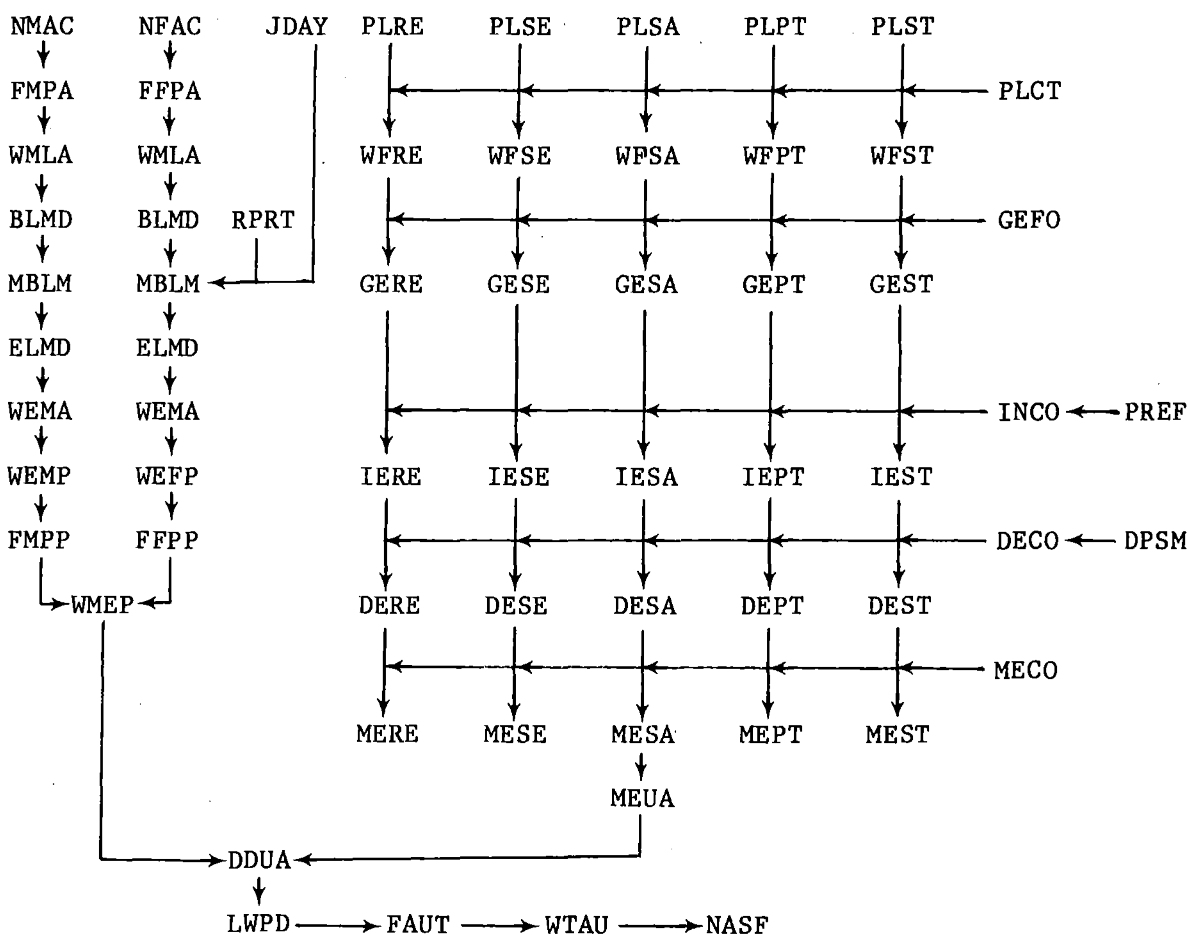
TOPIC 1. FORAGE RESOURCES

Forage resources are an appropriate base for the calculation of carrying capacities for wild ruminant range, because of the potential impact these animals can have on these resources. Calculations of carrying capacity in relation to forage resources are made in relation to particular nutrients in the forages consumed. Hence it is necessary to identify the nutrient being used as a base. Calculations of the amounts of forage consumed were described for an energy base in CHAPTER 12, TOPIC 3; for a protein base TOPIC 4, and for a mineral base in TOPIC 5 of CHAPTER 12.

The first of these, energy, has been evaluated quite thoroughly and calculations may be readily made for available data. The second, protein, has been evaluated to a considerable extent, and first-approximation calculations may be made. The third, minerals, are not well understood in the ecological context as requirements have not be determined and mineral compositions of different forages are not well known.

A flow sheet for the calculation of carrying capacity of white-tailed deer based on the forage production in different stages of forest succession in New York State is shown below. The meanings of all of the symbols have been defined and discussed, so the calculations may now be linked together within the concept of carrying capacity.



DEFINITIONS OF SYMBOLS USED

BLMD = Base-line metabolism per day - CHAPTER 7

DDUA = Deer days of forage per unit area - CHAPTER 20, TOPIC 2
DECO = Digestible energy coefficient - CHAPTER 11
DEPT = Digestible energy in pole timber area - CHAPTER 11
DERE = Digestible energy in regeneration area - CHAPTER 11
DESA = Digestible energy in sapling area - CHAPTER 11
DESE = Digestible energy in seedling area - CHAPTER 11
DEST = Digestible energy in saw timber area - CHAPTER 11
DPSM = Number of deer per square mile - CHAPTER 18, TOPIC 1

ELMD = Ecological metabolism per day - CHAPTER 7

FAUT = Fraction of the area used per unit time - CHAPTER 3, UNIT 3.2
FFPA = Fraction of the female population in each age class - CHAPTER 18, UNIT 2.1
FFPP = Fraction of the total population in the female population - CHAPTER 18, UNIT 2.1
FMPA = Fraction of the male population in each age class - CHAPTER 18, UNIT 2.1
FMPP = Fraction of the total population in the male population - CHAPTER 18, UNIT 2.1

GEFO = Gross energy in forage - CHAPTER 11
GEPT = Gross energy in pole timber area - CHAPTER 11
GERE = Gross energy in regeneration area - CHAPTER 11
GESA = Gross energy in sapling area - CHAPTER 11
GESE = Gross energy in seedling area - CHAPTER 11
GEST = Gross energy in saw timber area - CHAPTER 11

IEPT = Ingestible energy in pole timber area
IERE = Ingestible energy in regeneration area
IESA = Ingestible energy in sapling area
IESE = Ingestible energy in seedling area
IEST = Ingestible energy in saw timber area
INCO = Ingestibility coefficient

JDAY = Julian day of the year

LWPD = Length of the winter period in days

MBLM = Multiple of base-line metabolism - CHAPTER 7
MECO = Metabolizable energy coefficient - CHAPTER 11
MEPT = Metabolizable energy in pole timber area - CHAPTER 11
MERE = Metabolizable energy in regeneration area - CHAPTER 11
MESA = Metabolizable energy in sapling area - CHAPTER 11
MESE = Metabolizable energy in seedling area - CHAPTER 11
MEST = Metabolizable energy in saw timber area - CHAPTER 11
MEUA = Metabolizable energy per unit area - CHAPTER 11

NASF = Number of animals supported by the forage - CHAPTER 20, TOPIC 1
NFAC = Number of females in each age class - CHAPTER 18, UNIT 2.1
NMAC = Number of males in each age class - CHAPTER 18, UNIT 2.1

PLCT = Percent of land in each cover type - CHAPTER 13, UNIT 1.4
PLPT = Percent of land in pole timber stage - CHAPTER 13, UNIT 1.4
PLRE = Percent of land in regeneration stage - CHAPTER 13, UNIT 1.4
PLSA = Percent of land in sapling stage - CHAPTER 13, UNIT 1.4
PLSE = Percent of land in seedling stage - CHAPTER 13, UNIT 1.4
PLST = Percent of land in saw timber - CHAPTER 13, UNIT 1.4
PREF = Deer preference for forage species - CHAPTER 12, UNIT 1.2

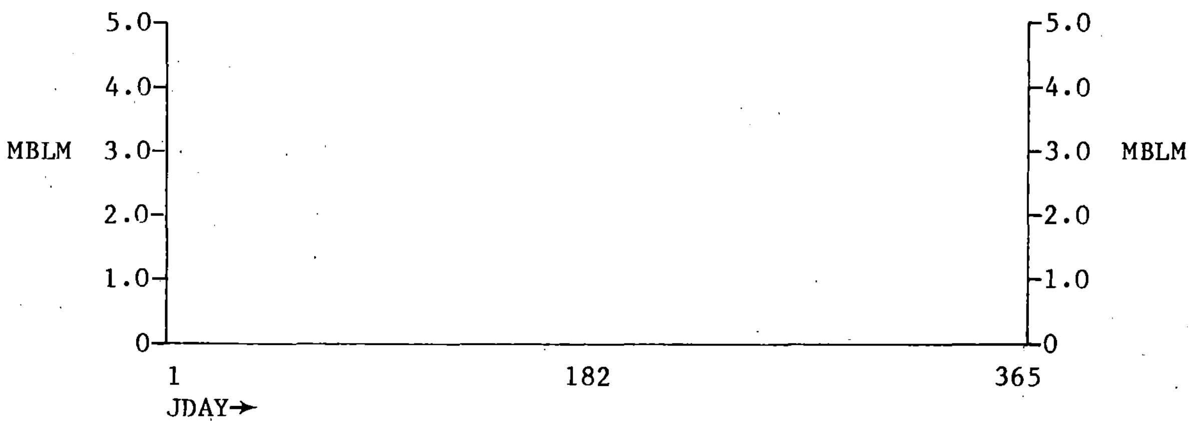
RPRT = Reproductive rate - CHAPTER 19, UNIT 1.1

WEFP = Weighted-mean ecological metabolism of the female population - CHAPTER 18, UNIT 2.5
WEMA = Weighted-mean ecological metabolism of the age class - CHAPTER 18, UNIT 2.5
WEMP = Weighted-mean ecological metabolism of the male population - CHAPTER 18, UNIT 2.5
WFPT = Weighted-mean forage production in pole timber area - CHAPTER 13, UNIT 1.4
WFRE = Weighted-mean forage production in regeneration area - CHAPTER 13, UNIT 1.4
WFSA = Weighted-mean forage production in sapling area - CHAPTER 13, UNIT 1.4
WFSE = Weighted-mean forage production in seedling area - CHAPTER 13, UNIT 1.4
WFST = Weighted-mean forage production in saw timber area - CHAPTER 13, UNIT 1.4
WMEP = Weighted-mean ecological metabolism of the population - CHAPTER 18, UNIT 2.5
WMLA = Weighted-mean live weight of the age class - CHAPTER 18, UNIT 2.2
WTAU = Weighted-mean time and area used - CHAPTER 3, UNIT 3.2

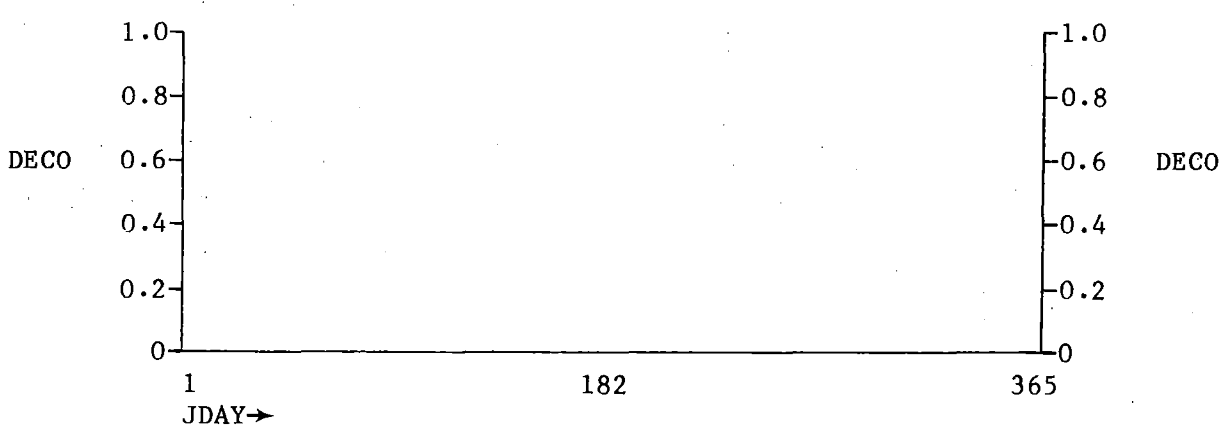
The first five UNITS that follow are based on energy and the sixth on protein. The basic formula for calculating carrying capacity as a relationship between resources required and resources available is the same for all nutrients; only the data are missing for some of the nutrients so they cannot be used as a base for calculating carrying capacity.

UNIT 1.1: CARRYING CAPACITY CHANGES IN RELATION TO ENERGY METABOLISM RHYTHMS

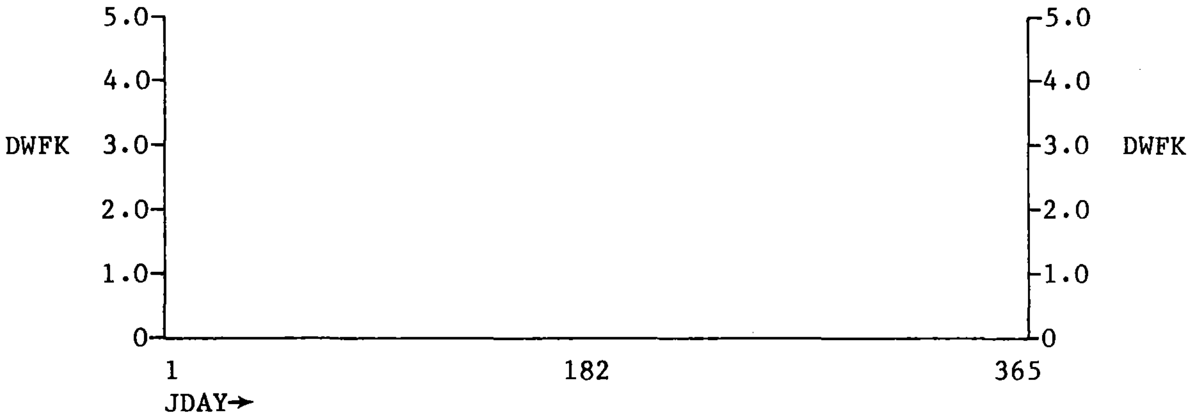
Forage consumption in relation to energy metabolism rhythms was illustrated for the annual cycle that was described for white-tailed deer in my paper in the Journal of Wildlife Management (Moen 1978). The calculations included seasonal changes in energy metabolism, seasonal changes in diet digestibility, and variations in the timing of the length of winter and arrival of spring. Seasonal changes in energy metabolism have also been discussed at length in CHAPTER 7 of this book, emphasizing the use of the multiple of base-line metabolism to represent different levels of cost throughout the year. As a review of the seasonal changes in ecological metabolism, draw the seasonal pattern of variations in the multiple of base-line metabolism (MBLM) in the space below.



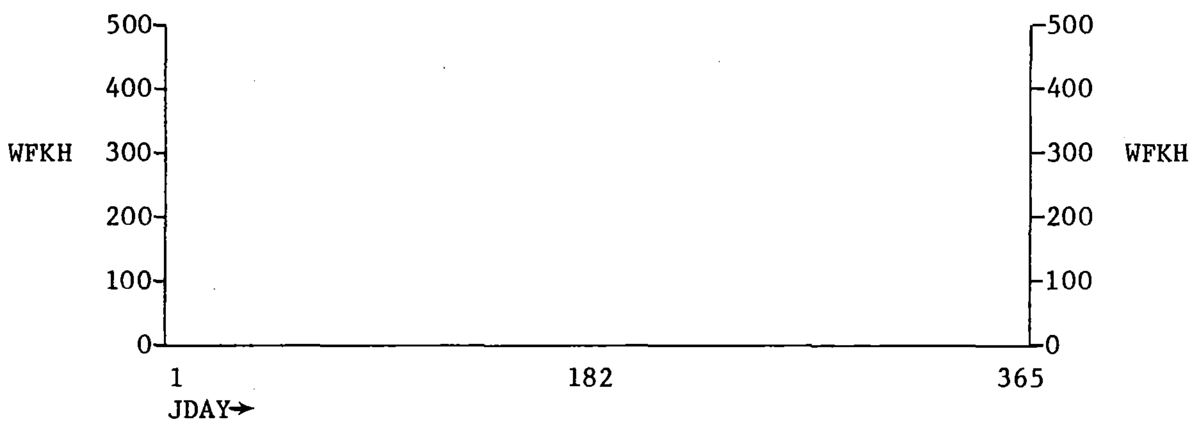
Diet digestibilities change as a result of seasonal patterns of cell development and plant growth. These were discussed in CHAPTER 11. As a review, draw the seasonal pattern of variations in digestible energy coefficient and metabolizable energy coefficients in the space below.



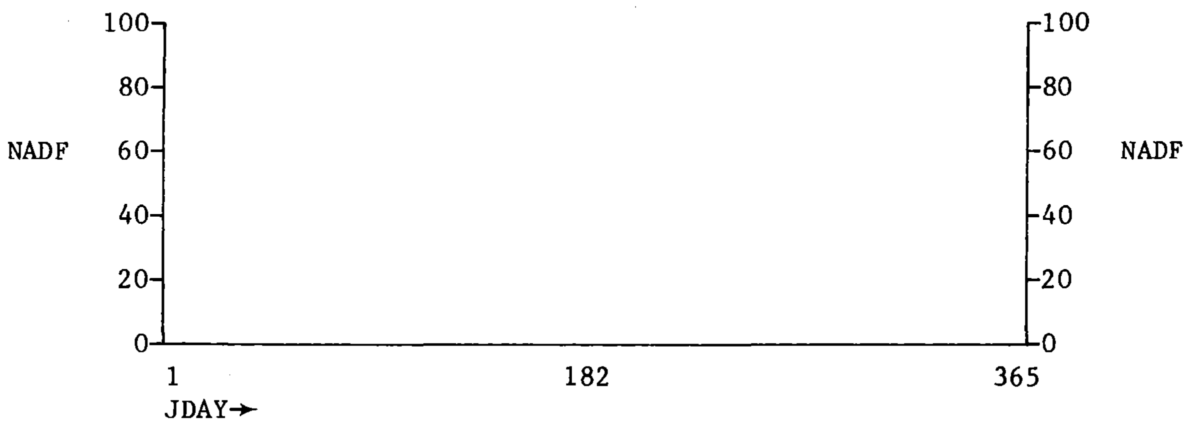
The amount of forage required to meet daily energy needs is calculated by dividing the ecological metabolism per day by the metabolizable energy in the forage. Doing that for your two review illustrations above, plot the pattern of dry weight forage in kg (DWFK) required to meet metabolic needs in the space below. How does your pattern compare to the calculated values published in Moen (1978:734 and 735)? Review the calculations of forage consumption, complete additional calculations as necessary, and then go on to the calculation of carrying capacity.



Calculations of carrying capacity must consider changes in the amount of forage available to wild ruminants throughout the annual cycle. Primary production in different plant communities was discussed in CHAPTER 13. As a review, draw the seasonal patterns of the weight of forage available in kg per hectare (WFKH) in the space below.



A final picture can now be drawn for this sequence. The number of animal days supported by the forage (NADF) plotted over the annual cycle will show that the carrying capacity of the range varies throughout the year. Specifically, the number of animal days supported by the forage will decline in the early part of the calendar year when winter is still present, and then rise sharply when plant growth begins and forage becomes abundant. As plant growth slows, NADF declines slowly. Then, when snow covers up much of the available forage from the previous summer growth leaving only the woody browse available, carrying capacity, expressed as NADF, declines sharply. As winter progresses, it declines further, at a slower rate. Illustrate the pattern below, mentally integrating these changes through the annual cycle.



The shape and values of the curve drawn above varies in relation to the specific values for ELMD, DECO, and WFKH through time. WORKSHEETS provide opportunities for you to compile your own data and make your own calculations.

LITERATURE CITED

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42(4):715-738.

REFERENCES, UNIT 1.1

CARRYING CAPACITY CHANGES IN RELATION TO ENERGY METABOLISM RHYTHMS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	9---4	319	322	odvi	symptoms, deer malnutritio	harris,d	1945
JWMAA	42--4	715	738	odvi	seas, metab, forage intake	moen,an	1978

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

HMECA 7---2 135 149 doca comp energ flow, graz anim ellis,je; jennin/ inpr

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
CEXSB	TB109	1	28	many	energ budg rang, ran lives	cook,cw	1970
ECMOA	30--2	187	206	many	energ dyn, food ch, old fi	golley,fb	1960
ESASA	26---	89	125	many	mamm cons mod for grasslan	anway,jc	1978
JWMAA	3---4	295	306	many	yellowst wint rnge studies	grimm,rl	1939

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
AECOD	3---1	45	54	....	energy flow and partioning	coleman,dc; andr/	1976

UNIT 1.2: CARRYING CAPACITY CHANGES IN RELATION TO HORIZONTAL AND VERTICAL DISTRIBUTIONS OF FORAGE

Forage energy is not uniformly distributed in space. Differences between stages in succession and between plant communities occur, and differences in the vertical distribution of forage within plant communities occur. These differences were discussed in CHAPTER 13.

The vertical distribution of forage is an important consideration in the winter when the balance between resources required and resources available is critical. The use of three different white-tailed deer weights will illustrate calculations of carrying capacity in relation to the vertical distribution of forage.

Suppose the data tabulated below are used to calculate ecological metabolism per day (ELMD) (see CHAPTER 7) and the height of forage reached in cm (HFRC) is calculated with the following equation from CHAPTER 1, WORKSHEET 2.2b, Page 36b:

$$HFRC = 145 + 0.792\ LIWK$$

where LIWK = live weight in kg, and may be considered equal to CLWK. Complete the two columns on the right in the table below.

MALES

CLASS	AGCL	JDAY	AGDA	NMAC	CLWK	IFWK	MWKG	MBLM	x	BLMD	=	ELMD	HFRC
ACa-.	____	____	____	____	____	____	____	____	x	____	=	____	____
ACb-.	____	____	____	____	____	____	____	____	x	____	=	____	____
ACc-.	____	____	____	____	____	____	____	____	x	____	=	____	____

SUMS = [____]
TNMP

FEMALES

CLASS	AGCL	JDAY	AGDA	NFAC	CLWK	IFWK	MWKG	RPRT	MBLM	x	BLMD	=	ELMD	HFRC
ACaa.	____	____	____	____	____	____	____	____	____	x	____	=	____	____
ACbb.	____	____	____	____	____	____	____	____	____	x	____	=	____	____
ACcc.	____	____	____	____	____	____	____	____	____	x	____	=	____	____

SUMS = [____]
TNFP

The weight of forage in kg per hectare in the 70-year-old mixed hardwood stand discussed in CHAPTER 13, WORKSHEET 1.3b, Page 24b. The equation, with rounded numbers, is given below.

$$WFKH = 2.3 + 0.04\ HFRC$$

For males, WFKH = _____ when CLWK = 45,

_____ when CLWK = 70, and

_____ when CLWK = 85.

For females, WFKH = _____ when CLWK = 42,

_____ when CLWK = 56, and

_____ when CLWK = 62.

Dry weight forage consumption in kg is determined by (See CHAPTER 12):

$$DWFK = ELMD/[(GEFO)(DECO)(MECO)]$$

and the number of animal days supportd by the forage is determined by:

$$NADF = WFKH/DWFK$$

Complete the following table.

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	____	____	____	/	____	=	____
ACaa.	____	____	____	/	____	=	____
ACb-.	____	____	____	/	____	=	____
ACbb.	____	____	____	/	____	=	____
ACc-.	____	____	____	/	____	=	____
ACcc.	____	____	____	/	____	=	____

Note how NADF varies due to differences in the amounts of forage within reach of the animals, and in relation to differences in ELMD. The larger, higher-reaching animals are not very considerate, of course, eating forage at the lower heights as well, depriving the smallest animals of some of the only forage they can reach.

The example above illustrates how the effects of different vertical distributions on carrying capacity may be calculated. WORKSHEETS provide opportunities for you to complete calculations for species and areas of your choice.

REFERENCES, UNIT 1.2

CARRYING CAPACITY CHANGES IN RELATION TO HORIZONTAL AND VERTICAL DISTRIBUTIONS OF FORAGE

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JAPEA	14-2	433	444	odvi	veget habitat classificatn	stocker,m; gilber	1977
PCGFA	14---	98	103	odvi	deter rnge carry capac, ga	moore,wh; ripley/	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				odhe			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ceel			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				rata			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CLCHA	18--7	605	612		est norm range & cum propo	harris,ek; demets	1972

CODEN	VO-NU	BEPA	ENPA	FRGE*	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	65-11	807	813	frge	forest cover and logging	young,ja; hedric/	1967
JRMGA	25--6	446	449	frge	yld, 2 for zon, n b, nov s	telfer,es	1972
PSAFA	1962-	165	167	frge	timb ovrstry detrm od fora	schuster,jl; hall	1962
RWLBA	9---1	1	146	frge	edge eff, lesser veg, adir	barick,fb	1950
XFPNA	112--	1	12	frge	seas forag use, elk & deer	edgerton,pj; smit	1971
XFWWA	43...	1	48	frge	rata st matthw islan range	klein,dr	1959
ZHIVA	11...	62	68	frge	rata fodder supply, zhivot	ustinov,vi; pokro	1954

*FRGE = forage type

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
CNSVA	27--6	37	37	brws	propos to imprv od habitat	severinghaus,cw	1973
JWMAA	5---1	90	94	brws	mgt sugges for wh-cedr typ	aldous,se	1941
JWMAA	23--3	273	278	brws	odvi win rng veg stud, wis	habeck,jr	1959
JWMAA	35--3	533	537	brws	wldlf food, hrdwd, reg cut	crawford,hs,jr; /	1971
JWMAA	40--2	326	329	brws	odvi brwse inventor, louis	pearson,ha; stern	1976
MXSBA	294--	1	43	brws	isl roy forst, wldlf, fire	hansen,hl; kreft/	1973
NAWTA	18---	581	596	brws	od yard carry cap, browsng	davenport,la; sw/	1953
NFGJA	14--2	193	198	brws	witchhob, site exp, brwsng	bailey,ja	1967
PCGFA	9----	134	156	brws	brow cens, 100 % clip meth	harlow,rf	1955
VILTA	9---3	45	192	brws	wiru, win habita, land use	ahlen,i	1975
WLSBA	6---4	259	260	brws	age, densi, fert, oak prod	wolgast,lj	1978
XFNSA	140--	1	4	brws	odvi browse resourc, arkan	segelquist,ca; p/	1972
XFSEA	2----	1	20	brws	od browse resourc, n georg	ripley,th; mcclur	1963

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	32--1	185	186	twig	brows yield, forst opening	halls,lk; alcaniz	1968

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	27--3	195	204	hrbg	graz val natv veg, so pine	campbell,rs	1946
ECOLA	35--1	59	62	hrbg	for prod, longlf pne, alab	gaines,em; campb/	1954
JECOA	45--2	593	599	hrbg	stand crop nat veg, subarc	pearsall,wh; newb	1957
JFUSA	63--4	282	283	hrbg	tree - herbage relations	hall,lk; schuster	1965
JRMGA	5---2	76	80	hrbg	herb, ungu, wint-rang util	buechner,hk	1952
JRMGA	26--6	423	426	hrbg	s pine overstory infl herb	wolters,gl	1973
PSAFA	1957-	156	158	hrbg	undrstory veg, stand chars	pase,cp; hurd,rm	1957

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	50--5	802	804	leav	foliage profile, vert meas	macarthur,rh; hor	1969

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
JFUSA	48--2	118	126	gras	chng pond pne bnchgras rng	arnold,jf	1950

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ASZBA	16--2	155	161	lich	prod arboreal lichns, rata	scotter,gw	1961

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	35...	259	284		ecolog, deer range, alaska	klein,dr	1965
JFUSA	46--6	416	425		util summ range plnts, uta	cook,cj; cook,cw/	1948
JWMAA	32--2	330	337		odvi food ylds, 4 for typs	segelquist,ca; gr	1968
JWMAA	42--4	799	810		ceel diet, actv, ldgpl pne	collins,wb; urne/	1978
WMBAA	18---	1	111		effs wldfre rata wint rnge	scotter,gw	1964

FRGE = forage type

frge = mixed or unspecified forage types
brws = browse
twig = twigs
hrbg = herbage or herbaceous vegetation
leav = leaves
gras = grasses
lich = lichens

CHAPTER 20, WORKSHEET 1.2a

Calculating carrying capacity for male white-tailed deer in relation to the vertical distribution of forage

The amount of forage (WFKH) varies with height above the ground, and can be calculated using the equation on Page 17 of this UNIT. Formats are given below and on the next page for tabulating five sets of calculations of carrying capacity for male white-tailed deer based on the vertical distribution of forage. Refer back to Page 18 for a review of the calculations of dry-weight forage in kg (DWFK) required to meet the cost of ecological metabolism per day.

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	_____	_____	_____	/	_____	=	_____
ACb-.	_____	_____	_____	/	_____	=	_____
ACc-.	_____	_____	_____	/	_____	=	_____
ACd-.	_____	_____	_____	/	_____	=	_____
ACe-.	_____	_____	_____	/	_____	=	_____
ACf-.	_____	_____	_____	/	_____	=	_____
ACg-.	_____	_____	_____	/	_____	=	_____
ACh-.	_____	_____	_____	/	_____	=	_____
ACi-.	_____	_____	_____	/	_____	=	_____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	_____	_____	_____	/	_____	=	_____
ACb-.	_____	_____	_____	/	_____	=	_____
ACc-.	_____	_____	_____	/	_____	=	_____
ACd-.	_____	_____	_____	/	_____	=	_____
ACe-.	_____	_____	_____	/	_____	=	_____
ACf-.	_____	_____	_____	/	_____	=	_____
ACg-.	_____	_____	_____	/	_____	=	_____
ACh-.	_____	_____	_____	/	_____	=	_____
ACi-.	_____	_____	_____	/	_____	=	_____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	____	____	____	/	____	=	____
ACb-.	____	____	____	/	____	=	____
ACc-.	____	____	____	/	____	=	____
ACd-.	____	____	____	/	____	=	____
ACe-.	____	____	____	/	____	=	____
ACf-.	____	____	____	/	____	=	____
ACg-.	____	____	____	/	____	=	____
ACh-.	____	____	____	/	____	=	____
ACi-.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	____	____	____	/	____	=	____
ACb-.	____	____	____	/	____	=	____
ACc-.	____	____	____	/	____	=	____
ACd-.	____	____	____	/	____	=	____
ACe-.	____	____	____	/	____	=	____
ACf-.	____	____	____	/	____	=	____
ACg-.	____	____	____	/	____	=	____
ACh-.	____	____	____	/	____	=	____
ACi-.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	____	____	____	/	____	=	____
ACb-.	____	____	____	/	____	=	____
ACc-.	____	____	____	/	____	=	____
ACd-.	____	____	____	/	____	=	____
ACe-.	____	____	____	/	____	=	____
ACf-.	____	____	____	/	____	=	____
ACg-.	____	____	____	/	____	=	____
ACh-.	____	____	____	/	____	=	____
ACi-.	____	____	____	/	____	=	____

CHAPTER 20, WORKSHEET 1.2b

Calculating carrying capacity for female white-tailed deer in relation to the vertical distribution of forage

The amount of forage (WFKH) varies with height above the ground, and can be calculated using the equation on Page 17 of this UNIT. Formats are given below and on the next page for tabulating five sets of calculations of carrying capacity for female white-tailed deer based on the vertical distribution of forage. Refer back to Page 18 for a review of the calculations of dry-weight forage in kg (DWFK) required to meet the cost of ecological metabolism per day.

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.	____	____	____	/	____	=	____
ACbb.	____	____	____	/	____	=	____
ACcc.	____	____	____	/	____	=	____
ACdd.	____	____	____	/	____	=	____
ACee.	____	____	____	/	____	=	____
ACff.	____	____	____	/	____	=	____
ACgg.	____	____	____	/	____	=	____
AChh.	____	____	____	/	____	=	____
ACii.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.	____	____	____	/	____	=	____
ACbb.	____	____	____	/	____	=	____
ACcc.	____	____	____	/	____	=	____
ACdd.	____	____	____	/	____	=	____
ACee.	____	____	____	/	____	=	____
ACff.	____	____	____	/	____	=	____
ACgg.	____	____	____	/	____	=	____
AChh.	____	____	____	/	____	=	____
ACii.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.				/		=	
ACbb.				/		=	
ACcc.				/		=	
ACdd.				/		=	
ACee.				/		=	
ACff.				/		=	
ACgg.				/		=	
AChh.				/		=	
ACii.				/		=	

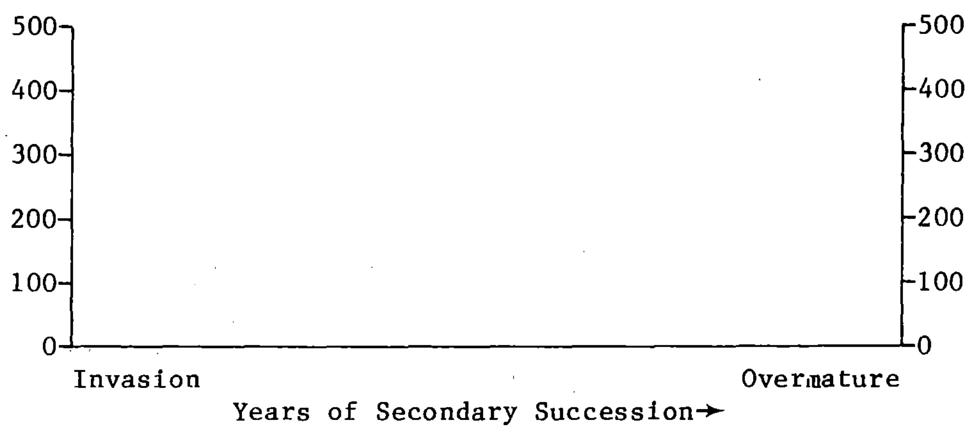
CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.				/		=	
ACbb.				/		=	
ACcc.				/		=	
ACdd.				/		=	
ACee.				/		=	
ACff.				/		=	
ACgg.				/		=	
AChh.				/		=	
ACii.				/		=	

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.				/		=	
ACbb.				/		=	
ACcc.				/		=	
ACdd.				/		=	
ACee.				/		=	
ACff.				/		=	
ACgg.				/		=	
AChh.				/		=	
ACii.				/		=	

UNIT 1.3: CARRYING CAPACITY CHANGES IN RELATION TO STAGES IN SUCCESSION

Forage production is, in part, a function of canopy characteristics. Canopy characteristics in forested areas change from no overhead canopy to a very dense overhead canopy as secondary succession proceeds from the early invasion stage to the mature forest. As the forest becomes overmature, the canopy opens up again and forage production increases in response to added light penetration.

As a review, draw the pattern of forage production expected over a period of secondary succession from the invasion stage to the overmature stage.



Compare your pattern above with that discussed in CHAPTER 13, UNIT 1.4.

Now select suitable average values for the weight and ecological metabolism of a population (MBLM = 2.5 is a suitable annual average to use for determining ELMD to demonstrate this pattern), and an average digestibility coefficient, and calculate the carrying capacity at one or several year intervals through the forage production pattern drawn above. How does your pattern compare to that of Wallmo and Schoen (1980), or to the results of calculations made in earlier CHAPTERS?

Calculations for populations in given areas may be made on the WORKSHEET at the end of this UNIT. It is my recomendation that management decisions concerning the hunting of wild ruminants should always be accompanied by evaluations of carrying capacity, thereby evaluating not only the potential changes in the animal population but also the potential effects of those changes on forage and range conditions.

LITERATURE CITED

Wallmo, O. C. and J. W. Schoen. 1980. Response of deer to secondary forest succession in Southeast Alaska. Forest Sci. 26(3):448-462.

REFERENCES, UNIT 1.3

CARRYING CAPACITY CHANGES IN RELATION TO STAGES IN SUCCESSION

SERIALS

CODEN	VO-NU	BEPA	ENPA	FRGE*	KEY WORDS-----------------	AUTHORS----------	YEAR
CNSVA	29--1	39	48	frge	return of the deer	severinghaus,cw	1974
FOSCA	26--3	448	462	frge	resp deer sec succ, alaska	wallmo,oc; schoen	1980

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
CNRDA	28--5	249	271	brws	alal, successn, quan, nutr	cowan,im; hoar,w/	1950
JFUSA	48-10	675	678	brws	deer in reln plnt successn	leopold,as	1950
JFUSA	56--6	416	421	brws	od brws prod fr felled tre	stoeckeler,jh; k/	1958
NAWTA	15---	571	578	brws	deer in reln plnt successn	leopold,as	1950

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	41--1	34	49	gras	orgnc produc, old fld succ	odum,ep	1960

CODEN	VO-NU	BEPA	ENPA	FRGE	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	85--3	231	234		chngs carr capac deer rnge	telfer,es	1971
ECMOA	24--4	349	376		ecol successi abandon farm	beckwith,sl	1954
FRCRA	29--3	218	232		survey, conif fores, rocki	cormack,rgh	1953
WMBAA	18---	1	111		effs wldfre rata wint rnge	scotter,gw	1964

FRGE = forage type

frge = mixed or unspecified forage type
brws = browse
gras = grass

*FRGE = forage type

CHAPTER 20, WORKSHEET 1.3a

Carrying capacity changes in relation to stages in succession

The format for calculating carrying capacity in relation to stages in succession is very similar to that for vertical distribution of forage shown in WORKSHEETS 1.2a and 1.2b. The only change is in the source of information on WFKH. In this UNIT, the successional pattern you illustrated on Page 23 is the source of WFKH. Complete calculations of the CLWK →ELMD → DWFK sequence as discussed in CHAPTER 12 and earlier in this CHAPTER, tabulate the results below, and calculate the number of animal days supported by the forage (NADF).

Review the flowsheet on Page 7 when you complete this WORKSHEET. Note that if a time period is designated, then the the number of animals supported by the forage (NASF) may be determined.

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACa-.	____	____	____	/	____	=	____
ACb-.	____	____	____	/	____	=	____
ACc-.	____	____	____	/	____	=	____
ACd-.	____	____	____	/	____	=	____
ACe-.	____	____	____	/	____	=	____
ACf-.	____	____	____	/	____	=	____
ACg-.	____	____	____	/	____	=	____
ACh-.	____	____	____	/	____	=	____
ACi-.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH	/	DWFK	=	NADF
ACaa.	____	____	____	/	____	=	____
ACbb.	____	____	____	/	____	=	____
ACcc.	____	____	____	/	____	=	____
ACdd.	____	____	____	/	____	=	____
ACee.	____	____	____	/	____	=	____
ACff.	____	____	____	/	____	=	____
ACgg.	____	____	____	/	____	=	____
AChh.	____	____	____	/	____	=	____
ACii.	____	____	____	/	____	=	____

CLASS	CLWK	HFRC	WFKH /	DWFK	=	NADF
ACa-.	____	____	____ /	____	=	____
ACb-.	____	____	____ /	____	=	____
ACc-.	____	____	____ /	____	=	____
ACd-.	____	____	____ /	____	=	____
ACe-.	____	____	____ /	____	=	____
ACf-.	____	____	____ /	____	=	____
ACg-.	____	____	____ /	____	=	____
ACh-.	____	____	____ /	____	=	____
ACi-.	____	____	____ /	____	=	____

CLASS	CLWK	HFRC	WFKH /	DWFK	=	NADF
ACaa.	____	____	____ /	____	=	____
ACbb.	____	____	____ /	____	=	____
ACcc.	____	____	____ /	____	=	____
ACdd.	____	____	____ /	____	=	____
ACee.	____	____	____ /	____	=	____
ACff.	____	____	____ /	____	=	____
ACgg.	____	____	____ /	____	=	____
AChh.	____	____	____ /	____	=	____
ACii.	____	____	____ /	____	=	____

* * * * *

CLASS	CLWK	HFRC	WFKH /	DWFK	=	NADF
ACa-.	____	____	____ /	____	=	____
ACb-.	____	____	____ /	____	=	____
ACc-.	____	____	____ /	____	=	____
ACd-.	____	____	____ /	____	=	____
ACe-.	____	____	____ /	____	=	____
ACf-.	____	____	____ /	____	=	____
ACg-.	____	____	____ /	____	=	____
ACh-.	____	____	____ /	____	=	____
ACi-.	____	____	____ /	____	=	____

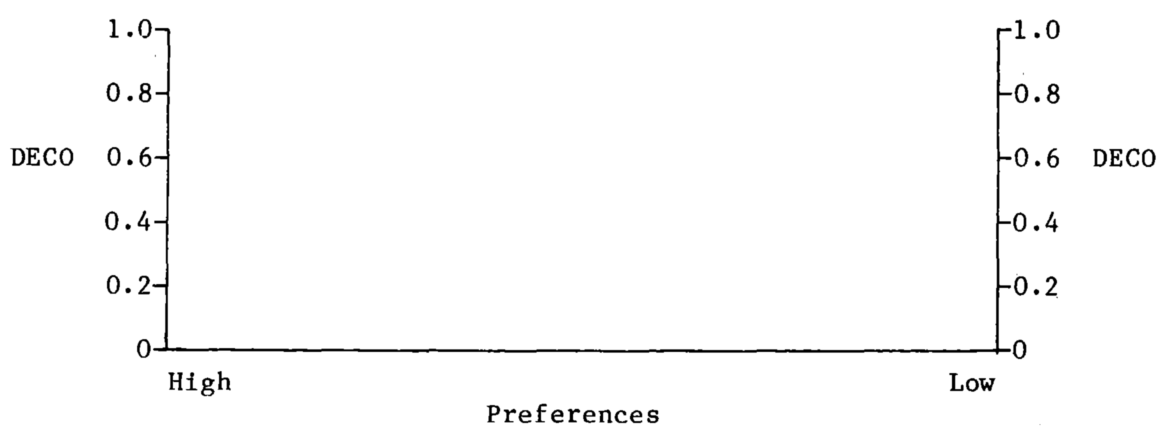
CLASS	CLWK	HFRC	WFKH /	DWFK	=	NADF
ACaa.	____	____	____ /	____	=	____
ACbb.	____	____	____ /	____	=	____
ACcc.	____	____	____ /	____	=	____
ACdd.	____	____	____ /	____	=	____
ACee.	____	____	____ /	____	=	____
ACff.	____	____	____ /	____	=	____
ACgg.	____	____	____ /	____	=	____
AChh.	____	____	____ /	____	=	____
ACii.	____	____	____ /	____	=	____

UNIT 1.4: CARRYING CAPACITY CHANGES IN RELATION TO BIOLOGICAL FACTORS AFFECTING FORAGE AVAILABILITY AND USE

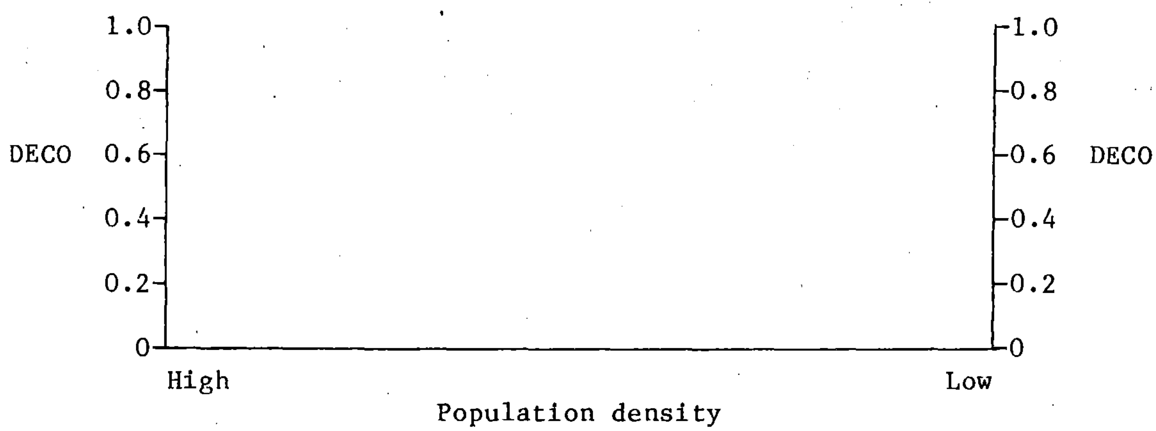
Carrying capacity changes occur in relation to biological factors affecting forage availability, since wild ruminants compete with others of their own species and with other species. The competition for forages eaten by two different species living on the same range means that a common resource that must be divided. Sometimes that common resource is shared by two species of wild ruminants (white-tailed deer and moose, for example), sometimes by a wild and domestic ruminant (mule deer and cattle, for example) and sometimes by a wild or domestic ruminant and a species in a different ORDER, such as rodents.

Competition between species is minimized by differences in food habits and preferences. Thus several species can coexist on ranges that are in good condition with a wide variety of vegetation. As the range condition deteriorates and less forage is produced and fewer forage species are present, competition increases.

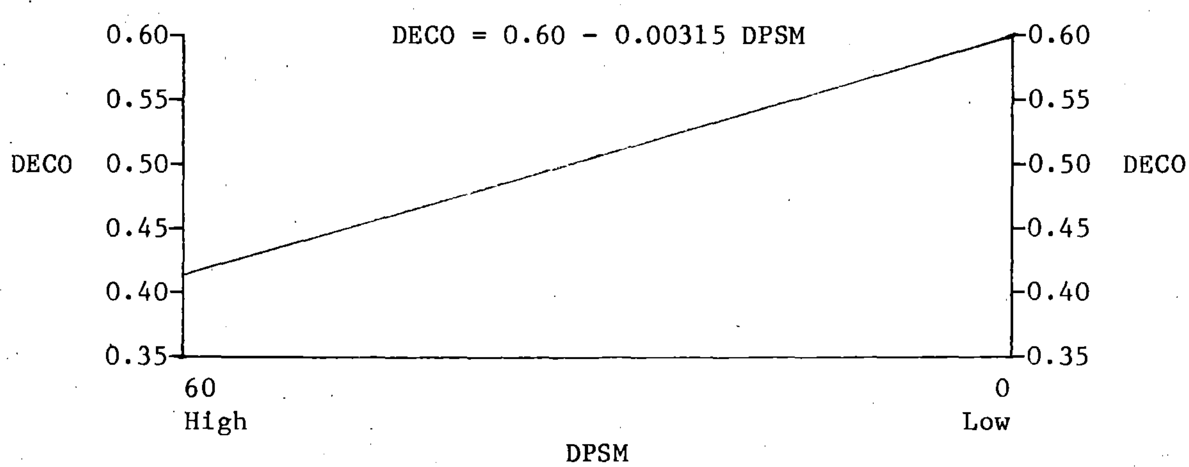
The effects of competition may be illustated with a single species that overpopulates the range. As their numbers increase, the most preferred foods are depleted and only less prefered foods are available for consumption. The relationship between preference and digestibility that was discussed in CHAPTER 12, UNIT 1.2. As a review, draw the relationship between forage preferences and digestibilities below.



If preferences are forced downward as a result of competition due to overpopulation, then the illustration on the previous page may be repeated with a new label on the x-axis.



What is the relationship between population densities and forage preferences left on the range? Discussions at Cornell's Wildlife Ecology Laboratory have resulted in the expression of digestibility coefficients in relation to deer per square mile. The concept has been expressed mathematically, using a linear regression equation to calculate DECO as a function of DPSM. The relationship is illustrated below.



The equation itself has not been calculated from discrete data sets, but rather from the 60 years of experience and reasonable judgement which I and C. W. Severinghaus, retired from the New York State Department of Environmental Conservation, claim to possess. We are convinced the slope of the line is in the right direction. Persons wishing to change the measured value of b should feel perfectly free to do so, in accordance with their reasonable judgement concerning their own local areas. Note that the line must go through the highest reasonable value for DECO (never 1.0) at a population density that has essentially no impact on the availability of any of the forage species on the range.

Derive new expressions for the concept if you wish, incorporating results published in the literature listed at the end of this UNIT and also in CHAPTER 12. Such exercises are not only mentally stimulating, but they are fun as thoughts are converted to words and words to equations.

REFERENCES, UNIT 1.4

CARRYING CAPACITY CHANGES IN RELATION TO BIOLOGICAL FACTORS AFFECTING FORAGE AVAILABILITY AND USE

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFNA	85...	231	234	od--	chan in car cap, w nova sc	telfer,es	1971
JRMGA	11--1	18	21	od--	livest, tech study competn	julander,o	1958
JWMAA	11--2	162	177	od--	survey over-pop ranges, us	leopold,a; sowls/	1947
JWMAA	17--2	101	112	od--	sheep competition in utah	smith,jg; julande	1953
NAWTA	9----	144	149	od--	carry capac mich dee yards	davenport,la; sh/	1944
NAWTA	18---	581	596	od--	yard carry capac, browsing	davenport,la; sw/	1953
PCGFA	14...	98	104	od--	deter rel range carry capa	moore,wh; rysley/	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	12--4	750	752	odvi	carryng capac, penn wdlnds	forbes,eb; overho	1931
FOSCA	1....	130	139	odvi	od, doca range relat, utah	julander,o	1955
JRMGA	18--1	1	17	odvi	de, livestock control graz	mcmahan,ca; ramse	1965
JRMGA	30--2	138	142	odvi	pop reac, aerial herbicide	beasom,sl; scifre	1977
JWMAA	10--1	60	63	odvi	summ brow, cut-ov hardw la	cook,db	1946
JWMAA	39--2	321	329	odvi	nutri, south, diff seasons	short,hl	1975
NAWTA	30---	321	335	odvi	feed coact bet hares and d	bookhout,ta	1965
NFGJA	21--1	47	57	odvi	carry capac deer range, ny	jackson,lw	1974
NYCOA	5---3	6	8	odvi	what's happen to deer rang	darrow,rw	1950
NYCOA	10--6	2	4	odvi	too many deer?	cheatum,el	1956

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ECMOA	47--3	255	278	odhe	odvi, ecological relations	anthony,rg; smith	1977
NAWTA	4----	560	569	odhe	ceel relationships, oregon	cliff,ep	1939
NAWTA	29---	404	414	odhe	ceel, doca, sum rang, utah	julander,o; jeffe	1964
UASPA	43--2	22	28	odhe	use of mtn rangeland, utah	julander,o	1966
WUICA	21...	1	53	odhe	mod for ecosys, par 7, res	garcia,jc; schre/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	9---1	11	14	ceek	elk, livestock competition	morris,ms	1956
JWMAA	7---3	328	332	ceel	comp, dom livest, summ for	pickford,gd; reid	1943
JWMAA	17--2	162	166	ceel	assoc w/alal on feed groun	mcmillan,jf	1953
JWMAA	30--2	349	363	ceel	range relat, livest, monta	stevens,dr	1966
MAMLA	40--3	355	376	ceel	caca, food selection, carr	goffin,ra; decrom	1976
NAWTA	4----	560	569	ceel	odhe, rel bet, oregon moun	cliff,ep	1939
NCANA	101-1	505	516	ceel	alal, rnge relns, rcky mts	stevens,dr	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	24--1	52	60	alal	snows hare, foo & rng comp	dodds,dg	1960
JWMAA	31--3	418	425	alal	odvi, compr win rng nov sc	telfer,es	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	40--1	151	162	rata	obmo, summ rnge relns, nwt	wilkinson,pf; sh/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	32--5	365	368	anam	livest, foods, dese steppe	johnson,mk	1979
NAWTA	15---	627	644	anam	rang ecol, wichita mt, kan	buechner,hk	1950
UTSCB	29--1	3	6	anam	season forage use, wes uta	beale,da; scotter	1968

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	13--4	417	419	ovca	od food relation, so n mex	halloran,af; kenn	1949

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRMGA	25--5	346	352	dosh	biga, guidlines, graz, ran	jensen,ch; smith/	1972

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JAECA	29--2	375	384	many	interspec relations, scotl	batcheler,cl	1960
JRMGA	28--1	43	47	many	diet overlap, southern col	hansen,rm; reid,l	1975
JWMAA	3---4	295	306	many	yellowst wint rang studies	grimm,rl	1939
JWMAA	41--1	76	80	many	foods of ungulates, colora	hansen,rm; clark,	1977
NCANA	103..	153	167	many	resour div, comm larg herb	hudson,rj	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AUKJA	81--3	436	436	ungu	birds associating with ung	benson,cw	1964
ECOLA	16--3	531	533		range capacity determinatn	stoddart,la	1935
FAFLB	13---	19	23	game	game on farms	kettlitz,wk	1962
NAWTA	6----	348	353	wldl	remov surplus from refuges	dumont,pa; krumme	1941
NAWTA	10---	251	256	biga	b ga-liv compet, west rang	stoddart,la; rasm	1945
NOSCA	51--2	101	110	wiru	hab util, resour partition	hudson,rj	1977
NWGRA	36--8	12	13	biga	livestock, national forest	haskell,es	1946
VILTA	9---3	45	192	wiru	wint habita, lnd use, scan	ahlen,i	1975

UNIT 1.5: CARRYING CAPACITY CHANGES IN RELATION TO PHYSICAL FACTORS AFFECTING FORAGE AVAILABILITY AND USE

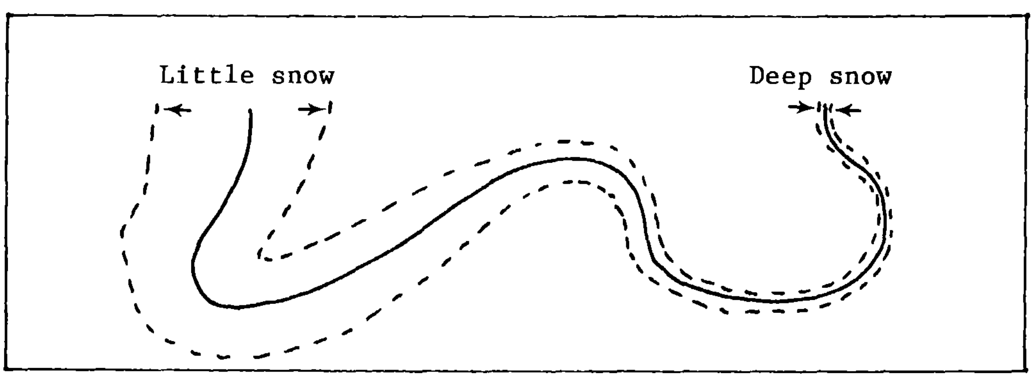
Physical factors such as topography and accumulated snow affect energy expenditures. Energy expenditures for vertical ascent are greater than for movement on horizontal surfaces (see CHAPTER 7, UNIT 4.3). Some wild ruminants live on mountainous topography and others live on rather flat land. Sometimes there are seasonal differences in topographies used. The tendency for deer to seek out the more level bottom-lands in the winter in some areas can be interpreted as an energy conservation response (Moen 1976). How is this change in topography reflected in energy savings, and how important are other factors in this apparent choice?

Questions such as the one above can be evaluated by determining a range of energy costs associated with different movement patterns on variable topographies and relating that pattern to forage consumption patterns. Recalculate ELMD to consider extremes in topography. Evaluate the likelihood of animals living at reasonable rates of ecological metabolism if they must traverse steep hillsides each day.

Recalculate ELMD in relation to increased snow depths too. Moving through snow is very costly (see CHAPTER 17) and there is a limit to the amounts of energy that can be expended for this activity. When does the cost of movement begin to exceed the returns from forage reached?

Even if ELMD is not increased as result of accumulating snow, the amounts of forage available in different stands goes down as snow covers up some of the forage. The amounts of forage covered by snow depends on the vertical distribution of forage and snow depths. Refer to the equation discussed earlier in UNIT 1.2, which was taken from CHAPTER 13, UNIT 1.3, and subtract the amounts of forage covered by 10, 20, 30. . . 100 cm of snow from the total amount of forage available to the height reached.

All of the factors mentioned above have been discussed in previous CHAPTERS. One very important physical factor to be illustrated next is the range areas used in different seasons. Wild ruminant ranges are often much smaller in the winter than during the rest of the year. The smaller area used by the population is reduced even further by snow accumulations that cause or at least encourage animals to stay on trails. These reductions are illustrated below.



The width of the activity corridor on either side of the trails is dependent on snow depths. As snow depths increase, the width of the activity corridor decreases. The overall area of winter range may be only a fraction of the summer range, and only a fraction of the range resources may be accessible.

The area of the winter range and the resources available to the animals over the area of the winter range is one of the most dynamic and variable factors in the calculation of carrying capacity. It varies relatively more than the sums associated with forage estimates, more than digestibility coefficients, even if they are estimated, and more than even careful estimates of the total population.

The area used and forage resources available to a population over time may be calculated with a weighted-mean procedure. Multiply the fraction of the days of a time period--winter, for example--by the area of the range that is accessible. The answer is the weighted time-area fraction, which is multiplied by the weight of the forage available to get the weighted-mean forage weight. The sample calculation below illustrates the procedure.

For a 220-day winter period:

Number of days	Fraction of the range
70	1.00
42	0.10
75	0.03
33	0.10
220	

The calculations, where NDFR = number of days on fractions of the range, LWPD = length of the winter period in days, FRTP = fraction of the time period, FRRA = fraction of the range, WFOK = weight of forage in kg, and WMFK = weighted-mean weight of forage in kg on the range, are:

NDFR/LWPD = FRTP x FRRA x WFOK

70/220 = 0.32 x 1.00 = ____ = ____
42/220 = 0.19 x 0.10 = ____ = ____
75/220 = 0.34 x 0.03 = ____ = ____
33/220 = 0.15 x 0.10 = ____ = ____

SUMS = 1.00 ____ = WMFK

Multiply the SUM by the weight of forage in kg to determine the forage within the area used over time. The result may be divided by the weighted-mean forage consumption per animal per day to get the carrying capacity in relation to area used over time.

Considerable attention should be given to the distribution, density, and areas used by ruminant populations throughout the year. Then, carrying capacity calculations may be made for the actual ranges and resource bases used.

REFERENCES, UNIT 1.5

CARRYING CAPACITY CHANGES IN RELATION TO
PHYSICAL FACTORS AFFECTING FORAGE AVAILABILITY AND USE

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	1----	410	415	od--	forest-car cap, food probs	clepper,he	1936

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ECOLA	57--1	192	198	odvi	energy conservatio, winter	moen,an	1976
JWMAA	39--3	563	569	odvi	effect snowmobiles on deer	dorrance,mj; sav/	1975
NFGJA	16--2	129	135	odvi	est area, deer habitat, ny	severinghaus,cw;/	1969
XATBA	840--	1	60	odvi	meth, herd cond, avail for	park,bc; day,bb	1943

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CNJNA	56--3	531	542	odhe	foo hab fll, win, spri, bc	willms,w; mclean/	1976
NAWTA	29---	404	414	odhe	ceel, doca, sum rang, utah	julander,o; jeffe	1964
NEXAA	567--	1	32	odhe	ft stanton hrd, ecol, n mx	wood,je; bickle,/	1970
UASPA	43--2	22	28	odhe	use of mtn rangeland, utah	julander,o	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBCPA	61---	43	48	ceel	oxy util dur locom by calv	cohen,y; robbins/	1977
NAWTA	29---	438	444	ceel	od, pinyon-jun wood, n mex	reynolds,hg	1964

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				alal			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	56--2	215	223	rata	energy expend, walk, tundr	white,rg; yousef,	1978
OIKSA	25--3	379	387	rata	relatv abund food in wintr	bergerud,at	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				anam			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				bibi			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovca			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				ovda			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				obmo			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
				oram			

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AMSCA	62--2	172	181	many	endangered spec: mod, pred	miller,rs; botkin	1974
JFUSA	45-10	749	754		dist.fr watr, grazng capac	valentine,ka	1947
NAWTA	10---	251	256	biga	b ga-liv compet, west rang	stoddart,la; rasm	1945
OIKSA	33...	182	189	....	imp landsc hetero, breedin	hansson,l	1979
VILTA	9---3	45	192	wiru	wint habita, lnd use, scan	ahlen,i	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
ATRLA	22--1	3	24	caca	energy metabolism, roe dee	weiner,j	1977

CHAPTER 20, WORKSHEET 1.5a

Area-time calculations of forage available

The format on Page 32 may be used to calculate the weighted-mean forage available, depending on conditions which affect the amount of area used over time. Complete calculations of weighted-mean forage available, using data for locations of your choice. It would be interesting to evaluate the effect of changes in use over time of areas in different stages of successon.

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

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____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

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____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

Location: ____________________

NDFR/LWPD = FRTP x FRRA x WFOK

____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____
____/____ = ____ x ____ = ____ = ____

SUMS = 1.00 ____ = WMFK

UNIT 1.6: CARRYING CAPACITY CHANGES IN RELATION TO FORAGE CONSUMPTION BASED ON PROTEIN REQUIREMENTS

Carrying capacity calculations based on protein requirements are made with exactly the same format as the energy calculations, except that the total protein requirement replaces ELMD, and the metabolizable protein in the forage replaces the metabolizable energy in the forage. Thus the formula for calculating dry-weight forage in kg (DWFK) required to meet daily protein needs is:

DWFK = Protein required per day/metabolizable protein in the forage

The basic calculation was discussed in CHAPTER 12, UNIT 4.4. Estimations of protein requirements may be made from material in CHAPTER 8 and protein in the forage may be estimated from literature listed in CHAPTER 11. Calculations of forage consumption are discussed in CHAPTER 12.

Once these calculations have been completed, the analysis of carrying capacity is completed by dividing the forage resources available by the forage resources required to determine the number of animal-days supported by the forage (NADF).

REFERENCES, UNIT 1.6

CARRYING CAPACITY CHANGES IN RELATION TO FORAGE CONSUMPTION BASED ON PROTEIN REQUIREMENTS

SERIALS

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odvi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ceel

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

anam

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

bibi

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovca

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

ovda

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

obmo

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

oram