TOPIC 4. CALCULATIONS OF FORAGE REQUIRED, PROTEIN BASE

The partitioning of nutrients from gross to the metabolizable level illustrated in the first part of CHAPTER 11 makes the final expression of nutrients available compatible with the expression of metabolic requirements. It is necessary, of course, to use the same units of measurement for expressing nutrients in both the numerator and the denominator of this relationship.

Protein-base calculations of daily forage consumption may be made in the same way as the energy-base calculations, except that protein is substituted for energy. The word formula is:

forage intake in kg per day = [(protein metabolism in g per day)/
(metabolically useful protein in the forage in g per day)]

This word formula for predicting intake is for an animal in a neutral nitrogen balance, with all of the protein required being met by ingested forage. This is not always the case as some of the protein required is met by urea recycled. This makes the denominator more complicated as the amount of urea recycled is a function of the protein content of the forage.

Seasonal variations in the two components of this basic relationship--protein metabolism and protein in the forage--occur. Absolute levels of protein metabolism vary in relation to ages, weights and reproductive rates.

The breakdown of forage materials into nitrogenous compounds that can be used by an organism is not a perfectly efficient process, so the ratios of digestible protein to crude protein and metabolizable protein to digestible protein are less than 1.0. These fractions represent the portion of the food ingested that is useful to the animal at each level of breakdown; the coefficients may be designated as the digestible protein coefficient (DPCO) and metabolizable protein coefficient (MPCO).

Expanded formulas for calculating forage consumption on a protein base, using four-letter symbols, are

$$DWFK = NTMD/[(CPFO)(0.16)](DPCO)(MPCO)$$

where DWFK = Dry-weight forage consumed in kg,
NTMD = Nitrogen metabolism per day,
CPFO = Crude protein energy in the forage,
0.16 = The nitrogen fraction of the protein,
DPCO = Digestible protein coefficient, and
MPCO = Metabolizable protein coefficient.

Calculations of daily consumption based on protein balances are illustrated in the next four UNITS. Seasonal variations in dietary protein and in protein metabolism are discussed in UNITS 4.1 and 4.2. Then, the role of seasonal variations in protein reserves are discussed in UNIT 3.3, and finally, the use of a nomogram to rapidly estimate intake is illustrated in UNIT 3.4.

There is less information available on protein metabolism and forage characteristics than on energy. The factors discussed in these units need to be evaluated further and equations derived for analyses in the total total animal-range relationship. Comparisons of predicted intakes based on energy and protein are of particular interest.

LITERATURE CITED

National Research Council. 1975. Nutrient requirements of sheep. National Acad. of Sciences. Washington, D. C. 72 pp.

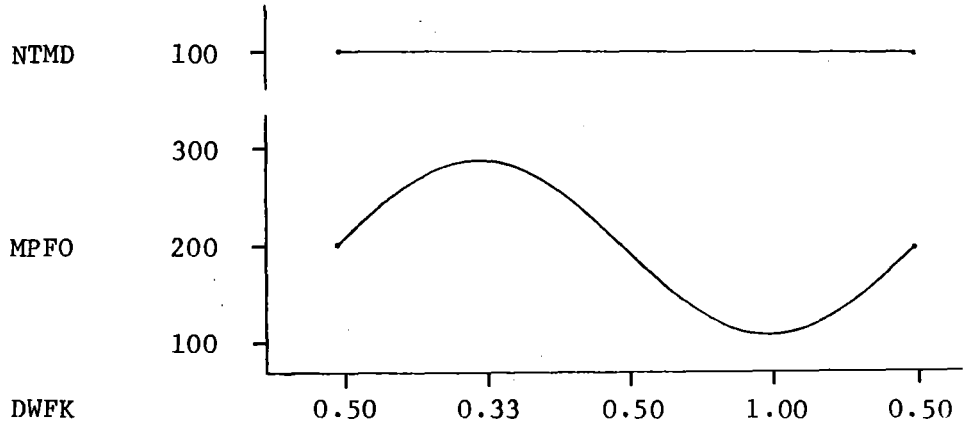
Robbins, C. T. 1973. The biological basis for the calculation of carrying capacity. Ph.D. Thesis. Cornell Univ., Ithaca, NY. 239 pp.

UNIT 4.1: EFFECTS OF VARIATIONS IN DIETARY PROTEIN

The amount of dietary protein is dependent on the phenology of the forage, current growing conditions, and the plant parts selected of the consumers. Dietary protein usually changes slowly, with a general pattern of winter minimums as animals ingest dormant forage and summer maximums as new growth is ingested. Dietary protein may change rapidly if foraging conditions change due to an early winter snowfall that covers higher-protein herbaceous forage and fruits, leaving only lower-protein woody browse exposed. Snow also makes movement to fields and other higher-protein agricultural food sources more difficult for those wild ruminants living in farm areas. Free-ranging animals consuming low-protein woody browse in late winter may shift to high-protein spring growth rather quickly if snow conditions permit rapid dispersal from winter concentration areas to areas with emerging spring growth.

The effects of variations in dietary protein are illustrated with the simplified relationship below. MPFO = metabolizable protein in the forage, NTMD = nitrogen metabolism per day, and DWFK = dry weight forage in kg. The formula is:

DWFK = NTMD/MPFO



The format for calculating the effects of changes in dietary protein on forage intake is illustrated on WORKSHEETS that follow.

REFERENCES, UNIT 4.1

EFFECTS OF VARIATIONS IN DIETARY PROTEIN

SERIALS

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

JWMAA 42--4 776 790 odvi diet prot, energ effc fawn seal,us; verme,1/ 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

JWMAA 37--3 279 287 alal importnc of nonbrowse food leresche,re; davi 1973

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

CJZOA 48--5 905 913 rata seas chang, ener, nit intk mcewan,eh; whiteh 1970

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

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

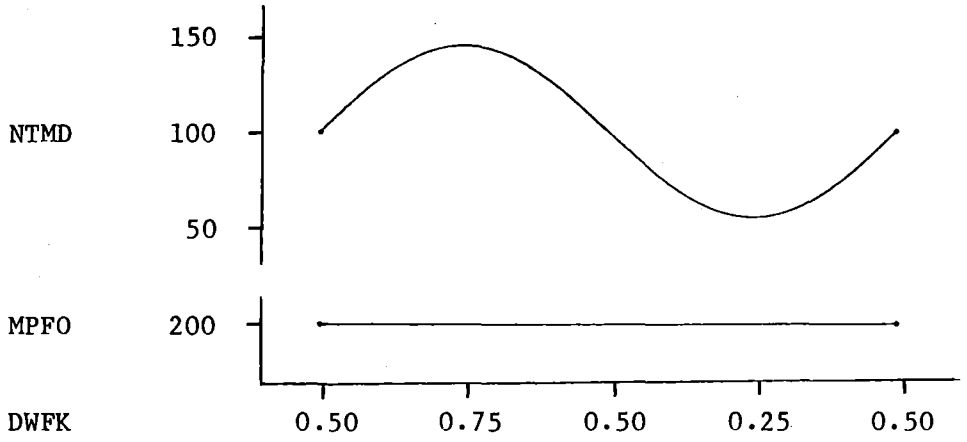
oram

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

CJZOA 48--6 1437 1442 many rumen nitrog level, variat klein,kr; schonhe 1970

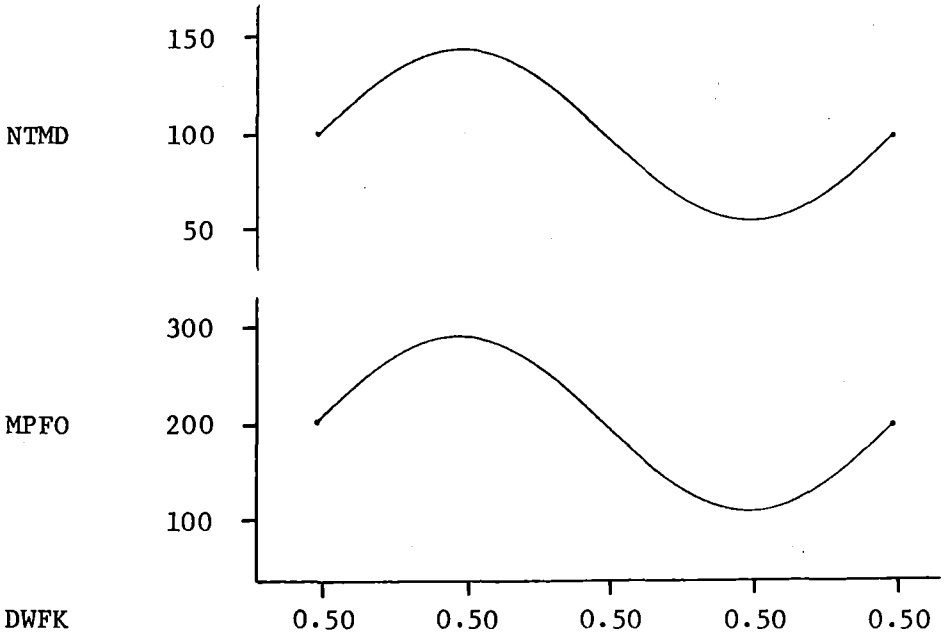
UNIT 4.2: EFFECTS OF VARIATIONS IN PROTEIN REQUIREMENTS

Seasonal variations in protein metabolism, discussed in CHAPTER 7, UNIT 6.1, may now be used to demonstrate their effects on forage consumption. The effects are illustrated with the simplified relationship below.

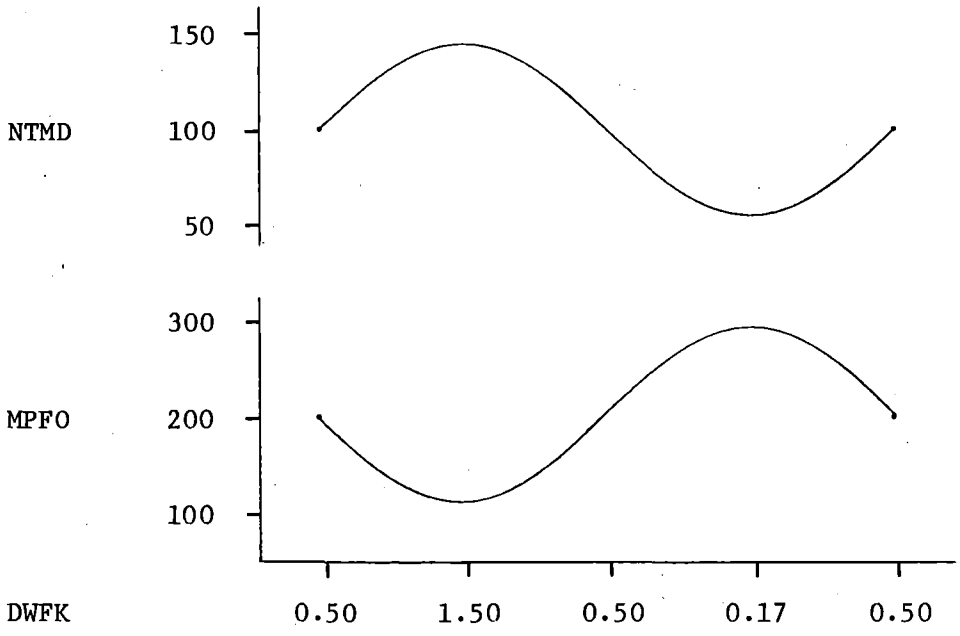


SEASONAL VARIATIONS

Seasonal variations in NTMD and in MPFO combine to cause variations in forage consumption. Suppose the simplified relationship above is combined with that illustrated in UNIT 4.1. Note how DWFK does not vary in this example if nitrogen metabolism and the metabolic protein in the forage are synchronized.



If NTMD and MPFO are not synchronized, then marked changes in DWFK occur when NTMD is high/low and MPFO is low/high.



These simplified illustrations help one understand the importance of timing and synchrony in seasonal variations of both protein regiment and protein quality of the forage on the range. The effects of changes in these two variables may be quantified with species-specific values in WORKSHEETS that follow.

REFERENCES, UNIT 4.2

EFFECTS OF VARIATIONS IN PROTEIN REQUIREMENTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
JWMAA	20--3	221	232	odvi	nutr req, growth, antl dev	french,ce; mcewe/	1955
JWMAA	31--4	679	685	odvi	protein requirement, fawns	ullrey,de; youat/	1967
JWMAA	33--3	482	490	odvi	dig energy req does, wintr	ullrey,de; youat/	1969
JWMAA	35--1	57	62	odvi	basal diet for nutr resear	ullrey,de; johns/	1971
NAWTA	22---	119	132	odvi	nutrient requirements	mcewen,lc; frenc/	1957
NAWTA	34---	137	146	odvi	eff nutr, clim on sou deer	short,hl; newsom/	1969
PAABA	600--	1	50	odvi	nutr req for grwth, antler	french,ce; mcewe/	1955
TNWSD	1965.	1	13	odvi	n hamp nutr studies, aims,	silver,h; colovo/	1965

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
SZSLA	21---	117	128	rata	aspcts of nutr, semi-domes	steen,e	1968

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

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

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UNIT 4.3: EFFECTS OF SEASONAL VARIATIONS IN UREA RECYCLING

Seasonal changes in the amount of urea recycled by wild ruminants are reflections of changes in the crude protein content of the forage, which is in turn a reflection of range phenology. Increases in the cost of living--ecological metabolism--are observed in late summer and early fall as fat reserves accumulate. As ecological metabolism decreases in the winter, the fat reserve is a source of energy that ameliorates the need for ingestion of all of the energy needed. The formula for determining forage consumption when energy reserves are mobilized to supplement the ingested forage as a source of energy is:

forage intake in kg per day = [(nitrogen metabolism in grams per day - urea recycled in grams per day/(metabolically useful protein in the forage in grams]

The contribution of recycled urea to the nitrogen metabolized and the forage equivalent it replaces can be determined by calculating the urea entry rate with the following formula from Robbins et al. (1974):

urea entry rate(g/hour) = urea pool size/turnover time

Urea pool size in grams per kg body weight may be estimated with the following equation, determined from data in Robbins et al. (1974):

$$UGKW = 0.039 + 0.016\ CPFO$$

where UGKW = urea in grams per kg body weight, and
CPFO = crude protein in the forage

The turnover time in the deer measured by Robbins et al. (1974) averaged 4 hours, so the urea entry rate in grams per hour (UEGH) is determined by:

$$UEGH = UGKW/4$$

The urea entry rate per day is:

$$UEGD = (UGKW)(6)$$

where 6 = 24/4.

The urea recycled, expressed as a percent of entry rate, may be calculated with the following equation, modified from Robbins et al. (1974):

$$UPER = e^{5.3197 - 0.5007\ \ln CPFO}$$

where UPER = urea recycled as a percent of entry rate, and
CPFO = crude protein in the forage.

These equations may be used to calculate the urea pool size, daily entry rate, and the percent of the daily entry rate recycled as urea (the remainder comes from dietary sources). The quantities involved may then be used to calculate the forage required to meet these nitrogen needs.

Recycled nitrogen represented from 31 to 18% of the total dietary nitrogen intake when 12-26% protein diets were fed (Robbins et al. 1974:190) to white-tailed deer. If a single estimate were to be made for deer on natural diets of about 10% protein, I would estimate that recycled nitrogen represents about a third (0.33) of the total dietary nitrogen intake. This may be interpreted to mean that about 3/4 and 1/4 of the daily nitrogen requirements are met by diet and urea recycling, respectively.

Please be cautious about using the above equations and estimates at this time. I am writing the equations and making the estimates on the basis of one paper and some logic. They are not meant to be definitive at this time, and need further verification on both deer and other species.

LITERATURE CTIED

Robbins, C. T., R. L. Prior, A. N. Moen and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Wildl. Manage. 39(4):684-691.

REFERENCES, UNIT 4.3

EFFECTS OF SEASONAL VARIATIONS IN UREA RECYCLING

SERIALS

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
PMASA	19---	72	79	odhe	annua cycl of condtn, mont	tabert,rd; white/	1959

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

BJNUA 33--1 63 72 rata seas, nut eff ser prot, ur hyvarinen,h; hel/ 1975

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

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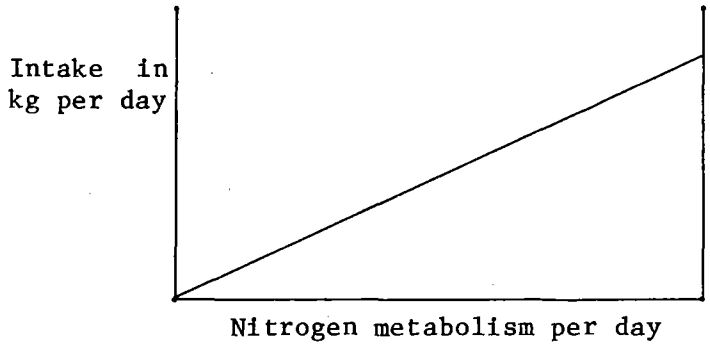
UNIT 4.4: NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, PROTEIN BASE

Forage requirements can be predicted from two biological functions--nitrogen metabolism of the animal and protein in the forage. The variations in each of these through the year make the calculations tedious when done manually. Programmed computing is very useful when available. A quick way to estimate forage required is by the use of a nomogram.

Estimates of forage requirements made with a nomogram are less accurate than those calculated with programmed computing, but they may be quickly made with the nomogram and they are likely to be as accurate as estimates of the number of animals in a population. Further, nomogram estimates are easy to make as seasonal variations in nitrogen metabolism and dietary protein occur.

The nomogram for predicting forage intake on a protein base includes nitrogen metabolism per day on the x-axis and predicted forage requirements on the y-axis. This is illustrated below.



The formulas for calculating the values to be plotted as the DECO lines were given in TOPIC 3 of this CHAPTER (Pages 33-34). In symbol form, the formula for a protein base calculation is:

$$DWFK = NTMD/(MPFO)(0.16)$$

where DWFK = dry-weight forage consumed in kg,
NTMD = nitrogen metabolism per day, and
MPFO = metabolizable protein in the forage.

This simplified nomogram illustrates the concept. A WORKSHEET is set up to facilitate the completion of a nomogram for species-specific values if desired.

REFERENCES, UNIT 4.4

NOMOGRAPHIC PREDICTIONS OF FORAGE REQUIRED, PROTEIN BASE

SERIALS

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

odvi

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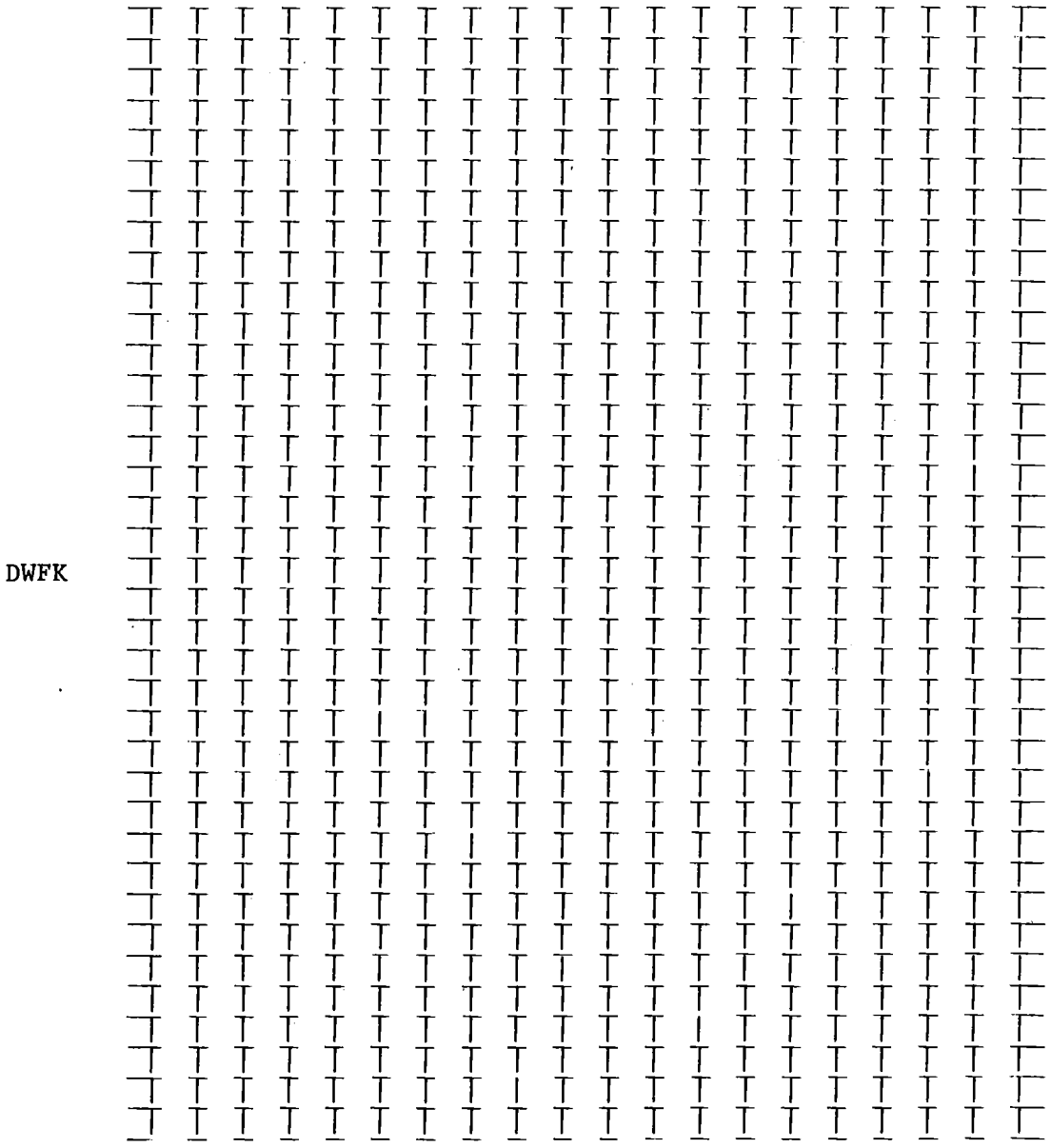
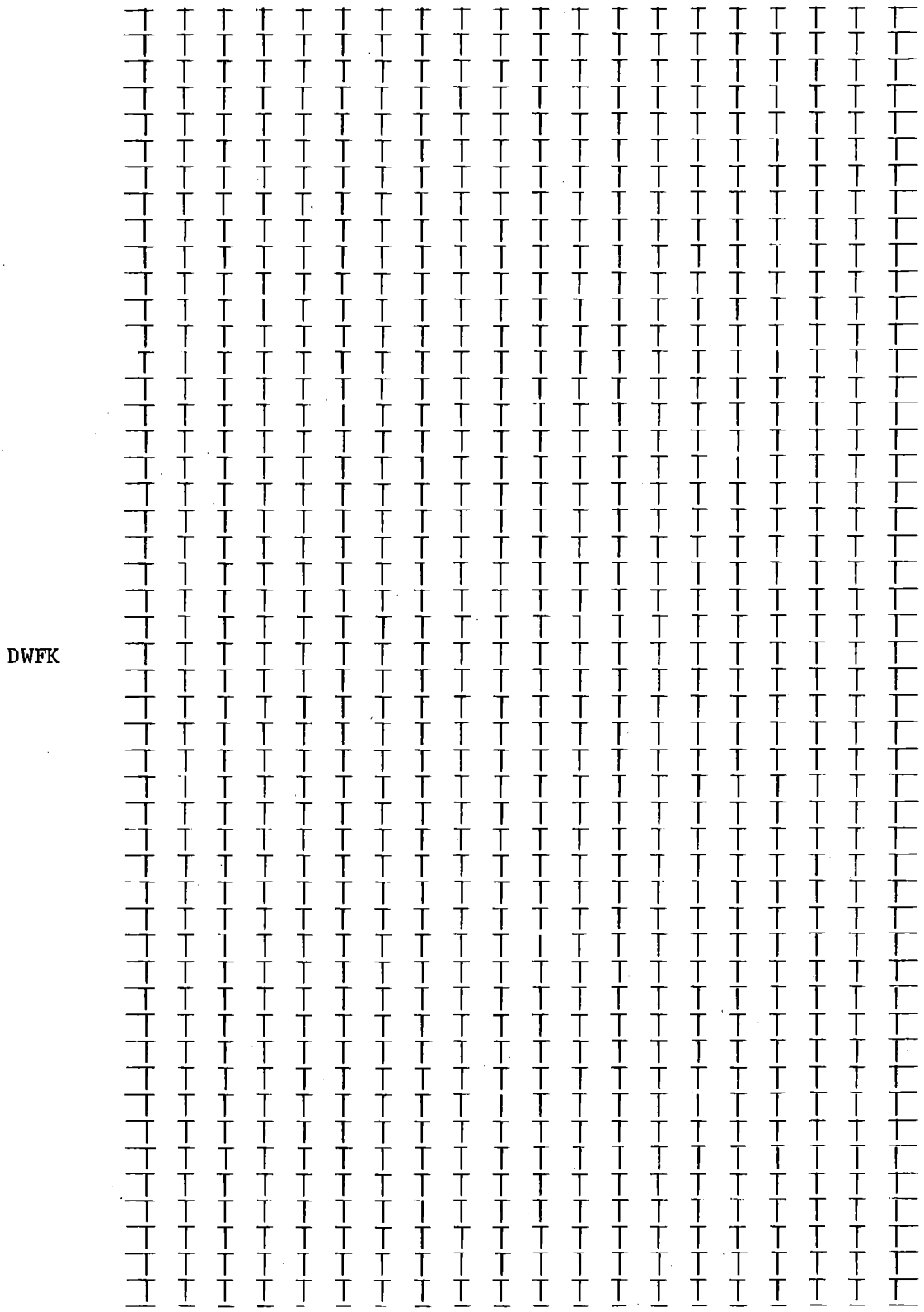
CHAPTER 12, WORKSHEET 4.4a

Nomograms for making predictions of forage required, protein base

The calculations necessary for making a nomogram have been described in this UNIT (page 61) and in the publications cited. Complete a nomogram in the grid below for smaller ruminants, and in the grid on the next page for the larger ruminants. Be sure to use the metabolizable protein in the forage when making the calculations.




DWFK
NTMD