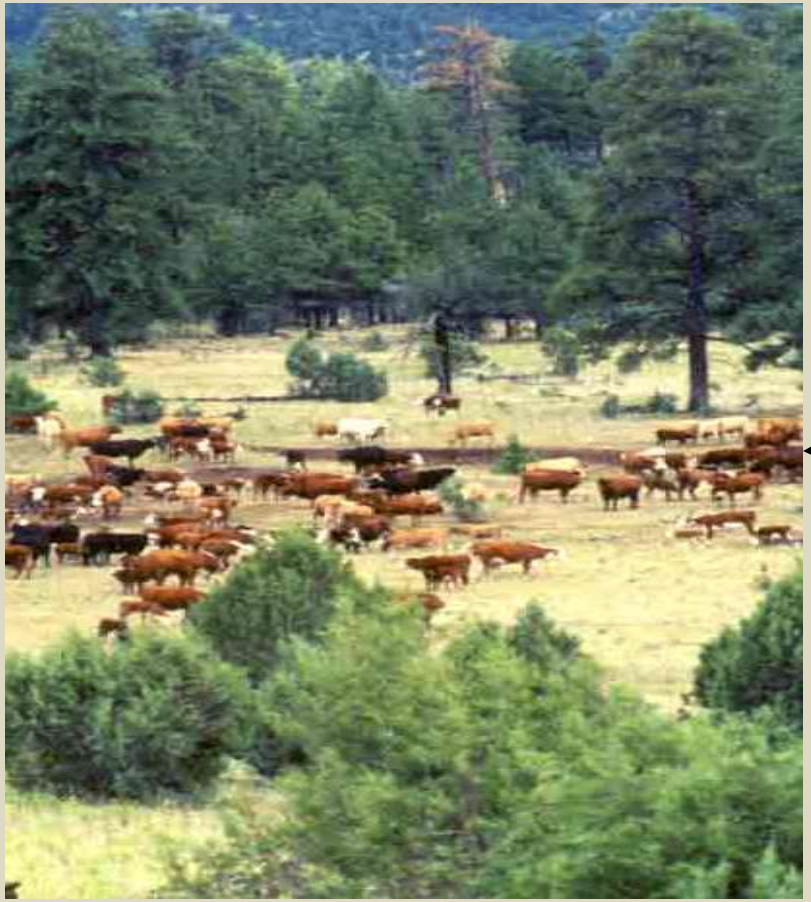
Livestock – Wild Ungulate Interaction in Arizona



William H. Miller
Dept. Applied Science & Mathematics
Arizona State University

Historic Perspective

In 1955 John Hall, then director of the Arizona Game and Fish Department, wrote that the wildlife-livestock interaction has been an issue since the turn of the 20th century. He further indicated that instead of decreasing in intensity, that the conflict has become broader and more bitter with time.

> ***"…we must face the facts, and the fact is that at present time all of the other conflicting interest on our rangelands must force us to work out some mutual solution to the problem of livestock verses wildlife."***

Multiple Specie Management

Nelson, (1984) defined multiple species management as the practice of managing for two or more large herbivore species, domestic and/or wildlife on the same pasture or range resource during the same year.

Multiple species utilization of a common resource generally results in more efficient use of the forage resource. However dual-use of a common resource may increase the likelihood of interspecific competition, and possible abuse of the grazing resource.

Interspecific Competition

Competition is defined as existing when:

1) A number of organisms utilize common resources that are in limited supply.

or

2) When organisms seeking a resource that is not in limited supply harm each other in the process.

Limiting Resource

Cooperrider (1982) reported that of the four potential limiting resources (food, water, cover, and space), that the competition for forage resources between elk and domestic cattle is more intense than any other combination of domestic and wild ungulate in the western United States.

Evaluation of Competition

- A major problem facing resource managers is the ability to quantify animal competition for the propose of resource allocation.
- An underlying concept of any approach for the evaluation of competition is that individuals of one competing species may be substituted for those of another at a rate described by the equation:

$$N_1 = K_1 - \alpha N_2 \text{ and } N_2 = K_2 - \beta N_1$$

Where:

- N is the number of species 1 and 2 possible on the area in light of the presence of the other species.
- K is the carrying capacity for species 1 or 2,
- α and β is the tradeoff rate for species 1on 2 and 2 on 1.

Determination of Tradeoff Rates

- Traditionally animal equivalence (AE) have been used as the tradeoff coefficients (α and β).
- The basis of AE is the ratio of total dry matter consumption between two species of some standard size.

Example: (Stoddard et al. 1974)

1 Beef Cow = 2 Elk and 2 Elk = 1 Beef Cow

1 Beef Cow = 5 Deer and 5 Deer = 1 Beef Cow

- The problem with this is that standardized AE do not take into consideration any variations in a number of factors that have a significant influence on competition.

Factors Influencing Tradeoff Rates

Competition for food between ungulate species involves several factors (Nelson 1984, Vavra et al. 1989). The most important factors include:

Consumption equivalence

Diet similarity

Range overlap

Timing of forage use

Foraging availability (height, quantity, and quality)

Density of competing species

Consumption Equivalents

- Consumption equivalence (CE_i), is expressed as a proportion of the average total daily dry matter intake (DMI) of one species relative to a second species, and is calculated as:

$$CE_{12} = (DMI_2 / DMI_1) \text{ and } CE_{21} = (DMI_1 / DMI_2)$$

- Use of a standard exchange rate is subject to a number of errors, not the least of which are that all animals of a particular species vary in body size and physiological requirements, and therefore, have different daily forage intakes.

Diet Similarity

- Both elk and cattle are dietary opportunists, using a variety of grasses, forbs and shrubs.
- Diet similarity between these two species can be highly variable within communities types and between seasons.

Summary of cattle and elk (c/e) diet composition by forage class and diet similarity in Arizona from 1985 to 1992.

	Diet Composition (%)			Diet	
Year	Grass	Forb	Shrub	Similarity	Source
1985	88/47	7/34	5/19	77.4	Brown (1990)
1986	84/32	11/26	5/42	59.7	Brown (1990)
1989	81/32	14/21	5/46	60.0	Brown (1990)
1990	81/71	19/29	0/0	98.4	Miller (1995)
1991	75/67	24/32	1/1	98.8	Miller (1995)
1992	95/89	5/11	0/0	99.5	Miller (1995)

Measurement of Diet Similarity

- Many of the indices used to examine diet similarity produce a single similarity value ranging between 0 (no similarity) and 1 (total similarity).
- While these methods provide good estimates of diet similarity they all suffer from the same problem. The output of a single value does not allow for disproportional tradeoff between the species being evaluated.

- McArthur and Levins (1967) proposed that if all factors - other than food consumption were disregarded, the impact of one species on another could be described as:

$$DS_{21} = \frac{\Sigma D_{i1}D_{i2}}{\Sigma D_{i1}^2} \quad \text{and} \quad DS_{12} = \frac{\Sigma D_{i1}D_{i2}}{\Sigma D_{i2}^2}$$

Where:

- DS_{21} is the impact of animal species 2 on species 1, and DS_{12} is the impact of specie 1 on species 2.
- D_{i1} is the quantity of food resource (*i*) consumed by animal species 1, and D_{i2} is the quantity of food resource (*i*) consumed by animal species 2.

Range Overlap

- Several researchers have recognized the effect pattern of animal distribution has on determining competition between wildlife species.
- If the potential competing species do not utilize the resource at the same location, then the potential for competition between the species does not exist.
- The amount of range overlap (area of joint use) can be estimated using field data such as pellet group counts and forage utilization samples as input.

- Using GIS, it is a tool capable of displaying the amount of habitat utilized by the competing species, and by a number of overlay techniques, determine the extent of overlap between the competing species.
- The R-factor is then estimated as:

where: $R_{12} = \frac{OA_{12}}{U_1}$ and $R_{21} = \frac{OA_{21}}{U_2}$

  - R_{12} is the R-factor, showing distributional competitive impact of animal species (2) on animal species (1),
  - OA_{12} is the area used by animal species (1) also used by animal species (2), and
  - U_1 is the total area used by animal species (1).

Timing of Use

Timing of use can be considered as a competitive factor in two ways:

1. If the potentially competing species use an area concurrently then the potential for competitive interaction is said to be two-way.
2. If the one species utilizes the forage resource prior to the arrival of a second species, and then departs, then the competitive interaction is one-way.

- Under the condition of one-way interaction, where the first species uses the forage and departs with the arrival of the second species, then the competitive factors of diet similarity and range overlap are based on the previous forage and habitat use of the first species with the subsequent forage and habitat use of the second species.
- If the first species returns after the departure of the second species, then the competitive interaction is based on the forage and habitat use of the second species with the subsequent use of the first species.

Timing of Use interaction:

Species 1 ⟶ Species 2 ⟶ Species 1

Tradeoff Coefficients

- As previously defined, tradeoff is the change in the number of one species with the addition or deletion of an individual of a second species to the system.
- Tradeoff can be expressed in terms of α and β, where:
  - α is the change in the number of species (1) with the addition or removal of an individual of species (2).

    and
  - β is the change in the number of species (2) with the addition or removal of an individual of species (1).

- Interspecific interaction is a complex relationship between two species and includes, range overlap, dietary overlap, timing of use, and consumption equivalents.
- On a quantitative basis, the tradeoff is the product of the interaction of all of these components, and can be calculated using the equation:

$$\alpha = CE_{21} \; x \; DS_{21} \; x \; R_{21} \; and, \; ß = CE_{12} \; x \; DS_{12} \; x \; R_{12}$$

where:

- E_{21} is the consumption equivalence for animal species 2 on 1,
- DS_{21} is the dietary overlap for animal species 2 on 1.
- R_{21} is range overlap for animal species 2 on 1,

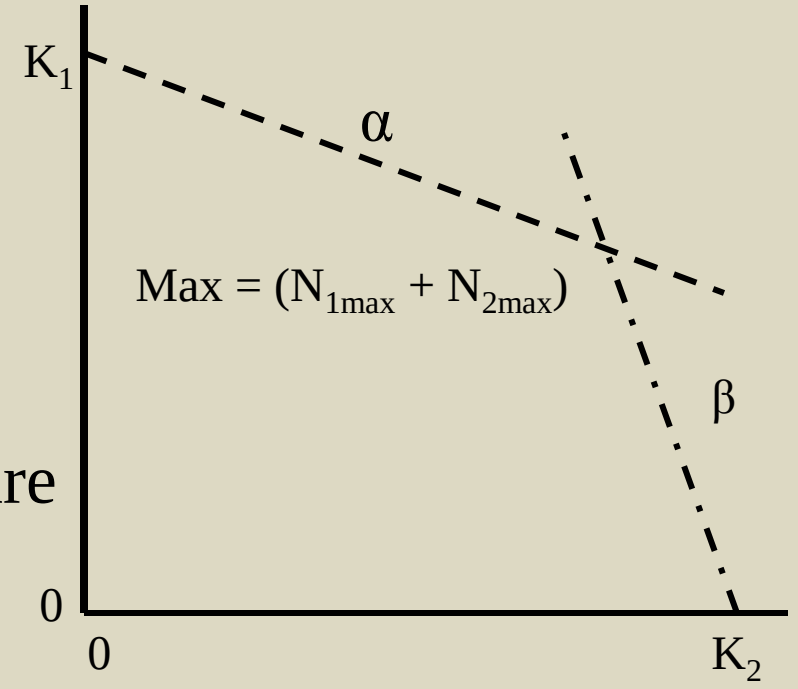
Tradeoff Curve

- The tradeoff curve provides a visual means of evaluating the competitive interactions of two species.
- The point at which the two lines intersect is the point of optimum numbers of both species the area can support.
- This value can be calculated using the Lotka-Volterra equation:

$N_{1max} = K_1 - \alpha K_2/(1-\alpha\beta)$ *and*
$N_{2max} = K_2 - \beta K_1/(1-\alpha\beta)$

where:

K is the carrying capacity of species 1 and 2, and α and β are the tradeoff coefficients.



Management Application

- Starting in 1990 we conducted a three year study to document the competitive interaction of cattle and elk on the Pivot Rock allotment of the Long Valley District, Coconino N.F. Arizona.
- Elk use of the area began in early spring following snow melt and continued until the introduction of cattle in mid-May.
- The allotment consisted of eight fenced adjacent pastures, and the grazing strategy was a deferred rotation with the length of grazing in each pasture ranging form 6 to 20 days depending on the size of the pasture.
- As cattle were moved from one pasture to the next, elk would displace to adjacent pastures, but never totally leaving the area, and would return after the cattle had moved to a new pasture.

Data on diet composition and habitat use were collected during three time perods

- Spring Elk Use: Pastures were sampled for forage production and utilization the day prior to cattle introduction into a specific pasture. Concurrently we collected fecal samples to determine elk diet composition. Animal distribution was determined using randomly located plot at a density of one plot/2 ha.
- Summer Cattle Use: Each pasture was sampled using the same methods described above, the day after the cattle were moved into a new pasture.
- Fall Elk Use: Each pasture was sampled a third time in late October-Early November to quantify fall elk use as described above.

Consumption Equivalence (CE):

Elk:	Mean Body Weight	205 kg
	Mean Consumption Rate	2.5 %
	Daily Intake	5.1 kg/day
Cattle:	Mean Body Weight	454 kg
	Mean Consumption Rate	2.5 %
	Daily Intake	11.4 kg/day

$CE_{21} = 11.4/5.1 = 2.24$ $CE_{12} = 5.1/11.4 = 0.45$

Diet Simalarity

Summary of the annual diet similarity between spring elk and summer cattle, and summer cattle and fall elk on the Pivot Rock study area, Long Valley Dist. Coconino N.F, Arizona.

	Study Year				
Interaction	1	2	3	Mean	Sd
Elk/Cattle	1.01	0.22	0.63	0.62	0.395
Cattle/Elk	0.57	0.93	1.07	0.86	0.259

Range Overlap

Summary of the annual range utilization and range overlap between elk and cattle on the Pivot Rock study area, Long Valley Dist., Coconino N.F., Arizona

	Animal Distribution and Range Overlap		
Year 1:	Spring Elk	Cattle	Fall Elk
Range Use (Ha.)	1,129	1,071	485
Area Overlap (Ha.)		465	162
Relative Overlap (%)		43.4	35.4
Year 2:			
Range Use (Ha.)	1,075	1,508	600
Area Overlap (Ha.)		636	353
Relative Overlap (%)		42.2	58.9
Year 3:			
Range Use (Ha.)	1,127	1,472	610
Area Overlap (Ha.)		733	245
Relative Overlap (%)		49.8	40.2
Mean Overlap		45.13	44.83

Tradeoff Coefficients

Summary of annual tradeoff coefficients between spring elk and summer cattle, and summer cattle and fall elk on the Pivot Rock study area, Long Valley Dist. Coconino N.F., Arizona

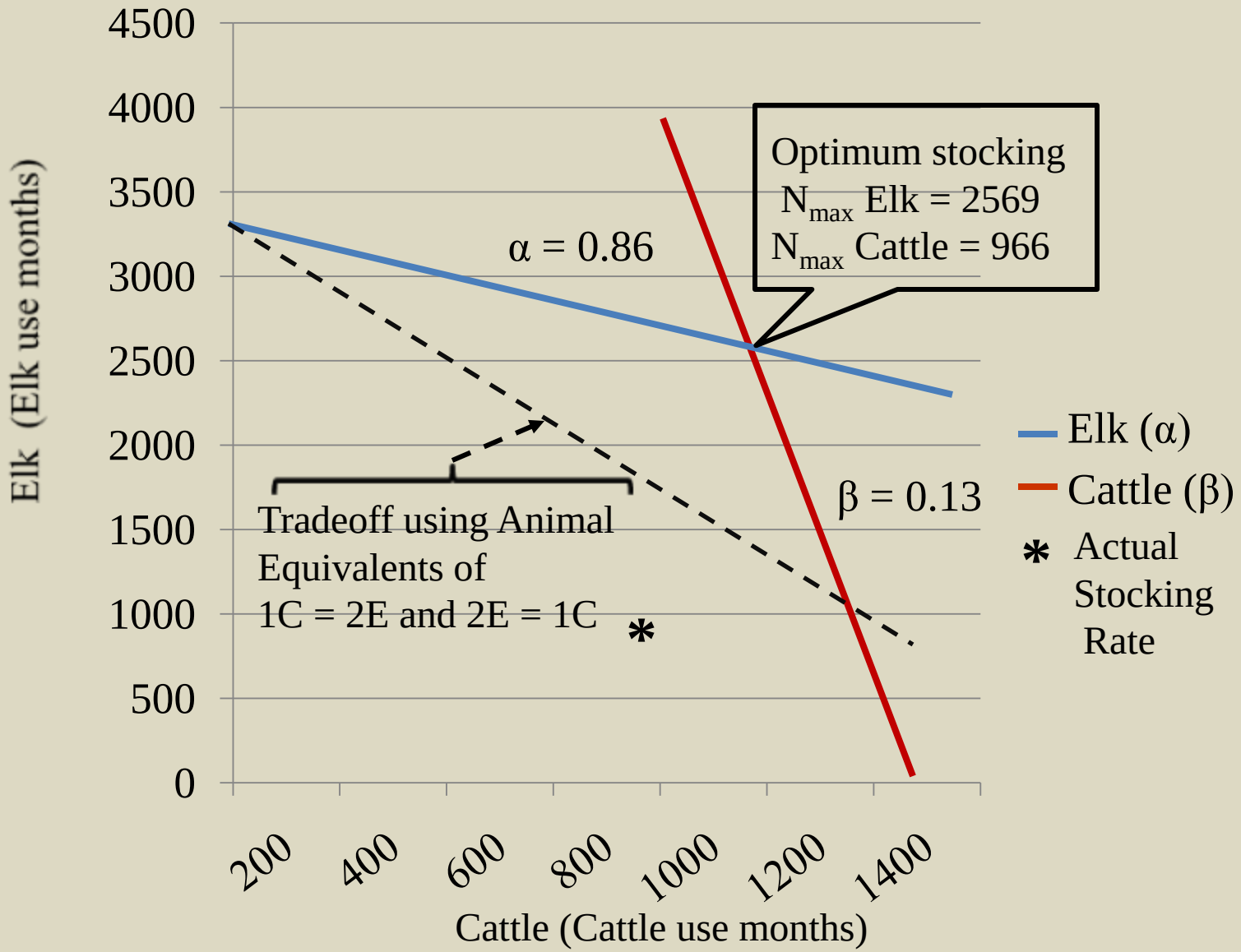
	Year				
Trade Off Class	1	2	3	Mean	Sd
Elk/Cattle (β)	0.20	0.04	0.14	0.13	0.06
Cattle/Elk (α)	0.42	1.21	0.95	0.86	0.33

Forage Availability

Summary of annual forage availability in animal unit months (AUM) for summer cattle, and and fall elk on the Pivot Rock study area, Long Valley Dist. Coconino N.F., Arizona.

	Year			
Animal	1	2	3	Mean
Summer Cattle	1824	1181	916	1307
Fall Elk	4816	2371	3016	3401

Tradeoff Curve



Summary

- The old animal equivalence is solely based on animal consumption equivalence and greatly overestimates the amount of competitive interaction between species.
- In addition to consumption equivalence, competition evaluation must include consideration for diet similarity, range overlap, timing of use, and forage available.
- A as whole most competitive interaction are much less severe than previously perceived.
- The use of tradeoff curves can provide a much clearer picture of the nature of the interactions between potentially competing species.