

Empirical Analysis of Pastoral Migration Decisions: Gabra Herders in Northern Kenya

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Abstract:

Recent research in range ecology suggests the process of resource degradation in African arid and semi-arid rangelands may be less reliant on how many animals are placed on the rangeland than on where these animals are placed. Analysis of pastoralist land use decisions indicates there is evidence rangeland condition influences livestock placement, but that food and income production strategies, herd characteristics and household characteristics also play critical roles.

Sub-Saharan Africa is experiencing an agrarian crisis. The extent of this crisis is indicated by the fact that on a continent where over seventy percent of the labor force is involved in agriculture, the past twenty years have witnessed declining per-capita agricultural production (Herbst 1993). Addressing this crisis in the area of livestock production will play a critical role in halting this decline, as livestock production accounts for twenty-five to thirty-five percent of agricultural production in Africa (USDA 1990).

The prevailing view in economics describes the crisis in livestock production as a manifestation of the “tragedy of the commons” described by Hardin (1968). This perspective implies African livestock producers accumulate more animals than is economically and ecologically efficient. The economic sub-optimality arises from the cost imposed on all herders when the aggregate herd is built up past the level of rangeland carrying capacity, causing high rates of stock mortality. The ecological sub-optimality arises from the long-term process of rangeland degradation caused by excessive stocking levels. This analysis of the situation has led to proposals that limit stocking levels. For example, Doran, Low et al. (1979) state “...Africa is now perhaps the classic example of a continent suffering from soil erosion caused by overgrazing”. They suggest “...it will be necessary either to implement measures that will induce stockowners to sell more cattle or, alternatively, to enforce control of cattle numbers.”

The empirical record of policies based on these proposals is disappointing. Scoones (1995) writes “the last 30 years have seen the unremitting failure of livestock development projects across Africa. Millions of dollars have been spent with few obvious returns and not a little damage. Most commentators agree that the experience has been a disaster...”

Recent ecological research may provide insight into some of the reasons for this failure. One important result is that rangeland productivity in arid and semi-arid lands, as well as “boom

and bust” cycles in livestock populations, may be more constructively viewed as consequences of exogenously determined rainfall levels rather than endogenously determined stocking rates (Ellis and Swift 1988; Westoby, Walker et al. 1989; Behnke and Scoones 1993). This implies that an assessment of economic sub-optimality based on herders exceeding the rangeland’s fixed carrying capacity is of limited use if the rangeland’s carrying capacity is fluctuating over time. A second result of note is the inability of studies of rangeland condition to clearly identify widespread rangeland degradation as an empirical phenomenon (McCabe and Ellis 1987; Hellden 1991; Abel 1993; Biot 1993). Taken together, these results indicate frequent drought events may prevent livestock populations from attaining levels where widespread degradation occurs. If this is the case, policies that limit stocking levels may bring about little significant change in rangeland condition while imposing great costs on herders’ welfare.

While the assumption of widespread degradation may be questionable, there is a growing amount of evidence associating localized degradation with key resources such as towns and water points (Schwartz, Shaabani et al. 1991; Dodd 1994). Understanding this phenomenon requires that we shift the focus of analysis from how many animals are placed on the commonly held rangeland to a focus on what determines where animals are placed within this rangeland. This study approaches this issue by empirically investigating variables that influence pastoralists’ land use decisions.

DESCRIPTION OF THE STUDY AREA

The Gabra are nomadic pastoralists who live in Marsabit District in northern Kenya. The Gabra livestock production system utilizes a mixture of camels, cattle, sheep, and goats. Households consume milk, meat and blood from animals. Livestock and livestock products such as milk are sold to generate income.

The Gabra share rights to rangelands that are best described as arid or semi-arid, as the vast majority of this area has median annual rainfall of less than 300 mm. The traditional Gabra migration strategy is to graze herds on rangelands near wells during dry periods, using the wells to water their animals. These rangelands are vacated during rainy periods, as temporary catchments provide water for animals in areas away from wells. This strategy spreads grazing pressure on rangelands by periodically vacating zones near permanent water, giving these pastures a chance to regenerate during the rainy season.

Herders report this pattern has been increasingly disrupted over the past 30 years by the growth of permanent settlements around wells. This disruption appears to have an ecological consequence. A recent evaluation of Marsabit District rangelands found 98% of the area exhibiting no evidence that rangeland productivity has been reduced by livestock use. The 2% exhibiting signs of degradation are associated with the areas surrounding towns (Schwartz, Shaabani et al. 1991). In attempting to understand this pattern, this study has two goals. The first is to identify the extent to which the traditional migration strategy has been disrupted. The second is to identify incentives associated with this disruption.

A MODEL OF LAND USE DECISIONS

To explore these issues, a utility maximization model of herder decision making is developed, where utility is a function of consumption. The model is designed so that a herder's land use decision is conditioned on rangeland condition, herd characteristics and household characteristics. The critical component of this model is identifying ways in which land use decisions influence consumption levels, and hence, herder's well being.

Concerning rangeland condition, assume that herder i can choose to graze his animals in either of two rangeland zones. Zone one is defined as the area in which a round trip walk to town

can be completed in a day, and zone two is the area where this trip takes more than a day.¹ Each herder selects the fraction of his herd's effective grazing time to be allocated to zone one, which is the land use choice variable $tz1_i$. This implicitly defines the percent of grazing time spent by herder i 's herd in zone two as $(1-tz1_i)$. Before making his choice, the herder observes a measure of the quantity and quality of pasture available in each zone. These observations are defined by the variables pa^{z1} and pa^{z2} .

The state of the rangeland influences consumption through milk production mp_i , as it is assumed milk production is an increasing function of pasture availability. Milk production is also influenced by the state of the herd. It is assumed milk production increases as herd size increases, where herd size is described by the total animal units in the herd, k_i .² Observed herd characteristics represented by the vector v_i also influence milk production. Unobserved variables that influence milk production are represented by the disturbance term ω . Total milk production is the sum of milk produced in the two zones.

$$(1) \quad mp_i = mp^{z1}(k_i, tz1_i, pa^{z1}, v_i, \omega) + mp^{z2}(k_i, (1-tz1_i), pa^{z2}, v_i, \omega)$$

Milk can be consumed directly by the household, or sold at price p to purchase other consumption goods. In the study area, women make decisions over milk allocation, while men make grazing time allocation decisions. Assume the husband in household i is familiar enough with the history of his wife's milk allocation that the fraction of the milk sold by his wife can be represented by a function $s(tz1_i, mp_i, k_i, \lambda_i, \psi)$, where λ_i captures household characteristics and

¹ More precisely, a radius the length of a five hour walk, a distance of 15 to 20 kilometers, defines zone one. The area outside the circle described by this radius is zone two.

² One animal unit is equal to 0.7 camels, 1 head of cattle, or 10 sheep or goats.

ψ is a disturbance term.³ It is assumed that this fraction is an increasing function of time spent in zone one, as proximity to town influences milk marketing due to transport and spoilage considerations. It is also assumed that this fraction is an increasing function of milk production, as sales occur during time periods when production is greater than household needs. Herd size is included as a wealth proxy, as milk marketing may be a production strategy adopted by certain wealth classes in society.

Another important factor in determining consumption levels in the study area is food aid. As food aid is distributed from towns, it is assumed the quantity of food aid received by herder i is a function of proximity to town. If a herder is far away from town, he may find that he expends more energy obtaining the food in town than is gained by consuming it. Food aid is also influenced by the amount of food delivered to town, denoted fad . These factors lead to specification of a food aid function $fa(tz1_i, fad)$.

All other consumption goods that are not a function of time spent in zone one are represented by the variable z_i .⁴ Assuming a weighting scheme represented by the vector γ can be used to make individual components of the consumption function commensurable, the following equation results.⁵

$$(2) \quad c_i = \gamma_1 \cdot p^m \cdot s(tz1_i) \cdot mp_i + \gamma_2 \cdot (1 - s(tz1_i)) \cdot mp_i + \gamma_3 \cdot fa(tz1_i, fad) + \gamma_4 \cdot z_i$$

Herders gain utility from consumption, where the utility function is common to all herders, holding household characteristics λ_i constant. We can write the problem facing herder i as :

³ Derivation of the $s(\cdot)$ function from the underlying decision process for the wife is left as a separate issue.

⁴ Note that this specification of a composite good z separates slaughter and sales decisions from the land use decision. Although there may be some correlation amongst these decisions, it is arguably slight. Further modeling efforts will explore these connections. For this paper's focus on land use decisions in a static setting, sales and slaughters are judged to add unnecessary dynamic complication to the model.

⁵ Such a weighting scheme could be the relative calorie value of each item. For example, a liter of milk exchanges for a kilogram of maize, but a kilogram of maize has 5 times the calorie value of a liter of milk.

$$(3) \quad \text{Max}_{tz1_i, z_i} \quad U \left(\gamma_1 \cdot p^m \cdot s(tz1_i) \cdot mp_i + \gamma_2 \cdot (1 - s(tz1_i)) \cdot mp_i + \gamma_3 \cdot fa(tz1_i, fad_i) + \gamma_4 \cdot z_i; \lambda_i \right)$$

where $mp_i = mp^{z1}(k_i, tz1_i, pa^{z1}, v_i, \omega) + mp^{z2}(k_i, (1 - tz1_i), pa^{z2}, v_i, \omega)$

Taking the first order condition with respect to $tz1_i$ leads to the following result.

$$(4) \quad \frac{\partial U}{\partial c} \cdot \left[\begin{array}{l} \frac{\partial s}{\partial tz1_i} \cdot mp_i \cdot (\gamma_1 \cdot p^m - \gamma_2) + \frac{\partial mp_i}{\partial tz1_i} \cdot (\gamma_1 \cdot p^m \cdot s(tz1_i) + \gamma_2 \cdot (1 - s(tz1_i))) \\ + \frac{\partial fa(tz1_i, fad_i)}{\partial tz1_i} \cdot \gamma_3 \end{array} \right] = 0$$

$$\text{where} \quad \frac{\partial mp_i}{\partial tz1_i} = \frac{\partial mp_i^{z1}(k_i, tz1_i, pa^{z1}, v_i, \omega)}{\partial tz1_i} - \frac{\partial mp_i^{z2}(k_i, (1 - tz1_i), pa^{z2}, v_i, \omega)}{\partial tz1_i}$$

Consider the following partially solved version of equation (4).

$$(5) \quad tz1_i^* = f(s(tz1_i^*), mp(k_i, pa^{z1}, pa^{z2}, tz1_i^*, v_i, \omega), k_i, pa^{z1}, pa^{z2}, p^m, fad, v_i, \omega, \gamma; \lambda_i)$$

From this representation, we can identify variables that influence the land use decision.

The herd size k_i , the pasture availability in the two zones pa^{z1} and pa^{z2} , the herd specific characteristics v_i and the household characteristics λ_i are all indicated by this model as potentially influencing grazing allocation decisions.

The functions concerning milk production and the share of milk sold also appear important in this decision. As these functions are determined by the optimal decision, they are not causes but results of the land use decision. As the nature of these functions is important to understand land use decisions, they are also estimated. Rearranging equation (5) leads to (6), which describes the relationships empirically investigated in the following section.

$$(6) \quad \begin{array}{l} tz1_i^* = g(k_i, pa^{z1}, pa^{z2}, p^m, fad, v_i, \omega, \psi, \gamma; \lambda_i) \\ s^* = h(tz1_i^*, k_i, mp_i^*, v_i, \psi) \\ mp_i^* = mp(k_i, pa^{z1}, pa^{z2}, tz1_i^*, v_i, \omega) \end{array}$$

EMPIRICAL ANALYSIS OF LAND USE INCENTIVES

To date, interviews have been conducted with 23 households to recover information for the period long rains 1993 to long rains 1997⁶. Each year consists of four distinct time periods: long rains, dry season following long rains, short rains, dry season following short rains. This provides a panel data set (n,t) , $n = 1, \dots, 23$, $t = 1, \dots, 17$ ⁷.

The data set does not contain precise observations on which animals were located in each zone for each time period, but does contain reliable information on the division of household labor for each period. As there is a direct connection between the labor force allocated to each zone and grazing time in each zone, the labor allocation decision is used as a proxy for the land use decision in the estimation procedure.

Family labor is allocated to a base camp or a satellite camp in each time period. Base camps can be in either zone one or zone two, satellite camps are always in zone two. If we observe all labor time allocated to zone one, which occurs when the base camp is in zone one and there is no satellite camp, then $tz1_{it} = 1$. If we observe all labor time allocated to zone two, which occurs when the base camp (and possibly also a satellite camp) is located in zone two, this indicates that $tz1_{it} = 0$. If we observe some labor time allocated to each zone, which occurs when the base camp is located in zone one and the satellite camp is in zone two, then $0 < tz1_{it} < 1$. We can further restrict the lower bound of this range, as the data show that herders never send more than 50% of their labor force to satellite camps. This implies we will observe a mix of time spent in zone one and zone two when $0.5 \leq tz1_{it} < 1$. For the 389 observations in the data set, full time occupation of zone two occurs for 38% of the observations, a base camp in zone one and a

⁶ This time period begins after the drought induced losses of 1992 and ends just after the drought induced losses of 1996. In this way, a full “boom to bust” cycle is represented.

⁷ As two of the 23 households have data for only 16 periods, the total sample size is 389 observations.

satellite camp in zone two is found for 32% of the observations, and full time occupation of zone one is found for 30% of the observations. An econometric framework that can be used to estimate this type of dependent variable is a tobit, with censoring limits at 0.49 and 1.

Regressors included in this estimation follow from the specification of $tz1^*$ in (6). Pasture availability is represented by two separate variables. The first records rainfall levels, which is assumed to be directly correlated with pasture availability. However, as rainfall is spatially variable, and rainfall data is only available for zone one, a second variable records the difference between herder's subjective evaluations of pasture availability for each zone.⁸ The herd specific characteristics υ_i and household specific characteristics λ_i are defined as follows. Herd characteristics include a measure of species composition measured by the ratio of livestock units which are large stock (camels and cattle) to those which are smallstock (sheep and goats) for a given herd. This variable is included because species differ in management and productivity. A second herd characteristic is the number of pack camels in the household, as lack of access to pack camels may constrain a herder's ability to use zone two. Household characteristics include the total number of household members; the number of unmarried household members between ages 10 and 30, which are the primary labor force for satellite camps; and the age and age squared of the household head. The disturbance term u_{it} consists of unobserved household characteristics π_{it} , the milk production disturbance ω_{it} and the milk share disturbance term ψ_{it} .⁹

Results are presented for a model that includes dummy variables for individual specific fixed effects and one that does not recognize individual specific effects. The fixed effects model

⁸ Pasture availability for each zone records herder's subjective evaluations on a 1 to 5 scale, where 1 is very low, 3 is average and 5 is very high. The difference used here is zone two minus zone one.

⁹ Work is currently being conducted on use of a SUR procedure to increase estimation efficiency.

can be written $tz1_{it} = \alpha_i + \beta' x_{it} + u_{it}$. The model that does not recognize fixed effects assumes all the individual-specific intercepts α_i are equal to a constant β_0 .

Table 1: Land Use Decision: 0 is no time spent in zone one, 1 is all time spent in zone one.
s.e. in parentheses

	Mean	Tobit: No Fixed Effects	Tobit: Fixed Effects
Constant	-	1.5417 *** (0.3784)	-
Food Aid Delivery 100 Tons	1.16	0.0209 (0.0198)	0.0310 * (0.0207)
Household Size # members	6.95	0.0568 *** (0.0201)	-0.1756 ** (0.0889)
Young Labor # Unmarried 10-30	2.53	-0.0821 *** (0.0212)	0.0418 (0.0891)
Age of HH head Years	50.92	-0.0312 ** (0.0144)	-0.2647 ** (0.1155)
Age² of HH head	2755.00	0.00029 ** (0.00012)	0.0028 *** (0.0011)
Herd Size TLU	44.09	-0.0044 *** (0.0018)	-0.0073 ** (0.0042)
Pack Camels # of pack camels	2.68	-0.0409 * (0.0276)	-0.0891 * (0.0642)
Herd Composition LS TLU/ SS TLU	1.55	0.0689 *** (0.0228)	0.0694 * (0.0512)
Rainfall Level mm in period	29.53	0.0019 * (0.0009)	0.0010 (0.0009)
Pasture Availability Diff. [1,5]	1.14	-0.1074 ** (0.0637)	-0.0041 (0.0683)
Log L	-	-310.2	-280.3

* indicates significant .10 level, ** indicates significant at .05 level *** indicates significant at .01 level

The fixed effect specification is significantly different from the specification that does not include individual specific terms, with a LR statistic of 59.8 with 23 restrictions.

Table one provides some evidence that there is an incentive effect of current fixed-point food aid distribution programs. Although only the fixed specification finds this result to be significant, both estimations provide similar coefficients. The results on household size and young labor force size are mixed. The first specification finds a significant positive coefficient for household size, while the fixed effects model finds a significant negative coefficient for household size. The sign on the coefficient for young labor also differs according to specification. As there is very little variation in household size and young labor force over time for a given household, there is reason to question the fixed effect result. With this in mind, we can interpret the first specification as indicating an increase in household size increases the family's ability to use the

extensive grazing zone. However, increasing the young labor force has an effect opposite than that anticipated, making herders more likely to stay in the zone around town rather than less. Both specifications find time in zone one to be a convex function of age. The first specification finds the minimum at 54 years while the fixed effect model finds the minimum at 47 years.

Increased herd size is associated with decreased time spent in zone one, although the coefficient is small. This result is of some interest, when compared to the implication of the Hardin model that herd sizes need to be limited.¹⁰ With regard to large stock, it appears that increasing the number of pack camels increases use of the extensive zone, but an increase in the ratio of largestock to smallstock decreases use of the extensive zone.

The coefficients for rainfall levels indicate these herders are no longer following the traditional strategy. Increased rainfall levels are associated with increased time in zone one, although this result is not significant for the fixed effects model. As the traditional pattern requires vacating the zone near town when rainfall increases, it appears this practice has been abandoned. However, herders do exhibit some sensitivity to differences in pasture availability between zones. Both specifications indicate that as pasture availability in zone two minus pasture availability in zone one increases, herders increase use of zone two, although this result is not significant in the fixed effects model.

Estimation of the milk allocation share function also proceeds by use of a tobit, in this case one which has a censoring point at zero. Of the 389 observations, 72% are at zero and 28% are between zero and one. Definition of regressors follows the specification for $s^*(.)$ in (6). Results are presented for a model with fixed effects and a model without fixed effects.

¹⁰ Although further estimation and simulation will be needed to explore this issue, it is possible that limiting herd sizes would induce more herders to locate in zone one, thus increasing degradation!

Table 2: Milk Allocation Share Function: 0 is none marketed, 1 is all marketed.
s.e. in parentheses

Variable	Means	Tobit: No Fixed Effects	Tobit: Fixed Effects
constant	-	-0.6716 *** (0.1025)	-
Herd Size TLU	44.09	-0.00008 (0.00098)	0.0033 * (0.0024)
Milk Prod l. / day	3.83	0.0292 ** (0.0140)	0.0271 ** (0.0133)
Time in Zone One [0,1]	0.54	0.2671 *** (0.0522)	0.1906 *** (0.0521)
Household size # members	6.95	-0.0317 *** (0.0088)	0.0063 (0.0436)
Log L	-	-132.4	-49.8

* indicates significant .10 level, ** indicates significant at .05 level *** indicates significant at .01 level

The fixed effect specification is significantly different from the specification that does not include individual specific terms, with a LR statistic of 165 with 23 restrictions.

The specifications differ in the sign and significance of the coefficient for herd size, with the fixed effects model identifying a positive and significant coefficient. The two models both identify a positive and significant effect of increased milk production on sales. Most importantly, both models indicate milk sales behavior is strongly influenced by the land use decision. While complete analysis of the incentive effects of milk marketing requires modeling the negotiation process between husband and wife, it is reasonable to interpret this result as indicating that influencing the level of his wife's participation in milk marketing factors into the husband's land use decision.¹¹

Milk production is estimated by assuming a Cobb-Douglas functional form and conducting OLS estimation in log-log form. Choice of regressors follows from the discussion of equation (1). A dummy variable for rainy season is included as herders' evaluation of pasture availability applies to a rainy season and its ensuing dry season. The equation estimated is as follows.

$$(7) \text{ mp}_i = \alpha_0 \cdot (k_i)^{\alpha_1} \cdot (\text{tz}1_i \cdot \text{pa}^{z1} + (1 - \text{tz}1_i) \cdot \text{pa}^{z2})^{\alpha_2} \cdot \exp(\alpha_3 \cdot \text{rs} + \alpha_4 \cdot \text{hc}_i + \omega)$$

¹¹ This interpretation is further supported by data gathered on expenditure patterns, as women spent 77% of milk earnings on food for the family.

Table 3: Milk Production. s.e. are in parentheses

	Means	OLS
Milk production liters/day	3.80	-
constant	-	-1.8512 *** (0.4265)
Herd Size TLU	44.08	0.7619 *** (0.1072)
Pasture Availability [1,5]	2.53	0.2852 ** (0.1384)
Herd Composition TLU ls / TLU ss	1.55	0.31147 *** (0.1093)
Rainy Season Dummy (1,0)	0.53	-0.1512 *** (0.0038)
R²	-	0.22

* indicates significant .10 level, ** indicates significant at .05 level *** indicates significant at .01 level

For the study period, herders report average pasture availability in zone one of 1.97 and in zone two of 3.12. As increased pasture availability has a positive and significant effect on milk production, it appears that herders are willing to trade off decreased milk production in order to reside closer to town. The results also indicate herd size has the expected positive and significant impact on milk production. The somewhat surprising result that the rainy season dummy has a negative and significant coefficient may be related to animal breeding periods. Finally, the coefficient for herd composition indicates that increasing the ratio of largestock to smallstock is associated with increased milk production.

CONCLUSION

The results of the estimation section indicate that food and income production strategies, herd characteristics and household characteristics play critical roles in influencing land use choices. They also indicate that these herders are not following the traditional strategy of vacating zone one during rainy periods. However, there is evidence that herder's land use choice is influenced by the difference in pasture availability between zones. While this does allow some degree of self-regulation in grazing pressure, incentives associated with towns concentrate grazing pressure. In light of these results, efforts to arrest degradation around towns must be designed in cognizance of food and income production strategies, herd characteristics, and household characteristics that influence use of resources near towns.

BIBLIOGRAPHY

- Abel, N. O. J. (1993). Reducing cattle numbers on southern African communal range: is it worth it? Range Ecology at Disequilibrium: new models of natural variability and pastoral adaptation in African savannas. R. H. Behnke, Jr, I. Scoones and C. Kerven. London, Overseas Development Institute: 173-195.
- Behnke, R. H. J. and I. Scoones (1993). Rethinking Range Ecology: Implications for Rangeland Management in Africa. Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas. R. H. B. Jr, I. Scoones and C. Kerven. London, ODI: 1-30.
- Biot, Y. (1993). How Long can High Stocking Densities be Sustained? Range Ecology at Disequilibrium: new models of natural variability and pastoral adaptation in African savannas. R. H. Behnke, Jr, I. Scoones and C. Kerven. London, Overseas Development Institute: 153-172.
- Dodd, J. L. (1994). "Desertification and degradation in Sub-Saharan Africa: The Role of Livestock." Bioscience **44**(1): 28-34.
- Doran, M. H., A. R. C. Low, et al. (1979). "Cattle as a Store of Wealth in Swaziland: implications for livestock development and overgrazing in east and southern Africa." American Journal of Agricultural Economics **61**: 41-47.
- Ellis, J. E. and D. M. Swift (1988). "Stability of African Pastoral Ecosystems: Alternate paradigms and implications for development." Journal of Range Management **41**(6): 450-459.
- Hardin, G. (1968). "The Tragedy of the Commons." Science **162**: 1243-1248.
- Hellden, U. (1991). "Desertification-- time for an assessment." Ambio **20**: 372-383.
- Herbst, J. (1993). The Politics of Sustained Agricultural Reform. Hemmed In: Responses to Africa's Economic Decline. T. M. Callaghy and J. Ravenhill. NY, Columbia University Press.
- McCabe, J.T. and J. Ellis. (1987). "Beating the odds in arid Africa." Natural History **96**(1): 32-41
- Schwartz, H. J., S. Shaabani, et al., Eds. (1991). Range Management Handbook of Kenya. Nairobi, Republic of Kenya, Ministry of Livestock Development.
- Scoones, I. (1995). New directions in pastoral development in Africa. Living with Uncertainty: new directions in pastoral development in Africa. I. Scoones. London, Intermediate Technology Publications Ltd.: 1-36.
- USDA (1990). World Agricultural Trends and Indicators, 1970-89. Washington, DC, USDA.
- Westoby, M., B. H. Walker, et al. (1989). "Opportunistic management for rangelands not at equilibrium." Journal of Range Management **42**: 266-274.