

4. As with photo-plots, record all pertinent information that will help you relocate and interpret your photos. Again, several landscape photos taken in several directions will help you to relocate the photo-point in the future.

5. Organize your photos and forms in a 3-ring binder by date and photo-point identification number.

How do I make sure that I am photographing the same landscape area each time I go into the field?

1. On each subsequent sampling occasion, bring to the field your 3-ring binder that contains previous photos and forms. Use your previous photos and forms to relocate the photo-point stake.

2. Prepare the photo identification form and place it in the photo area as described above.

3. Refer back and forth between your camera's view finder and a previous photo until you are satisfied that your view finder includes the same landscape shown in the earlier photo. Take the photo.

GENERAL RECOMMENDATIONS

- Take photos at about the same season of year so that differences in plant growth and phenology (e.g., seed-set, flowering) or management activities (e.g., before vs. after grazing) do not confound photo interpretation.

- Whenever possible, establish comparison photo stations in both grazed and ungrazed key areas that are similar in every aspect except grazing (e.g., similar soils, topography, precipitation) to allow evaluation of grazing effects.

- Slide film lasts longer in storage than prints. Slides can be made into prints that can be used to illustrate changes to people in the field and to relocate photo-points.

- Weather permitting, use the same camera lens size, film type and speed each time you sample. We recommend using 100 or 200 ASA film for the bright and sunny days that are typical of Arizona.

FINAL THOUGHTS

Changes in rangeland attributes occur relatively slowly in the arid southwest, particularly in upland areas. Riparian areas have more potential to change rapidly in response to both management and precipitation. Be patient! Repeat color photography will help you document subtle rangeland changes, but probably won't provide sufficient information to evaluate all of your goals and objectives. Consider also collecting quantitative data like precipitation, soil moisture, forage production and utilization, species frequency, vegetation cover, and actual use (i.e., stocking rates).

Repeat color photography should be an important part of any rangeland monitoring program. It is relatively fast and inexpensive, and can help tell a convincing story when implemented over several years. If you are not currently participating in a rangeland monitoring program, repeat color photography is an excellent way to start. It may be the only type of monitoring you have time for, at least initially. So the next time someone says “show me” how things have improved, show them your photos. Remember**, a picture can be worth a thousand words.**

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[3]All illustrations were originally published in identical or similar form in the Interagency technical reference manual (1996). They are reproduced here by permission of Bureau of Land Management’s National Applied Resource Sciences Center, Denver, CO.

FROM:

Arizona Ranchers' Management Guide
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RANGELAND MANAGEMENT INFORMATION ON THE WEB

Barbara Hutchinson,[1] Jeanne Pfander,[2] and Michael Haseltine[3]

INTRODUCTION

For the past four years, an interdisciplinary team at the University of Arizona has been involved in the development of a comprehensive web site on the topic of managing rangelands. Part of a national-level initiative to create an electronic library of agricultural information called the Agriculture Network Information Center (AgNIC), the Arizona AgNIC web site provides access to a wide variety of rangeland resources as well as links to other agricultural information. Figure 1 shows the home page for the site, located at: http://ag.arizona.edu/agnic/range.html.

Besides a section that contains general introductory information about the subject, there are five main categories that include the majority of the site s resources: Rangeland Science; Practical Tools; Policy Issues; Education, Teaching and Careers; and General Resources. The right side panel provides a list of special highlighted resources contained in the web site, while the left side panel gives the user opportunities to learn more about the site and its developers, to search the site, to ask specific questions, and to provide feedback.

NAVIGATING THE WEB SITE

On subsequent pages two icons are used throughout the site to signify whether or not the section was developed by Arizona AgNIC. For instance, if a miniature of the Arizona AgNIC symbol is seen, it indicates that the

Figure 1. Managing Rangelands Home Page

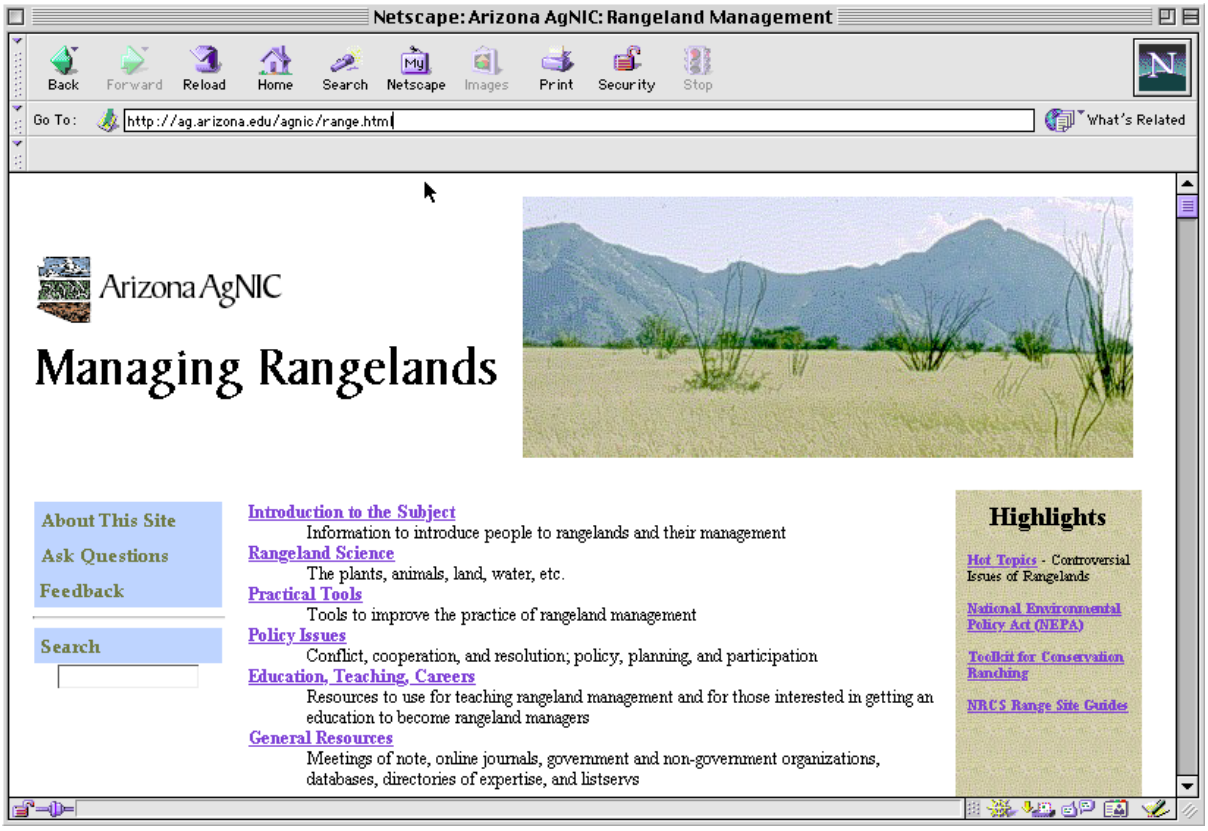
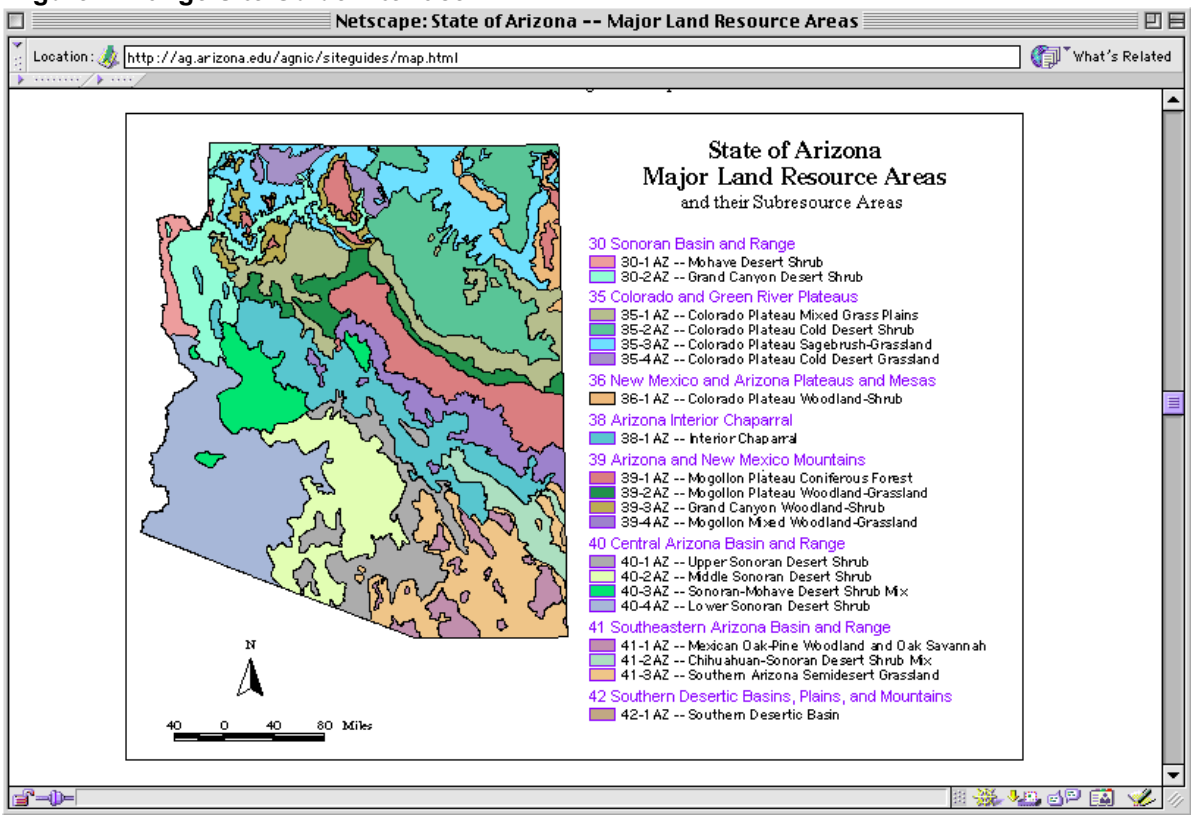


Figure 2. Range Site Guide Interface



link is to pages the AgNIC team has prepared. Links with the offramp sign take users to sites prepared by other people and organizations.

After leaving the home page, the user will notice a blue navigational bar at the top of each page that includes links to every other major section of the site. The Arizona AgNIC symbol at the top and bottom of each locally developed page is a hot link that will always take the user back to the Managing Rangelands home page. If leaving the site via an off-ramp page, the user will need to use the browser s back button/arrow to return to the Managing Rangelands home page.

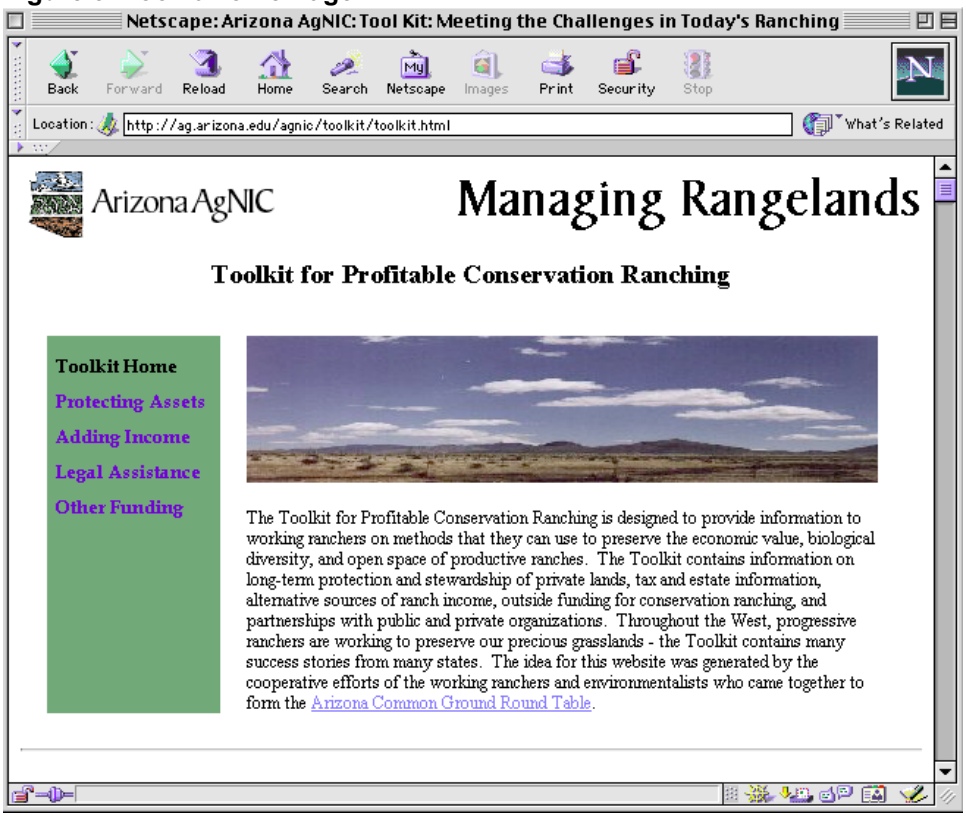
WEB SITE SECTIONS

Rangeland Science

This section is oriented toward the scientific study of rangelands, their understanding and management. Topics on the main page are specified in several different ways. Under the general topic are *Special Resources,* which usually feature those resources created especially for the site by University of Arizona project personnel, but may also include links to particularly noteworthy web resources compiled elsewhere. The *Other Information* section is primarily composed of links to other related sites on the web.

Of particular interest to Arizonans are the selections Range Site Descriptions for Arizona and the Santa Rita Experiment Range. Range (or Ecological) Site Guides are produced by the Natural Resources Conservation Service and provide information on the ability of land to produce vegetation and hence support grazing based on soil and climate. As with much of this web site, the work is ongoing for putting up all Arizona range site guides and creating simple methods for using them. However, interactive maps are available to help the user locate specific information (see figure 2).

Figure 3. Tookit Home Page



The Santa Rita Experimental Range web site provides data and repeat photography from the first experimental range in the United States, founded in 1903, and located south of Tucson. The photos demonstrate changes in vegetation through the years from various locations on the 53,159-acre site.

Other resources are organized by specific topic and can be reviewed by clicking on the topic of choice as noted in the bar at the top: Animals | Climate | Land | Plants | Water. These include links to both Arizona AgNIC and non-Arizona AgNIC web sites with information in these areas.

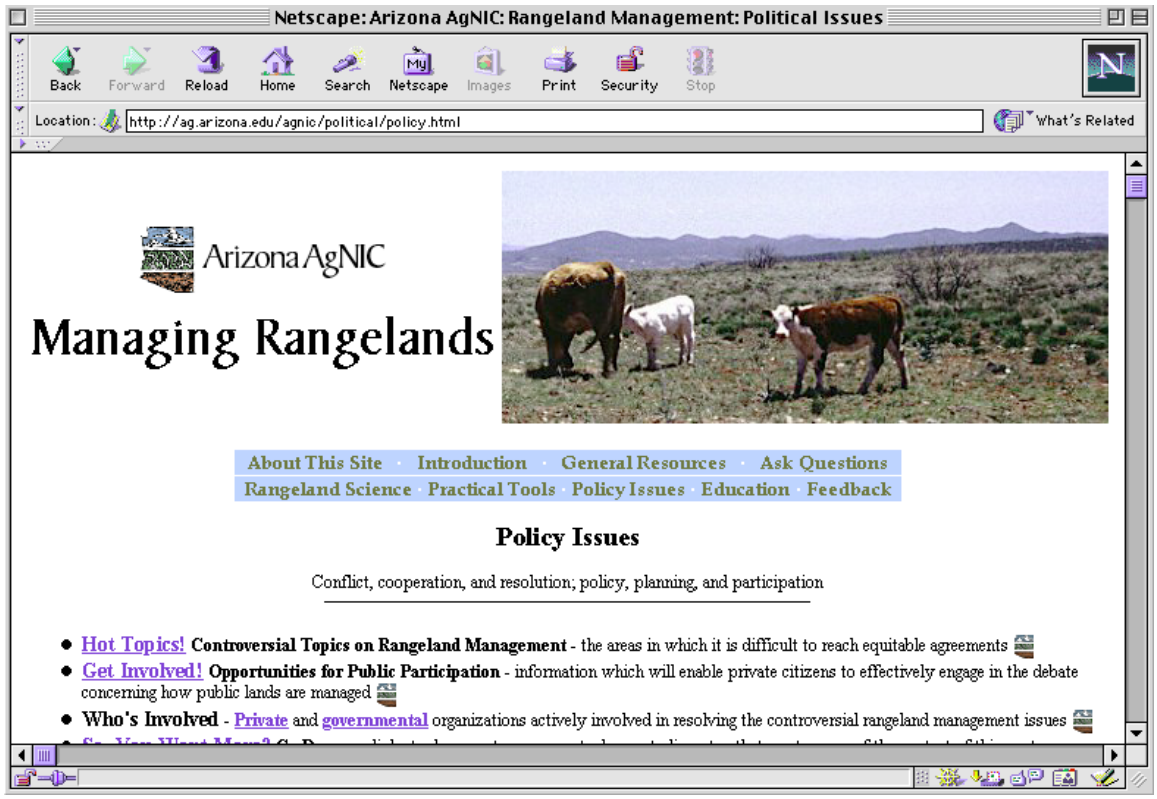
Practical Tools

The main page for the section on Practical Tools is organized similarly to Rangeland Science. At the top are those resources that hold promise for helping users answer questions of a practical nature that can lead to new and better management strategies.

Here you can find links to information on noxious weeds, rangeland health standards, and the full-text of the *Arizona Ranchers Management Guide*.

Of particular note is the Toolkit for Profitable Conservation Ranching (Figure 3). This sub-section was prepared in cooperation with the Arizona Common Ground Roundtable, a state-wide group of ranchers, environmentalists, researchers, public agency personnel, sportsmen, and other interested citizens who are seeking to identify tools and policy changes that will conserve Arizona s open spaces (see their web site at: http://udallcenter.arizona.edu/commonground/). Links provide information on how to preserve open space through such means as conservation easements, land trusts, and family trusts. Alternative forms of income generation for ranches are discussed, such as guest ranches, summer camps, and fee hunting, and the toolkit also includes information on finding

Figure 4. Policy Issues



legal assistance and supplemental grants and funding opportunities.

Policy Issues

Managing the rangelands of the western United States involves many different people, groups, and agencies with differing points of view. Issues surrounding the preservation, conservation, and fair use of rangelands are often controversial and seem intractable. The resolution of those conflicts involves developing a constructive dialog based on finding common ground and areas of compromise. This section of the web site focuses on aspects of the policy and political issues regarding our rangelands.

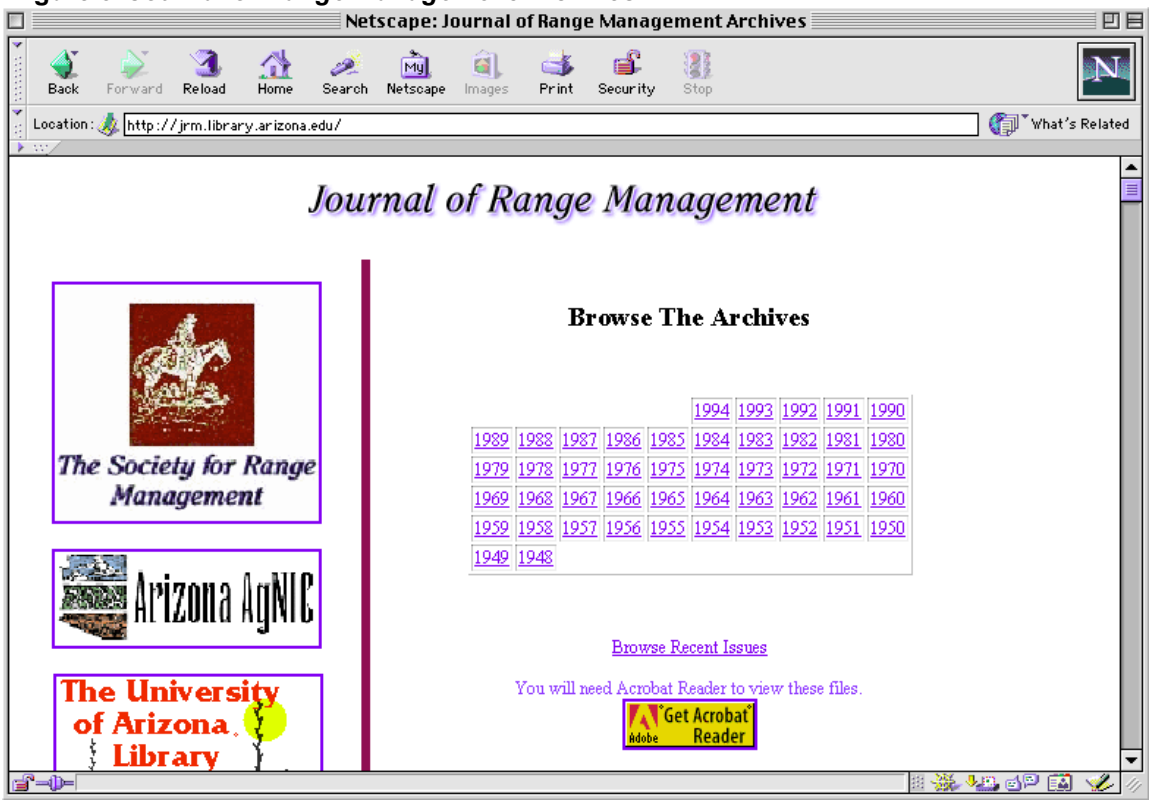
Beginning with a link to a section on hot topics, the user can find links to other web sites on the subjects: Indian Lands, Urbanization, Water and Riparian Areas, Recreation, Mining, Logging, Grazing on Public Lands, and Wildlife and Endangered Species. Each of these topics is divided into three sub-sections providing background information, newspaper items, and information on legal issues.

The Get Involved section provides an in-depth review of the National Environmental Policy Act (NEPA) including a description of federal regulations, various agency implementation procedures, and a discussion of how NEPA has been interpreted by the courts. It also provides links to facilitate public participation in the process of making decisions about how public lands are used.

Education, Teaching, and Careers

To assist teachers and students in their academic pursuits, this section provides links to potentially useful teaching materials, lists of college programs in rangeland management, and guidance in planning for a career in this field. In particular, faculty in the Rangeland Program at the University of Arizona

Figure 5. *Journal of Range Management* Archives



are preparing an online textbook for the site titled, *Principles of Rangeland Science and Management.* At the time of this publication, Chapter 4 (Ecology and Management of Rangeland Vegetation) and Chapter 5 (Rangeland Inventory and Monitoring) are in place. Within these chapters are links to further explanations and to related readings.

General Resources

This section contains links to academic institutions with rangelands programs, selected Extension publications, online bibliographic databases, online journals, meeting announcements, government and non-government organizations, directories of expertise, and related listservs. Of particular importance, project staff from the University of Arizona Library have worked with the Society for Range Management to digitize articles (Volumes 1—47,1948—1994) of the *Journal of Range Management,* and make them available through this web site. Each article in these issues may be read in its entirety online with Adobe Acrobat Reader, which must be installed.

Ask Questions (Left Side Panel)

The web site provides an interactive form in this section for questions about rangelands. First-time users should read the Frequently-Asked-Questions (FAQ) about this reference service, linked at the top of the form.

Individuals using the query form should fill out all five sections with their name, email address, occupation and affiliation, the question, and additional information that will provide context for the question. A response to the question is usually provided within 24 hours.

Queries have been received from many different geographic locations worldwide and many different kinds of users. Questions from Arizonans make up a large percentage of all queries.

Feedback From Users

The project team for the Managing Rangelands web site is committed to improving the site and making it more useful. The interactive feedback form gives users the opportunity to evaluate the site and make suggestions (additional sites to link to, etc.).

Searching for Specific Information

A search function is provided that allows users to enter words, phrases, or combinations of words using Boolean operators (and, or, not), to find specific locations where those words are mentioned on the Managing Rangelands web site. It provides a means to locate specific information or resources when the user is not sure how to find that information or has tried and not been successful.

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FROM:

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

RUSLE APPLICATIONS ON ARIZONA RANGELANDS

Christopher Jones[1]

INTRODUCTION

The Revised Universal Soil Loss Equation (RUSLE) is a standardized soil erosion prediction equation that can be used for many land use situations. The USDA Natural Resource Conservation Service is the primary user of RUSLE. Because of the variable nature of rangelands and their large size, there are limitations of the use of RUSLE on rangelands. With understanding of those limitations, RUSLE can still serve as an effective and easy tool to indicate average annual soil loss per acre.

Arizona ranchers and rangeland managers often find RUSLE useful to estimate, monitor, and predict soil loss. The tool is site specific, readily available, inexpensive, and fairly easy to use. Its most common application is to examine and address areas with known erosion problems.

Soil loss is important because there is a direct relationship between soil depth and plant growth. It is a valuable parameter to help gauge and determine potential range condition. Land use normally has more effect on soil loss than any other single factor. Of the major factors affecting soil loss, land use is generally the only one that can be changed to control soil loss. A decrease in soil loss over time would demonstrate that management practices being used are environmentally sound. Conversely, an increase may point to a need to address management practices and/or landscape vulnerability.

Efforts to create an equation to estimate soil erosion began in the 1930s (Cook, 1936). Subsequent research by various agencies of the U.S. Department of Agriculture and universities resulted in the Universal Soil Loss Equation, presented in *Agriculture Handbook No. 537* (Wischmeier and Smith, 1978). The revised equation, RUSLE, was made available in 1992 as a computer-based application that can now be accessed over the Internet. It can be found at

http://www.sedlab.olemiss.edu/rusle/

The program is updated on a regular basis and is available as a download at no charge. This website includes links for assistance, including rangeland specialists based out of Tucson, and other complimentary information. Two other resources necessary for using RUSLE are the assistance of the nearest USDA Natural Resources Conservation Service (NRCS) office and the *Agriculture Handbook No. 703,* "Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)" (Renard et al., 1997).

This paper is intended to provide a basic understanding of RUSLE, concerns for rangeland applications, and what land managers can do to implement RUSLE. Although there is debate about RUSLE's accuracy for rangeland applications (Weltz, Kidwell, and Fox, 1998), USDA scientists and researchers are continually improving the equation's utility. Other erosion simulation models, such as the Water Erosion Prediction Project (WEPP), are just too complex and/or cost prohibitive for most rangeland managers. At present, RUSLE is readily available, inexpensive, and fairly easy to execute. Its limitations for rangeland applications are identifiable and can be addresed to provide useful information. Until other erosion simulation models are developed for the general user, RUSLE

continues to be the primary soil erosion prediction tool in use today.

THE EQUATION

Based on the 1978 Universal Soil Loss Equation (USLE), RUSLE is as follows:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Where:

A = Average annual soil loss per unit area predicted by the model (tons/acre/year).

R = Rainfall-runoff erosivity factor—the rainfall erosion index.

K = Soil erodibility factor—the soil-loss rate per erosion index unit for a specified soil on a standard plot.*

L = Slope length factor—the ratio of soil loss from the field slope length to soil loss from a 72.6-ft length under identical conditions.

S = Slope steepness factor—the ratio of soil loss from the field slope gradient to soil loss from a 9% slope under otherwise identical conditions.

C = Cover-management factor—the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow.

P = Support practice factor—the ratio of soil loss with a support practice such as contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

*The standard plot is defined as a 72.6-ft. length of uniform 9% slope in continuous clean-tilled fallow.

Like its predecessor USLE, RUSLE is a lumped empirical model in a simple linear equation, the product of the above six factors. In the equation, all the factors and subfactors are calculated together to give an estimated soil loss as an annual average. As revised, current knowledge of erosion science is incorporated into the subfactors that make up the factors used.

THE FACTORS

The following is a brief description of each factor (Renard et al., 1997):

Rainfall-Runoff Erosivity Factor (R): The R-factor quantifies the effect of raindrop impact and also reflects the amount and rate of runoff likely to be associated with precipitation events. The R-factor is calculated as total storm energy (E) times the maximum 30-minute intensity (I_{30}), or EI, and is expressed as the rainfall erosion index. Index maps are used to determine the local value used for R. The R-factor is estimated by a methodology that includes information gathered from over 1,000 National Weather Station rain gauges.

Soil erodibility factor (K): The K-factor is the rate of soil loss per rainfall erosion index unit as measured on a standard plot, as defined in the above section. It represents the average long-term response of a specific soil and its profile to the combined effects of rainfall, runoff, and infiltration. It is expressed as the change in the soil loss per unit of applied external force or energy.

Slope length factor (L): The L-factor incorporates the ratio of rill erosion (caused by flow) to interrill erosion (raindrop impact) to determine the loss of soil as compared to the standard plot length of 72.6 ft. Slope length is defined as the horizontal distance from the origin of overland flow to the point where deposition occurs (a flattened slope) or runoff concentrates into a defined channel, usually within 400 feet of surface flow. RUSLE is most accurate when slope lengths are considered in 1,000-ft. distances or less.

Slope steepness factor (S): The S-factor reflects the influence of slope gradient on erosion as compared to the standard plot steepness of 9%. The program is designed to account for non-uniform slopes and slopes greater than 20% as well. Slope steepness has a greater effect on soil loss than slope length. The factors L and S are evaluated together in RUSLE.

Cover-management factor (C): The C-factor is used to reflect the effect of management practices on erosion rates. The RUSLE program user can easily compare the relative impacts of management options by making changes in the C-factor to reflect grazing impact or burning. For range-land applications, average annual values for the C-factor are usually used. The C-factor is determined using subfactors for prior land-use, canopy cover, soil cover, surface roughness, and soil moisture.

Support practice factor (P): The P-factor is the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage. Soil-disturbing practices such as ripping, root plowing, contour furrowing, and chaining that result in storage of moisture and reduction of runoff are considered the major rangeland support practices.

USING RUSLE

"The principal number that RUSLE computes is average annual soil loss, but it also displays a wide range of other values that provide insight into how conditions at the given site affect soil loss. For example, the amount of ground cover from the previous year's forage is one of those variables. Another important piece of output information is time in the vegetation growth cycle when the soil has reduced cover in relation to when erosive rains occur. If intense, erosive rains occur when the soil is relatively bare, and higher erosion rates can be expected. To control erosion means giving special attention to make sure that the ground has cover when the intense rains occurs."

—G. H. Foster & the RUSLE Development Team 1999

The RUSLE user's most important resource is the local NRCS office. The nearest office can be found in the phone book under the government listings. The District Conservationist and his/her staff are familiar with RUSLE's applications and the erosion science behind it, as well as with the strengths and weaknesses of both. They will be instrumental in helping the user to get the most meaningful information out of RUSLE. Once the local soil conservationist is contacted, he or she will visit the field site, meet with the land user, and discuss the needs and interests of the land user. The conservationist and the land user can develop a conservation plan together where site-specific conditions and the interests of the land user are given primary consideration (Foster et al., 1999).

The Agriculture Handbook No. 703, "Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)" (Renard et al., 1997), provides maps, graphs, tables, and explanations of each factor of the equation, and is necessary to use RUSLE effectively. It is available at no cost while supplies last. Contact the USDA Agricultural Research Service, Southwest Watershed Research Center, 2000 East Allen Road, Tucson, AZ 85719, to receive a copy. You may also request it through the website http://www.sedlab.olemiss.edu/rusle/ or local NRCS office.

The RUSLE program available at the website is currently version 1.06b. It is free and can be downloaded for use. The website also provides a tutorial for practice. At some time in the near future, a new version of the program

will be available, RUSLE 2 (Yoder and Lown, 1995). This version will be Windows-based, making it more flexible and easier to use. RUSLE 2 will also be backward compatible, meaning that it will accept information from earlier versions of RUSLE.

CONCERNS FOR APPLICATION

As there is a direct relationship between soil depth and plant growth, better soil conservation should be a management goal for rangeland managers. Soil loss is a valuable parameter to help gauge range condition and potential.

It is important to remember that RUSLE is only a model of the natural erosion process. It attempts to account for as many variables as necessary to make it practical for a wide range of land uses. In the case of its use for rangelands, however, studies conducted to examine RUSLE's accuracy showed that the soil loss estimates were considerably less than methods RUSLE is evaluated against (Weltz et al., 1987; Renard and Simanton, 1990; Benkobi et al., 1993). Their method of evaluation, single storm simulations, may or may not reflect an annual average as RUSLE is designed to estimate (Renard, 1999).

When applied for rangeland purposes, RUSLE is limited in its ability to account for a very large area. The natural variability of vegetative cover, soil types, topography, precipitation events, and other influencing factors within that area is inherently complex. Weltz, Kidwell, and Fox (1998) point out that the "distribution and connectivity of the bare soil interspaces and vegetation patches are more important than the absolute amount of bare soil in determining potential runoff and soil erosion rates." Research is needed to address the spatial distribution of bare soil and should be incorporated in later versions of RUSLE.

For the Arizona rangeland manager, a great concern for using RUSLE should be the limitation of slope length. Allotments in the tens and hundreds of thousands of acres would require many subsets of slope lengths under 1000 ft. to assure that results are meaningful. This would require detailed and careful design in the selection of slope lengths to estimate annual soil loss over a large area. Use of RUSLE on identified problem erosion areas may be more practical.

The other erosion simulator model developed for rangeland soil loss prediction is the Water Erosion Prediction Project (WEPP) model. WEPP is a process-based erosion simulation model (Nearing et al., 1989), with a continuous simulation option to reflect erosion over time. It is used to estimate soil loss per event, as opposed to giving an annual average soil loss like RUSLE. WEPP separates factors that influence soil erosion and other factors that RUSLE lumps together to calculate. WEPP can be effective on a field size of over 1,975 acres. According to Weltz, Kidwell, and Fox (1998), studies have shown the WEPP model to give good results in predicting runoff volume and peak discharge (Stone et al., 1992; Tiscareno-Lopez, 1994; Kidwell, 1994). However, observations of sediment yields using WEPP have been less consistent (Weltz et al., 1997; Mokhothu 1996).

The greatest limitation of the WEPP model for the general user is its complexity of variables to be estimated and entered by the user. Like RUSLE, it too is limited by slope lengths. The user needs to gather a great deal more on-the-ground information to use the model effectively, which may require substantially more time and expert assistance. According to scientist K.G. Renard, the WEPP model has proven so complex in its application that RUSLE will remain the primary tool for estimating soil loss for the foreseeable future (1999).

Ongoing research and revision of RUSLE is conducted primarily by the USDA Agricultural Research Service, NRCS, and associated Land Grant universities. Limitations to its universal usage, such as in the case of rangelands, are identified and research is conducted to resolve the problem or at least incrementally improve the accuracy of the equation's results. These advances in soil erosion science are then incorporated into the program.

CONCLUSION

The technology behind RUSLE has been developed over decades of research and field-testing by U.S. federal agricultural agencies and universities. Although it has limitations when used for rangeland applications, they are recognizable and assistance is available to overcome and/or interpret results to make RUSLE's estimates useful. Research is ongoing to improve the utility of RUSLE and address limitations for rangeland applications.

Because the RUSLE program is easy to use and resources to apply it are readily available, many rangeland managers should find it worthwhile to estimate average annual soil loss. It can provide an inexpensive but useful parameter to examine how management practices influence range use and soil conservation.

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FROM:

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Russell Tronstad, George Ruyle, and Jim Sprinkle, Editors.
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A SUMMARY OF LIVESTOCK GRAZING SYSTEMS USED ON RANGELANDS IN THE WESTERN UNITED STATES AND CANADA

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[4]*This article was inspired by a presentation made by Dr. Bowns at the Arizona/Utah Range Livestock Workshop held in St. George and Kanab Utah, April 9–10, 1996. Dr. Bowns' presentation was entitled, "Animal Response to Grazing Systems." We acknowledge Thomas DeLiberto, Robin Grumbles, Kim McReynolds, and George Ruyle for reviewing earlier drafts of this manuscript.*

GLOSSARY OF TERMS AS USED IN THIS ARTICLE

Continuous grazing—grazing a particular pasture or area the entire year, including the dormant season (see season-long grazing).
Deferment—a period of nongrazing during part of the growing season (see rest).
Grazing system—planned effort by rangeland managers to leave some grazing areas unused for at least part of the year.
Rest—distinguished from deferment in that nonuse occurs for 12 consecutive months rather than just part of the growing season (see deferment).
Rotation—scheduled movement of grazing animals from one pasture to another.
Season-long grazing—grazing a particular area or pasture for an entire growing season (see continuous grazing).

INTRODUCTION

Specialized grazing systems were first conceptualized in the United States at the turn of the 20th century and became a major focus of range researchers and managers by the 1950s (Holechek et al., 1998). In the intermountain West, deferred-rotation received considerable attention during the 1950s, followed by rest-rotation during the 1970s. More recently, rangeland managers have used short duration grazing to more intensively control when and where domestic animals graze rangelands.

When properly applied, grazing systems are powerful tools that can help rangeland and livestock managers achieve management objectives related to rangeland and livestock production (e.g., forage production, average daily gain), as well as those related to ecosystem structure (e.g., wildlife habitat) and function (e.g., erosion control, water quantity and quality). However, selection of the proper grazing system is contingent upon the uniqueness of the setting in which it is applied (e.g., topography, soils, vegetation types, climate, etc.).

The objectives of this article are to provide an overview of the major grazing systems that have been used on rangelands in the western U. S. and Canada, to summarize the conditions under which they may be applicable (Table 1), and to highlight examples from the southwestern U. S. when relevant. Our discussion is largely a synopsis of Holechek et al.'s (1998) recent review of grazing systems (chapter 9), and of Vallentine's (1990) discussion of the same topic (chapters 13 and 14).

CONTINUOUS AND SEASON-LONG GRAZING

Continuous and season-long grazing are technically not grazing systems *per se* because there is no attempt to leave a portion of the range ungrazed by

livestock for at least part of the growing season (see glossary). Some have speculated that desirable plants, particularly grasses, will be grazed excessively under continuous or season-long grazing. However, research does not support this view when proper stocking is implemented. With continuous grazing, stocking rate must be very light during the growing season because adequate forage must be left to carry animals through the dormant season. Under light stocking, animals are allowed maximum dietary selectivity throughout the year. For example, cattle and sheep preferentially select forbs (i.e., broad-leaved plants) during certain times of the year, which can greatly reduce grazing pressure on grasses. Rotation systems that restrict livestock from part of the range during the growing season can waste much of the forb crop because many forb species complete their life cycle quickly and become unpalatable after maturation. Another advantage of continuous or season-long grazing over rotation systems is that livestock are not moved from one pasture to another. Moving livestock too frequently can reduce animal production (weight gains, calf crops, etc.).

Continuous or season-long grazing works best on flat, well-watered areas (i.e., watering points no more than 2 miles apart) where precipitation occurs as several light rains throughout the summer, and where most plants have some grazing value (e.g., the shortgrass prairie, northern mixed prairies of the Great Plains). Continuous or season-long grazing has also worked well in the California annual grasslands where annual plants need only to set seed each year to maintain themselves, in contrast to perennial grasses that must store carbohydrates for use during dormancy and for use during the initiation of growth when dormancy breaks.

DEFERRED-ROTATION

Deferred-rotation grazing was first developed in 1895 and later implemented in the early 20th century by Arthur Sampson (the "father of range management") in the Blue Mountains of Oregon. Sampson's system involved dividing the range into 2 pastures with each pasture receiving deferment until seed set every other year. Several modifications of deferred-rotation have been used involving more than 2 pastures; however, its key feature is that each pasture periodically receives deferment (typically every 2 to 4 years, depending on the number of pastures).

According to Holechek et al. (1998), *plant response* for deferred-rotation grazing was superior to continuous or season-long grazing on Palouse bunchgrass ranges, mountain coniferous forest ranges, sagebrush bunchgrass ranges, and tallgrass prairie ranges. *Animal performance*, however, did not differ in studies comparing continuous, season-long, or deferred-rotation systems on Palouse bunchgrass (Skovlin et al., 1976) or coniferous mountain ranges (Holechek et al., 1987). In the tallgrass prairie, individual animal performance decreased with deferred-rotation compared to continuous grazing (Owensby et al., 1973), possibly due to lower forage quality (i.e., older, more mature forage) in the deferred pastures. However, grazing after seed set, when perennial grasses tend to be more tolerant to grazing, may allow higher stocking rates and compensate for lower gain per animal without damaging rangeland resources.

Deferred-rotation has been used as a tool to address seasonal preferences for riparian plant species exhibited by livestock. Seasonal deferment (and hence, seasonal grazing) can help sustain a balance of riparian species in some wetland areas by alternating grazing and browsing pressure on herbaceous and woody plants, which inhibits one life form from gaining a competitive advantage over the other. For example, deferment has been applied in the spring and early summer to reduce livestock use of riparian

herbaceous plants such as grasses, sedges, and rushes, while summer and fall deferment has been used to reduce livestock use of riparian shrubs and trees (Swanson, 1987). Thus, deferred-rotation, as described here, draws on our knowledge of animal foraging behavior to exclude livestock from riparian areas during the season(s) in which they are most likely to preferentially overuse herbaceous or woody plants. This is important because riparian plant species are often cited as critical structural components of wildlife habitat for both game and non-game species (e.g., nesting and hiding cover; Kauffman et al., 1982; Chaney et al., 1990), and as playing a functional role in capturing sediment and dissipating erosive energy in streams (Riparian Area Management, 1993).

REST-ROTATION

The rest-rotation system was designed by Gus Hormay of the U. S. Forest Service and was first implemented in the 1950s and 1960s. Although the original system was designed to rotate grazing and rest periods among 5 pastures using 1 to 3 herds over a 5-year cycle (Hormay, 1970), other variations of rest-rotation have used 3 or 4 pastures in a 3- to 4-year cycle. Hence, under rest-rotation, 1 or 2 pastures are rested the entire year while the remaining pastures are grazed seasonally depending on the number of pastures and herds. For example, 1 pasture in a 3-year, 3-pasture rest-rotation might be managed as follows during a 3-year cycle: 1) Graze the entire year or growing season; 2) Defer, then graze; and 3) Rest. This schedule rests about 1/3 of the range annually.

Rest-rotation has shown superiority over continuous and season-long grazing on mountain ranges where cattle may heavily use riparian areas under all grazing strategies (Platts and Nelson, 1989). Rest provides an opportunity for the vegetation around natural or developed water to recover and helps meet multiple use objectives (e.g., providing hiding cover for birds and mammals, leaving ungrazed areas for public viewing and enjoyment). Hence, rest-rotation provides many of the advantages for riparian habitats discussed under deferred-rotation. Additionally, rested pastures provide forage for emergency use during severe drought years, and provide opportunities to implement relatively long-term rangeland improvement practices (e.g., burning, reseeding, brush control) during scheduled rest periods. However, a disadvantage of all grazing systems that periodically exclude livestock is that elk or other wild herbivores may graze “rested” pastures, negating some of the benefit of rest or deferment from livestock grazing (Halstead, 1998).

Other disadvantages cited for rest-rotation are reduced individual animal performance due to forced animal movements from pasture to pasture, and increased stocking density in grazed pastures, which can reduce dietary selectivity (Gray et al., 1982). However, this criticism may emanate more from failure to properly adjust stocking rates to compensate for resting 20 to 40% of the total grazing area each year, rather than a definite failure of rest-rotation. For example, research on mountainous range in northeastern Oregon showed that cattle weight gains per hectare or per animal did not differ among rest-rotation, deferred-rotation, and season-long grazing systems when utilization averaged about 35% for each system over a 5-year period (Holechek et al., 1987). The point to remember is that the benefits of a full year of rest can quickly be nullified if previously rested pastures are overgrazed, particularly in arid regions where frequent drought conditions can impede rangeland recovery (Cook and Child, 1971; Trlica et al., 1977).

SANTA RITA

The Santa Rita grazing system is basically a 1-herd, 3-pasture, 3-year rest-rotation system that was modified for midsummer rainfall and concomitant forage production patterns that typically occur in the hot semi-desert grasslands in southeastern Arizona (Martin and Severson, 1988). A 3-year rotational schedule for 1 pasture is as follows: 1) Rest 12 months (November to October); 2) Graze 4 months (November to February); 3) Rest 12 months (March to February); and 4) Graze 8 months (March to October). Each pasture receives rest during both early spring and "summer-monsoon" growing periods for 2 out of every 3 years, but each year's forage production is also grazed (first year's growth is grazed in winter). A full year of rest before spring grazing allows residual vegetation to accumulate which helps protect new spring forage from heavy grazing. Target utilization levels in grazed pastures are 30-40%. Martin and Severson (1988) concluded that the Santa Rita system promoted recovery of ranges in poor condition, but had little advantage over moderate continuous grazing on ranges in good condition.

SEASONAL SUITABILITY

A common practice of seasonal suitability grazing systems is to partition and manage diverse vegetation types that differ due to elevation, ecological site, ecological condition, or precipitation, and to move animals based on seasonal forage production in the partitioned vegetation types (Holechek and Herbel, 1982). Disparate vegetation types are typically fenced, but livestock movements can also be controlled by turning on (or off) watering points, the latter technique most commonly employed in the southwestern U. S.

In southwestern deserts, seasonal suitability systems use creosote bush (*Larrea tridentata*) and mesquite (*Prosopis* spp.) shrublands during winter and early spring, while tobosa grass (*Hilaria mutica*) and alkali sacaton (*Sporobolus airoides*) ranges are used during summer (or during spring with adequate moisture). Although creosote bush and mesquite dominated shrublands typically have little perennial grass understory, they may contain nutritious plants like 4-wing saltbush (*Atriplex canescens*), winterfat (*Ceratoides lanata*), and cool-season annual forbs, which are preferred by livestock when perennial grasses are dormant (Holechek and Herbel, 1982). Tobosa grass and alkali sacaton are comparatively less nutritious during dormancy, and more efficiently utilized by livestock when they are actively growing. Pastures dominated by Lehmann lovegrass (*Eragrostis lehmanniana*), a warm-season grass introduced from South Africa, can also be used in this system to relieve summer and early fall grazing pressure on native perennial grasses.

Seeded introduced grasses may be an important component of other seasonal suitability systems because of their ability to provide forage both earlier and later than native range. For example, rotating livestock through native range in summer, crested wheatgrass (*Agropyron cristatum*) pastures in spring, and Russian wildrye (*Elymus junceus*) pastures in the fall more than doubled grazing capacity in Alberta (Smoliak, 1968). Seasonal suitability has also been used on mountain ranges in the northwestern U. S. where grassland (south-facing slopes), forest (north-facing slopes), and meadow (riparian) vegetation types provide late spring/early summer use, late summer/early fall use, and fall grazing, respectively (Holechek and Herbel, 1982). In Utah, seasonal suitability has been practiced where desert (winter use), foothill (spring use), and mountain ranges (summer use) are managed as separate, seasonal grazing units (Cook and Harris, 1968).

BEST PASTURE

Because summer rainfall in the southwest U. S. usually comes in the form of intense but isolated thunderstorms, summer moisture patterns are typically spotty and unpredictable. It is not uncommon for areas of a ranch separated by only a few miles to vary greatly in the amount of precipitation received from a storm event. The best pasture grazing system, as originally proposed by Valentine (1967), attempts to match cattle movements with irregular precipitation patterns and associated forage production without regard to a rigid rotation schedule. For instance, when a local rain event causes a flush of annual forbs in a particular pasture, cattle are moved to that pasture, and then moved back to the previous pasture once acceptable utilization levels of the ephemeral forb resource have been achieved. On the other hand, if a pasture that is tentatively scheduled for grazing continues to miss localized rainstorms while another pasture continues to receive moisture, the rotation schedule for the two pastures could be flip-flopped. Because livestock movements are not rigidly timed to a particular timetable, the best pasture system requires that land managers command a mindset of high flexibility.

The best pasture system may also be timed to match seasonal forage quality changes across ecological sites, and thus, embraces some elements of the seasonal suitability system. For example, pastures containing black grama (*Bouteloua eriopoda*) as the primary forage species may be deferred until the dormant season when it is higher in protein compared to pastures dominated by blue grama (*Bouteloua gracilis*) or hairy grama (*Bouteloua hirsuta*). Because black grama is relatively less resistant to grazing than many other perennial grasses, winter grazing has less impact on this species than use during the growing season. This approach works best when some of the pastures in the "rotation" contain winter annuals and palatable shrubs.

As with the seasonal suitability grazing system, the best pasture system may involve turning on (or shutting off) watering points in grazed (deferred or rested) pastures. Cattle learned within a year to follow active watering points on a 3,160-acre ranch in southeastern Arizona (Martin and Ward, 1970). Because localized heavy grazing around watering points was controlled during Martin and Ward's eight-year study, perennial grass forage production nearly doubled with the best pasture system compared to continuous grazing.

SHORT DURATION

Short duration grazing differs from other specialized systems in that a grazing area is typically divided into several small pastures (also called paddocks or cells), each of which may receive *more than one period* of nonuse *and* grazing during a single growing season. The number of nonuse and grazing periods depends on the rate and amount of forage produced within each pasture. Short duration grazing commonly uses 5 to 12 pasture units in which there are grazing periods lasting from 3–14 days. Pasture rotations may be conducted more frequently during periods of rapid growth and less frequently during periods of slower growth. A grazing period is followed by a variable nongrazing period of up to 60 days to allow for forage regrowth. The actual duration of each pasture's nongrazing period depends on growing conditions.

Proponents of short duration grazing maintain this system benefits rangeland resources and domestic livestock production in several ways when properly implemented, including: improved soil water infiltration and increased mineral cycling due to animal impact (e.g., "hoof action"), increased

photosynthesis that provides longer periods of available leafy forage to livestock, improved animal distribution and plant utilization, reduced percentage of ungrazed "wolf" plants, lower labor costs, better individual animal performance, and improved rangeland condition. The most attractive contention of short duration grazing to livestock producers is that higher stocking rates and stock densities can be used because of the "shorter duration" of grazing and more intensive management.

Rangeland research indicates that managers should carefully consider several factors before investing in a short duration grazing system, particularly in arid regions (see Holechek et al., 1998, 2000, for recent reviews of short duration grazing research). Arid areas typically have short growing seasons (less than 60 days) due to low precipitation levels, cold weather, or both; this minimizes the positive aspects of repeated periods of heavy defoliation followed by nonuse, especially when inadequate growing conditions (e.g., drought) can limit the regrowth potential of heavily grazed plants. Concentrating a large number of animals in smaller pastures that have recently received high intensity storms can cause soil compaction and decrease infiltration rates. Increased trail density around water has been problematic in pastures that have been partitioned around a central watering point. Short duration grazing usually calls for extra labor for herding and large amounts of fencing to partition a large grazing area into smaller grazing areas because it is more costly to fence arid rangelands (less forage/unit area = more fence needed) than more productive areas (more forage/unit area = less fence needed). Frequent pasture rotations can take a toll on animal production measures and care must be taken to prevent mother-dam separations during livestock movements. Finally, there is simply less room for error in arid regions to decide when animals should be moved or destocked; failure to move animals at the correct time or to destock during drought can cause long-term damage to desert grasses.

Holechek et al. (1998) asserted that short duration grazing works best on flat humid areas that have extended growing seasons (at least 3 months), greater than 20 inches of average annual precipitation, and an average annual forage production of greater than 2000 lbs./acre. However, the same authors identified 2 cases where short duration grazing might be successfully used in arid areas: 1) in flat, low-lying areas with deep, productive soils that collect water runoff from less productive upland areas, and 2) on exotic grass seedings (e.g., Lehmann lovegrass, crested wheatgrass) where grazing resistance and capacity may be higher than native rangeland.

SOME FINAL THOUGHTS ON GRAZING SYSTEMS

- There is an infinite combination of climates, soils, topography, and vegetation types that occur across the western U. S. and Canada, which makes choosing the "correct" grazing system a challenge. No grazing system will work everywhere, or, as Dr. William Krueger from Oregon State University puts it, "every grazing system will fail somewhere." The system you choose must be tailor-made to your unique situation (Table 1).

- Implementing a grazing system does not eliminate the need to heed basic principles of grazing management (stocking rates, season of use, frequency of use, kind or mix of animals, animal selectivity, etc.).

- Grazing systems require greater, rather than less management input, compared to continuous or season-long grazing. Increased attention to range and livestock *management* (see next point) may often be a primary reason for the success of a particular grazing system.

Table 1. Distinguishing features of grazing systems used in the western United States and Canada, and situations where they may be applicable (see text for details).

Type of grazing system	Distinguishing features	May be applicable when you have…
Continuous or Season-long	Continuously graze an area the entire year (continuous), or the entire growing season (season-long). These are not grazing systems per se (see text).	…flat, well-watered rangeland, where most plants have similar grazing value, with a uniform precipitation pattern that encourages regrowth. …also, may be applicable in some areas of the California annual grasslands.
Deferred-rotation	Periodically defers each pasture in the rotation. Animals are rotated through the other pastures on a seasonal basis.	…distribution problems where animals habitually overuse " convenience areas" (e.g., riparian areas), or where there are multiple use objectives.
Rest-rotation	Periodically rests each pasture in the rotation for 12-months. Animals are rotated through the other pastures on a seasonal basis.	…generally, same criteria as deferred-rotation.
Santa Rita	Modification of the rest-rotation system to where each pasture receives rest during both the early spring and " summer-monsoon" growing periods 2 out of every 3 years.	…semidesert grassland where forage production is irregular and heavily influenced by midsummer ' monsoons' and winter precipitation.
Seasonal suitability	Diverse vegetation types are partitioned and grazing rotation is managed based on seasonal changes in forage production.	…diverse vegetation types that can be partitioned and managed as separate units based on seasonal differences in plant phenology, forage quantity, and forage quality.
Best pasture	Matches cattle movements to vagaries of forage production due to irregular precipitation patterns or disparate range (ecological) sites.	…irregular forage production due to spotty precipitation patterns, or grazing areas that require special management due to species differences in forage production and/or resistance to grazing.
Short duration	Frequently rotates a single cattle herd through multiple, smaller pastures allowing for relatively brief periods of rest in previously grazed pastures. Use levels are typically heavy due to increased stocking rates and stock densities.	…generally, the same criteria as for continuous and season-long (but see text). This system typically requires more capital investment and labor than other grazing systems.

- Animal distribution tools such as riding (Budd, 1999), proper placement of nutrient blocks (Martin and Ward, 1973), selective culling based on animal behavior characteristics (Howery et al., 1996, 1998), range improvements (burning, reseeding, water developments), and control of access to watering locations (Martin and Ward, 1970) should be implemented in ways that complement the intended management outcomes of grazing systems.
- Flexibility is the hallmark of successful range management in arid regions. Strict adherence to animal numbers and livestock movement dates without regard to vagaries in forage production can be counterproductive to both rangeland and livestock production. Adjust stocking rates and rotation dates so that livestock numbers are in balance with forage supply (Howery, 1999).

- Rangeland monitoring is critical to document both successes and failures of grazing systems and other management activities (Smith and Ruyle, 1997). Rangelands are extremely variable in the kind and amount of vegetation they are capable of producing. This variability is apparent across the land (space) and across the years (time) as anyone who has spent time on a ranch knows. Monitoring techniques are available to help you determine how much variability you can expect on your ranch across both space and time. Monitoring data are really the "proof of the pudding" as to whether your grazing system and management practices are accomplishing your goals and objectives (Smith and Ruyle, 1997).

- Evaluate a new grazing system over a period of 6–12 years so that several weather cycles can be evaluated (Martin, 1978). This prevents erroneously assigning success or failure to a new grazing system when abnormally high or low precipitation years may be the primary cause.

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