Managing range cattle for risk—the STEERISK spreadsheet

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Abstract

Variable weather, forage production, weed and pest problems, and livestock prices contribute to uncertainty in range livestock production. Because returns from livestock production, in which producers invest money and other resources, are uncertain, these variables are sources of risk. The STEERISK spreadsheet gives producers a tool to estimate the chances of different levels of forage production, test different management and marketing strategies, and estimate returns from them. Examples of STEERISK applications include selecting the most profitable stocking rate and evaluating the profitability of weed and insect control.

Key Words: profitability, risk, variability of returns, optimization, stochastic modelling, economics

Range livestock production is a risky business. The producer must balance productivity, stability, and sustainability, as defined by Conway (1987). If a production system offers high average profits (high productivity) but a great deal of year-to-year variation in profits (low stability), or threatens the long-term productivity of the range (low sustainability), it may be less desirable than a system with somewhat lower productivity but greater stability and sustainability. This is especially true of range systems in which (1) the profit margin is so low that the producer may not be able to survive more than 1 or 2 successive years of losses, and (2) the time and cost of restoring depleted range may be prohibitive.

Variability and uncertainty are often used as synonyms for risk, but this is inappropriate. Economists define risk as a lack of predictability about structure, outcomes, or consequences in a decision or planning situation. However, there is a known or defined probability distribution of possible outcomes (Hertz and Thomas 1983). To the producer, risk involves an investment of resources in a situation in which the possibility or level of return is uncertain. In other words, risk is uncertainty that the producer bets money on.

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Four major sources of economic risk must be considered in range livestock production.

1. Variability of weather, especially precipitation, which is reflected in variability of forage production.
2. Uncertainty about livestock prices, interest rates, and other financial variables.
3. Possible destruction of forage by pests or disease.
4. Danger of permanent damage to range plant communities and soil resources.

Changes in technology and government programs also may contribute to risk.

The STEERISK spreadsheet was developed to help cattle producers evaluate the impact of stocking rate and variability in forage production and prices on steer gains and on returns to land, labor, and management. STEERISK allows the producer to estimate returns from a range of possible levels of forage production, stocking rates, and buying and selling prices for cattle. From these possibilities, the producer can choose the stocking rate and marketing schedule which best fits his/her risk strategy and expectations of forage production and prices in a particular year, and estimate the consequences of errors in estimating forage production and prices.

Rationale and Structure of STEERISK

Three types of information are needed for risk analysis:

1. Responses of livestock, range plant communities, and other segments of the range ecosystem to weather and management.
2. Data sets or simulations from mathematical models to determine range of weather and forage availability and probability of each level of weather and forage variables.
3. A technique for economic analysis of weather and management impacts.

The climate generator (Richardson et al. 1987) and the plant

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       A        B         C         D         E        F     G    H    I    J        K          L    M    N    O    P        Q          R        S
 1   STEERISK                                                                                       AAAAAAAAAAA
 2                                                                                                  AAAAAAAAAAAAA
 3   Insert value in cell marked [          ]; start with Actual max gain = 0.95,                                A AAA
 4     Theoretical max gain = 1.13, Rate of drop = 0.00625                                                        AAAA
 5   Actual maximum gain, kg/da             [    0.95 ]    Initial weight, kgg    [     250 ]                     AAAA
 6   Theoretical maximum gain, kg/da (a)[    1.13 ]    Purchase price, $//kg  [    1.71 ]      AAAAAAAAAAAAAAARRRRRRRRRR          SSSSSSSSS
 7   Rate of drop in gain (b)             [ 0.00625 ]    Selling price, $/kkg   [    1.59 ]   *AGRICULTURAL*RESEARCH*SERVICE*     SSSSSSSSSSS
 8   Days on pasture                       [     150 ]    Interest rate, %       [   12.25 ]  AAAA             AAAA           RRRR  SSSS
 9                                                                                           AAAA             AAAA           RRRR  SSSS
10   Interest cost, $/head          $21.52                                                   AAAA              AAAA      RRRRRRRR    SSSSSSSS
11   Misc. costs, $/head/day   [     $0.20 ]                                                 AAAA              AAAA    RRRRRRRRR       SSSSSSSS
12     (includes veterinary care, supplements, transportation, and death loss)                AAAA            AAAA   RRRR                  SSSS
13   Carrying cost, $/head          $81.52                                                    AAAA          AAAA    RRRR                  SSSS
14   Carrying cost, $/head/day       $0.54                                                     AAAAAAAAAAAAAAAA       RRRRRRRRRRRRSSSSSSSSSSSS
15     (includes interest, change in value of initial weight, and misc. costs)                  AAAAAAAAAAA            RRRRRRRRRRSSSSSSSSSS
16
17    Prob. of                -----------Optimum SR------------  ------------Fixed SR---------------  ------------Flexible SR-------------
18    higher     Forage                 Daily    Gain,   Return      Steer       Daily    Gain,  Return                  Daily    Gain,   Return
19    forage     prod'n,     Steer      gain,     kg/   to LLM,     da/ha        gain,     kg/   to LLM,     Steer       gain,     kg/   to LLM,
20    prod'n     kg/ha       da/ha      kg        ha     $/ha     [ 120.0 ]      kg        ha     $/ha      da/ha        kg        ha     $/ha
21
22      0.01       1685     106.2      0.74     78.2   $66.58      120.0        0.68      82.2   $65.46   [  40.0 ]     0.95     38.0   $38.68
23      0.03       1685     106.2      0.74     78.2   $66.58      120.0        0.68      82.2   $65.46   [  40.0 ]     0.95     38.0   $38.68
24      0.05       1565      98.7      0.74     72.6   $61.84      120.0        0.65      78.1   $58.95   [  40.0 ]     0.95     38.0   $38.68
25      0.07       1541      97.2      0.74     71.5   $60.89      120.0        0.64      77.2   $57.53   [  40.0 ]     0.95     38.0   $38.68
26      0.09       1517      95.7      0.74     70.4   $59.94      120.0        0.64      76.3   $56.06   [  40.0 ]     0.95     38.0   $38.68
27      0.11       1505      94.9      0.74     69.8   $59.46      120.0        0.63      75.8   $55.30   [  40.0 ]     0.95     38.0   $38.68
         .                                                                                                                             .
         .                                                                                                                             .
         .                                                                                                                             .
         .                                                                                                                             .
66      0.89        734      46.3      0.74     34.1   $29.00      120.0        0.11      13.0  ($44.57)  [  40.0 ]     0.79     31.6   $28.47
67      0.91        731      46.1      0.74     33.9   $28.88      120.0        0.10      12.5  ($45.37)  [  40.0 ]     0.79     31.5   $28.38
68      0.93        669      42.2      0.74     31.0   $26.43      120.0        0.01       1.1  ($63.51)  [  40.0 ]     0.76     30.3   $26.36
69      0.95        648      40.9      0.74     30.1   $25.60      120.0       -0.03      -3.3  ($70.45)  [  40.0 ]     0.74     29.8   $25.59
70      0.97        584      36.8      0.74     27.1   $23.07      120.0       -0.15     -18.5  ($94.65)  [  40.0 ]     0.70     28.1   $22.90
71      0.99        548      34.6      0.74     25.4   $21.65      120.0       -0.24     -28.6 ($110.74)  [  40.0 ]     0.67     27.0   $21.11
72
73      Mean       1118      70.5      0.74     51.9   $44.16      120.0        0.31      37.3   ($5.88)     120.0      0.85     33.8   $24.06
```

Fig. 1. Sample copy of the STEERISK spreadsheet [coding on 5.25 in (133 mm) diskettes, in metric or English units, available without charge from the author].

component (Hanson et al. 1988) of the SPUR model (Wight and Skiles 1987) were used to generate sample values of forage production over a 50-year period. These were expressed as peak standing crop without grazing, on mixed-grass prairie rangeland as found on the High Plains of eastern Wyoming. Fifty levels of forage production and the probability of range production exceeding each level are listed in columns B and A, respectively, of STEERISK (Fig. 1).

The optimum stocking rate (SR) for each year was calculated, using the method outlined by Hart et al. (1988a). Briefly, this method establishes a critical SR below which average daily gain (ADG) is constant. Below this critical SR, gain/ha and return to land, labor, and management increase linearly as SR increases. Therefore, unless prices are such that grazing is unprofitable at all SR's, the most profitable SR will be at or above the critical SR.

At SR's above the critical, ADG = a – bH, when H = stocking rate in steer days/ha, a and b are constants for a particular type of range and cattle, and b is adjusted for peak standing crop as illustrated by Hart et al. (1988a). Values of a and b are entered in cells E6 and E7 of STEERISK (Fig. 1). ADG at the critical SR is entered in cell E5.

Gain per ha or $G = aH - bH^2$ and gross return per ha per year or $R_G = P(aH - bH^2)$ when P = selling price. The user enters selling price in cell K7. Carrying cost per animal per day = C and includes the margin between purchase price and selling price, interest, supplemental feed, and veterinary costs, death loss, etc. STEERISK calculates C from days on pasture, initial weight, purchase price, interest rate, and miscellaneous costs (entered in cells E8, K5, K6, K8, and D11, respectively) and displays it in D14. It also displays interest cost per head (D10) and total carrying costs per head (D13). The equations used, coded for Lotus Symphony Release 2.0[1], are shown in Table 1. The program is available on 5.25 in (133 mm) diskettes from the author. Other spreadsheets may be used, but they might require changes in the "if-then" functions (columns beginning with J22 and P22) and mean functions (row 73).

Table 1. Equations used in the STEERISK spreadsheet (Fig. 1).

Location	Equation
Cell:	
D10	(E8/365*(K8/100)*(K5*K6))
D13	((K6-K7)*K5+(D11*E8)+D10)
D14	(D13/E8)
Column beginning with cell:	
C22	((K7*$E&6-$D$14)/(2*$K&7*(E7*1000/B22)))
D22	(E6-(E7*1000/B22*C22))
E22	(C22*D22)
F22	(E22*K7-(C22*D14))
H22	H20
J22	@IF(@ISERR(@SQRT(E5-(E6-(E7*1000/B22*H22))),E5,(E6-(E7*1000/B22*H22)))
K22	(H22*J22)
L22	(K22*K7-(H22*D14))
M22, O22	Dummies containing brackets indicating data entry.
N22	Data is entered in each cell by the user.
P22	@IF(@ISERR(@SQRT(E5-(E6-(E7*1000/B22*N22))),E5,(E6-(E7*1000/B22*N22)))
Q22	(N22*P22)
R22	(Q22*K7-(N22*D14))
Row 73	(@B22..B71), (@C22..C71)...(@R22..R71)

Net return to land, labor, and management or $R = PaH - PbH^2 - CH = (Pa - C)H - (Pb)H^2$. Maximum return per ha occurs when R

[1]Mention of a trademark or proprietary product does not constitute a warranty of the product by the U.S. Department of Agriculture and does not imply approval to the exclusion of other products that also may be available.

no longer increases with an increase in H (stocking rate) or when $dR/dH = (Pa - C) - (2Pb)H = 0$ which is equivalent to $H = (Pa - C)/(2Pb)$. This H is the SR at which return to land, labor, and management is maximized. The equations for calculating optimum SR, and ADG, gain/acre, and return/acre to land, labor, and management at optimum SR (columns C thru F of STEERISK), are listed in Table 1.

STEERISK allows the user to enter a fixed SR in cell H20, calculates ADG, gain/acre, and return/acre at that SR for all levels of forage production, and prints the results in columns J thru L. The user may also enter different SR's for each level of forage production in column N, and STEERISK will calculate and print ADG, gain/acre, and return/acre in columns P thru R.

Examples and Applications

An Example

Optimum SR was calculated for each year using cattle prices prevailing in 1986 and 1987 (Hart et al. 1988a). Prices in 1986 (purchase price \$1.59/kg, sale price \$1.37/kg) were less than the average of recent years, while prices in 1987 (purchase price \$1.71/kg, sale price \$1.59/kg) were well above average. Carrying costs (C) were \$0.70 per head per day in 1986 and \$0.71 in 1987. An initial steer weight of 250 kg and a 150-day grazing season were assumed.

Forage production ranged from 570 to 1,750 kg/ha of dry matter (Fig. 2), with a mean of 1,170 kg/ha and a standard deviation of the mean of 280 kg/ha. Forage production on the High Plains is near average in fewer years and substantially above or below average in more years than would be expected in a statistically normal distribution. SPUR produced a similar distribution of forage production. Optimum SR's ranged from 24 to 72 steer-days (SD)/ha at 1986 prices and 31 to 94 SD/ha at 1987 prices; averages were 48 and 63 SD/ha, respectively.

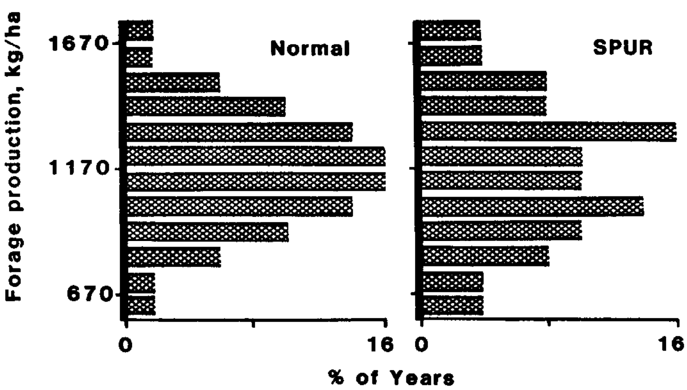

Fig. 2. Frequency distribution of levels of forage production generated by SPUR, compared to statistically normal distribution.

The Soil Conservation Service recommends an initial SR of 36 SD/ha on mixed-grass prairie in good condition in southeast Wyoming (SCS 1986). At fixed SR's of 40, 60, and 80 SD/ha, net returns to land, labor, and management ranged from \$4.97 to \$22.96, -\$12.61 to \$27.86, and -\$43.57 to \$28.37, respectively, at 1986 prices (Fig. 3). At 1987 prices, comparable figures were \$16.53 to \$37.41, \$1.50 to \$48.47, and -\$29.05 to \$54.45. As fixed SR's increased, the probabiliy of higher returns in years of high forage production also increased, but so did the probability of greater losses in years of low forage production. At 80 SD/ha, losses occurred in 26% of the years at 1986 prices and 8% of the years at 1987 prices.

When SR was adjusted annually to the optimum for current forage production and prices, returns ranged from \$9.41 to \$28.70 at 1986 prices and \$18.23 to \$55.61/ha at 1987 prices. At 1986 prices, the average net returns at 40, 60, 80, and optimum SD/ha were \$17.63, \$15.86, \$7.04, and \$19.19/ha. The pattern was similar at 1987 prices, although net returns were higher. Returns at 40, 60, 80, and optimum SD/ha were \$31.22, \$34.55, \$29.70, and \$37.19/ha.

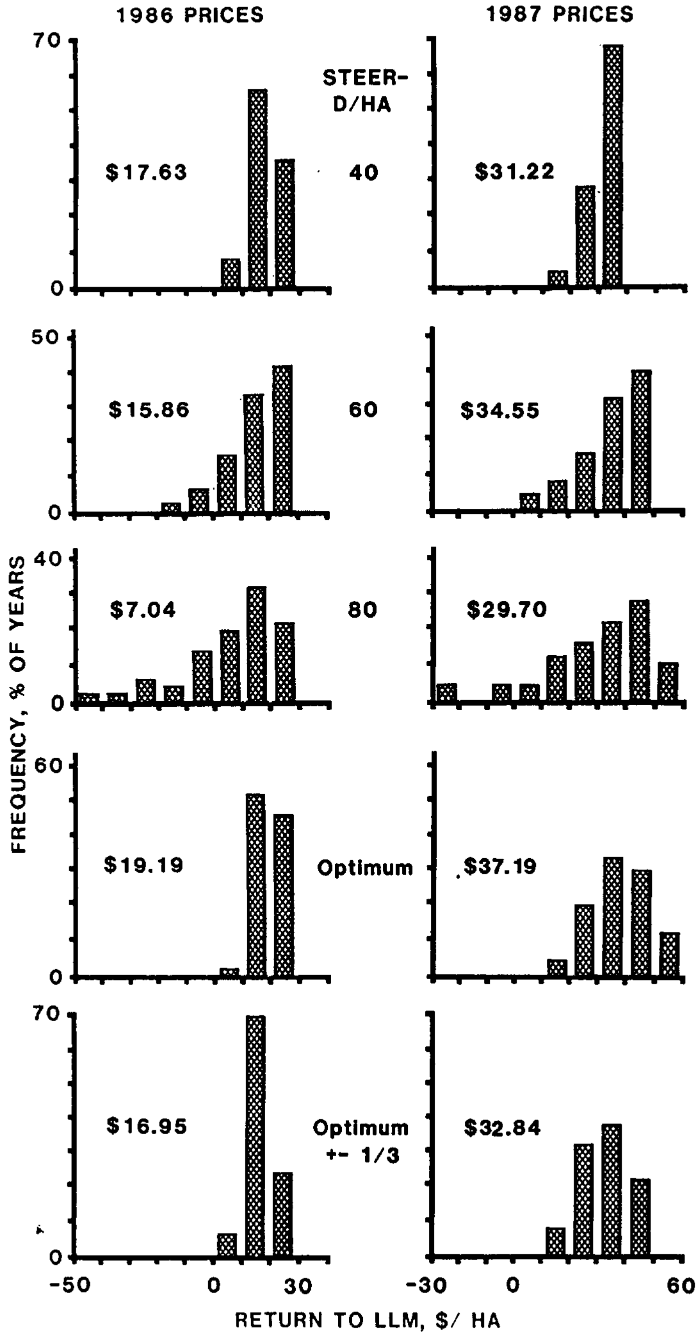

Fig. 3. Frequency distribution of net returns to land, labor, and management under fixed stocking rates (SR) of 40, 60, and 80 steer-days/ha, flexible optimum SR, and optimum SR ± 1/3 at 1986 and 1987 cattle prices. Dollar figure in each section of the graph indicates mean return per ha at that SR and price level.

To take advantage of flexible optimum SR's in real life, it is necessary to estimate SR early in the season. This can be done with some accuracy on the High Plains. Forage production is largely determined by precipitation in March, April, and May. At Cheyenne, annual forage production in kg/ha = 1923 - (86567/March–May precipitation in mm); $r^2 = 0.94$ (Hart 1987). Cattle customarily go on range pastures in May, so producers usually can estimate forage production before the grazing season starts.

Estimation may be less accurate in other regions, but in our example over- or under-estimating the optimum SR by one-third reduced net returns in any year by only 11% at 1986 prices and by 13% at 1987 prices. These levels of return are nearly the same as those at 60 SD/ha, but with the reduced variation noted at optimum SR. Producers can use STEERISK to estimate the risks from over- or under-estimating optimum SR, however small.

Risks from over- or under-estimating prices when setting optimum SR's may be even smaller. If SR is set at optimum for 1986 prices when actual prices are at 1987 levels or vice versa, average returns will be reduced only 1%. Greater discrepancies between expected and encountered prices will produce greater reductions, but this risk is less than that from improper SR. The greatest risk posed by uncertain prices is that of underestimating the margin, usually negative, between buying and selling price of cattle. Expected selling price may be taken from market predictions or calculated by the methods of Blake et al. (1984) or Nance et al. (1985). STEERISK allows the producer to evaluate a whole range of selling prices, above and below those expected, and to assess the consequences of over- or under-estimating selling price.

The risk posture of the individual cattle producer also must be considered. Antle (1987) and Binswanger and Barah (1980) noted that actual risk levels may be considerably different from risks perceived by producers, and McSweeny et al. (1987) discussed ways in which to present risk to producers. A risk-averse producer may worry that forage production or selling price has been overestimated, and will therefore choose a stocking rate less than the calculated optimum (Bernardo and Engle 1990). On the other hand, a producer in a sound financial position and willing to take more risk may choose to stock at higher than the calculated optimum.

Weed and Pest Control

The producer may also use STEERISK to decide whether pest control will be profitable. Hart et al. (1987) used the calculations presented in the spreadsheet to demonstrate that reducing SR may be a more profitable alternative than grasshopper control, even when grasshoppers reduce forage production by 50%. In their example, such a reduction in forage production decreased returns by \$21.84/ha, from \$23.97 to only \$2.13/ha, if SR was not adjusted. If SR was adjusted to the new level of forage production, returns were reduced by only \$10.97/ha. Unless the grasshopper population could be reduced to normal levels by control measures costing less than \$10.97/ha, reducing SR would be more profitable than control.

Similar calculations could be applied to weed and brush control or prescribed burning, but here the benefits usually persist for more than 1 year. A biological response function, estimating the mean and variability of forage production for each year following treatment, is required (Ethridge et al. 1984, Tanaka and Workman 1988). For each succeeding year, calculated levels of forage production are entered in column B for each level of probability, and the parameters for the grazing pressure-gain function for the appropriate range and livestock type are entered in cells E5, E6, and E7. Mean and variability of returns in each year after treatment can then be compared to those before treatment, to assess the benefits of treatment and the point at which treatment can be profitably reapplied. Torell and McDaniel (1986) used a similar approach to determine optimum treatment schedule to control honey mesquite, but did not incorporate variability of forage production and returns. Bernardo et al. (1988) incorporated variability of forage production in their analysis of prescribed burning, but used a probability distribution rather than a grazing pressure-gain function to calculate steer gains.

Adapting STEERISK to Other Range and Livestock Types

Few locations have sufficient historic records of forage production to develop probabilities of different levels of forage production. On the other hand, many locations have sufficient weather records to provide a data base from which researchers can calculate such probabilities, using SPUR (Wight and Skiles 1987), GRAZE (Parsh and Loewer 1987), or other models. The small departure of SPUR simulations from a normal distribution of forage production (Fig. 2) indicate mean and variance of production might be adequate.

Researchers may calculate responses of livestock to grazing pressure (from which values of a and b, cells E6 and E7, can be calculated) from these same models, the simpler SMART (Hart 1989), or from stocking rate studies. Studies in which forage production as well as gain and SR are reported (Klipple and Costello 1960, Launchbaugh 1957, Johnson 1953, Seamands 1968, Hart et al. 1976, Sims et al. 1976, Willms et al. 1985 and 1986, Hart et al. 1988b), so that grazing pressure can be calculated easily, are more useful than those in which only gain and SR are reported (Sarvis 1941, Houston and Woodward 1966, Bement 1969). Many similar studies can be found in the literature or excavated from researchers' files.

Once researchers have calculated probabilities of each level of forage production and the response of livestock to grazing pressure for a particular location and range type, this information can then be made available to livestock producers.

STEERISK may also be used to evaluate marketing strategies. For example, a producer might like to delay marketing because an increase in selling price is anticipated. However, gains decrease as the grazing season advances and may drop below carrying costs if marketing is delayed too long; the anticipated price increase might not be enough to compensate for these daily losses. STEERISK, using different values of a and b for different ending dates of the grazing season from SMART (Hart 1989) or other models, can calculate returns from different marketing dates.

Long-Term Damage to the Range

STEERISK will not estimate the risks associated with long-term damage to the range from overstocking. However, stocking rates which are likely to reduce sustainability of grazing on mixed-grass ranges also are likely to reduce short-term returns (Torell et al. 1989). Conversely, stocking rates which maximize short-term returns on these ranges are unlikely to produce permanent damage. At Cheyenne, forage production on moderately or heavily stocked range (43 and 67 SD/ha, respectively) did not change relative to each other or to that of an adjacent ungrazed range during 7 years of grazing (Hart 1991). Profits were maximized at approximately the higher stocking rate (Hart et al. 1988a). Similar results were reported by Sims et al. (1976), Willms et al. (1985), and Klipple and Costello (1960).

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