TOPIC 1. POPULATION ESTIMATES

One of the most difficult tasks facing the wildlife biologist is that of making accurate estimates of populations. The problems encountered when trying to count free-ranging and elusive animals, even large ruminants, are many, and populations are very easily underestimated because of the difficulties in seeing each individual in its natural habitat.

Two kinds of estimates--direct and indirect--may be made. Direct estimates involve the counting of individuals observed in their habitat. Indirect estimates involve the observation of evidence of their presence, with interpretations of that evidence used to estimate abundance. The former is called a census, and is intended to indicate absolute numbers. The latter results in an index, and is intended to indicate relative numbers. Direct estimates are discussed in UNITS 1.1 and 1.2, and indirect estimates in UNIT 1.3.

Population dynamics may be interpreted from either direct or indirect estimates. Changes from year to year may be inferred from changes in either absolute or relative numbers. Since there are errors inherent in both kinds of estimates, errors will occur in estimations of change. These errors can be substantial, and were large enough in the analyses of the population dynamics of the Seneca Army Depot herd in New York State to make it necessary to revise the estimates annually rather than at three-year intervals (Moen and Sauer 1977).

Observed population predictions are discussed in UNIT 1.4. This unit includes references in the SERIALS list that describe population estimates determined by direct or indirect means. The large number of references will provide a data base for units in both TOPIC 1 and TOPIC 2.

LITERATURE CITED

Moen, A. N, and P. Sauer. 1977. Population predictions and harvest simulations. Pages 26-36 In: Proc. Joint Northeast-Southeast Deer Study Group Meeting, Blackstone, VA.

REFERENCES, TOPIC 1

POPULATION ESTIMATES

BOOKS

TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS----------	AUTHORS/EDITORS--	YEAR
edbo	wiso	wadc	635	many	wildlf mgmnt techn, 3rd ed	giles,rh,jr,ed	1969
edbo	psup	uppa	420		statist ecol, vol II, proc	patil,gp,ed; pie/	1971
edbo	wiso	wadc	206	many	manual of wildlf conservat	teague,ad,ed	1971
aubo	hapr	nyny	506		est anim abun & rel params	seber,gaf	1973

UNIT 1.1. DIRECT ESTIMATES; AERIAL COUNTS

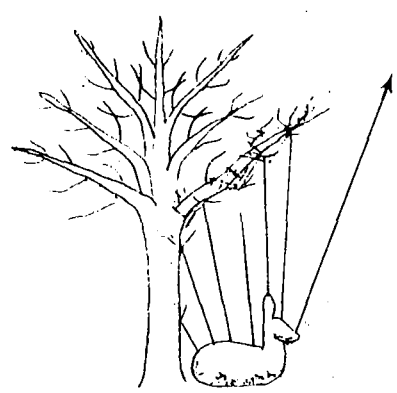
Direct estimates of populations involve the counting of individual animals from the air or from the ground. Aerial counts of wild ruminants have been conducted for over 40 years. Many flights have been made for the purpose of gathering state and local information, and the results have been used in management decisions. Many of these results are not published in the readily-available professional literature.

Aerial counts may be quite successfully made in open terrain when the animals may be distinguished from the ground surface in the background. Counts of caribou on the tundra and bison on the prairie, for example, are readily made directly from either helicopters or fixed-wing aircraft. Either entire herds may be counted, or transects flown and total numbers estimated by extrapolation.

Aerial counts of animals living in forested or shrubby habitats are much less accurate than those in open terrain. Small scattered shrubs cause difficulties by giving the ground a mottled appearance into which the animals may blend very well. An overstory conceals animals bedded under the tree canopies, often resulting in large underestimations of the actual population. Aerial counts of forested areas are best made when leaves have fallen and there is a uniform snow background.

Direct aerial counts have been supplemented by tests of remote sensing techniques. Photography may be used successfully when lighting conditions provide the necessary contrast. The pictures provide a permanent record of the areas viewed. A rather recent technique that has been evaluated is the use of thermal or infrared imagery. This technique is based on the contrast in heat emitted from an animal and from its background.

Instrumentation is available that detects differences in heat emitted from surfaces with temperatures less than 1°C apart. Thus a white-tailed deer, with a surface temperature of about 10°C in still air when air temperature is 0°C and about 5°C in a 10 mph wind at 0°C air temperature, does provide sufficient contrast for thermal detection. The infrared energy emitted, however, is absorbed and diffused by any overhead cover present. Thus an animal bedded under a canopy would not provide the contrast necessary to identify the thermal image as an animal. This is illustrated below.



There are other sources of thermal energy that provide contrast too. Rocks, water puddles, tufts of vegetation, . . . just about anything different from the desired uniform background, such as snow, provides thermal contrasts on the imagery. The problem then is in identifying the sources of thermal contrast, distinguishing animals of the target species from objects in the habitat.

There is yet another problem with the use of thermal imagery. Different species present similar thermal images. The radiant surface temperatures of white-tailed deer, mule deer, red fox, cottontail, and snowshoe hare all overlapped in part of the air temperature - wind velocity combinations tested (Moen 1974). These results, along with the problems considered in preceding paragraphs, lead me to conclude that thermal sensing introduces many new problems but few new advantages over good contrast photography. The best conditions for infrared imagery -- large animals against a snow background -- are also the best for black and white or color photography. Standard photography equipment is much less expensive than thermal detection equipment, and the photography equipment is readily available.

Aerial counts may provide considerable information in addition to just numbers of animals. Information on sex and age ratios may be obtained for some species while they are being counted from the air. Muskox, ideally suited for direct counts, may also be aged by body size and horn length while being counted (Taber 1969). Bison calves are smaller and lighter in color than adults, but yearlings may be difficult to distinguish from adults. The horns of sheep indicate both sex and age, but horns of goats are not different enough to be distinguished. Such information, gathered while counting numbers, is very useful when representing population structures.

Direct aerial counts are often supplemented by ground counts. Comparisons between the two are useful, and usually made to evaluate less-costly ground methods in relation to more costly aerial methods. Direct estimates by ground counts are discussed in UNIT 1.2.

LITERATURE CITED

Moen, A. N. 1974. Radiant temperatures of hair surfaces. J. Range Manage. 27(5):401-403.

Taber, R. D. 1969. Criteria of sex and age. Chapter 20 In: R. H. Giles, Jr. (Ed.). Wildlife Management Techniques. The Wildlife Society, Washington, D. C. 623 p.

REFERENCES, UNIT 1.1

DIRECT ESTIMATES; AERIAL COUNTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	17--1	97	98	od--	aerial deer counts	petrides,ga	1953
JWMAA	20--3	327	328	od--	conduct deer stud, helicop	aldous,cm	1956
NAWTA	10---	234	241	od--	ceel, meth det nums & rnge	hunter,gn	1945

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFNA	88--1	41	45	odvi	dist, number, wint, quebec	miller,fl	1974
ICNSA	12--1	98	98	odvi	aerial deer survey	sanderson,gc	1953
JWMAA	36--3	875	884	odvi	cens airborn therm imagery	graves,hb; ellis/	1972
JWMAA	38--2	366	368	odvi	chang rad temp, anim, wind	moen,an; jacobsen	1974
JWMAA	41--2	197	206	odvi	aer sampl, mark recap cens	rice,wr harder,j	1977
JWMAA	43--3	777	780	odvi	precisi in helic censusing	beasom,sl	1979
NAWTA	24---	201	215	odvi	food habits, everglades de	loveless,cm; liga	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JRMGA	25--6	480	481	odhe	deer detec by therm scanng	parker,hd,jr: dri	1972
JWMAA	21--1	33	37	odhe	comp air, groun count, col	gilbert,pf; grieb	1957
NEXAA	567--	1	32	odhe	ft stanton hrd, ecol, n mx	wood,je; bickle,/	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	15--1	81	87	ceel	censusin by airplane, wash	buechner,hk; bus/	1951
JWMAA	24--1	15	21	ceel	on afognak island, alaska	troyer,wa	1960
JWMAA	30--2	364	369	ceel	aerial count, 2 herds, mon	lovaas,al; egan,/	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BFRNA	23...	1	9	alal	an aerial moose census, bc	edwards,ry	1952
JWMAA	18--3	403	404	alal	compar, aerial ground cens	edwards,ry	1954
JWMAA	19--3	382	387	alal	aerial reconnaissa, summer	bowman,ri	1955
JWMAA	30--4	767	776	alal	aer cens, quadrat samp uni	evans,cd; troyer/	1968
JWMAA	33--4	910	916	alal	aerial census, newfoundlan	bergerud,at; manu	1969
JWMAA	38--2	175	182	alal	accur, precis, aerial cens	leresche,re; raus	1974
PNSIA	27---	43	58	alal	od, surv, kejimujik nat pk	wood,tj	1973
WLMOA	48---	1	65	alal	habitat select, forest mgt	peek,jm; urich,d/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CWPNB	40...	1	18	rata	obmo, aerial surve, nw ter	miller,fl; russel	1974
CWPNB	44...	1	8	rata	obmo, aerial surve, nw ter	miller,fl; russel	1975
JWMAA	27--3	438	449	rata	aerial winter census carib	bergerud,at	1963
JWMAA	28--2	391	401	rata	aer cens, strat rand sampl	siniff,db; skoog,	1964
NAWTA	21---	499	509	rata	aerial cens, nelchina herd	watson,gw; scott,	1956
NPOAA	1972-	83	88	rata	air and ground surv, norwy	gossow,h; thorbjo	1972

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	14--3	295	298	anam	aerial census, west states	springer,lm	1950
NAWTA	15---	627	644	anam	rang ecol, wichita mt, kan	buechner,hk	1950

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	14--4	445	451	bibi	aerial censu, wood buff pk	fuller,wa	1950

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	12--3	302	304	ovda	air cens, mt mckinl nat pk	sumner,l	1948

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CWPNB	33...	1	9	obmo	rata, prelim surv, nw terr	miller,fl; russe/	1973

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ECOLA	33--4	441	450	anim	exp meths in popul dynamcs	smith,fe	1952
JOMAA	22--2	148	157	mamm	techns for study populatns	blair,wf	1941
JWMAA	2---2	131	134	biga	carrying capacity of range	young,va	1938
JWMAA	14--4	472	473	wldl	use helicopter in wld work	buechner,hk	1950
JWMAA	32--4	751	759	biga	infrared scanng tech, cens	croon,gw; muccul/	1968
NAWTA	7----	343	354	biga	aerial census, nort dakota	saugstad,s	1942
NAWTA	10---	234	241	biga	meths deter numbers & rnge	hunter,gn	1945
NAWTA	20---	519	532	biga	aerial survey tech, northe	banfield,awf; fl/	1955

UNIT 1.2: DIRECT ESTIMATES; GROUND COUNTS

When the overhead canopy is dense enough to preclude aerial counts, on-the-ground drives may be used to count animals on small areas of land. Such drives require large numbers of persons to drive the animals and a line of watchers to count the animals driven through an open area or across a road where they may be easily seen. Sampling problems contribute to errors, and the results are dependent on the amount of past experience and alertness of the observers.

How many observers are needed to drive and count animals? The number is very dependent on the species being counted and on the habitat. A drive over 500 acres in east central Minnesota showed that two radio-tracked white-tailed deer ran back between drivers four times (Tester and Heezen 1965). One was not seen one of those times, even though 58 people participated in the drive and the drivers, were, presumably within sight of each other at all times. The use of 58 people on a drive covering 500 acres indicates the necessity for large numbers when making such direct estimates from the ground. Costs are very high, probably prohibitive, if persons involved must be paid for their services.

Some direct counts are made as other work is being completed. Roadside counts, for example, may be conducted by biologists and laypersons that travel the same routes repeatedly. The direct counting of animals seen is not an estimate of the actual number in the area, of course. Some conditions enhance opportunities to count larger fractions of the actual numbers. Late winter concentrations of deer in the Northeast, mule deer winter concentrations, elk congregating in winter feeding areas . . . these all provide opportunities to observe and count larger percentages of the total number in the area.

Behavior patterns must also be considered when counting animals. More are observed grazing in early morning and late evening than in mid-morning and mid-afternoon. Cervids are, in general, active around sunrise and sunset, with other activity periods around noon and during the night. If counts are dependent on the animals' normal activity patterns, then daily activity patterns discussed in CHAPTER 4 need to be given serious consideration. Drives may appear to be less dependent on the daily activity pattern, but it is my belief that a deer drive conducted just after the morning feeding period has ended will result in fewer whitetails being observed than if the drive were conducted just before the late afternoon feeding period was to begin. Some of these subtle effects may be hard to detect and prove; I suggest that they be considered and plans made accordingly as circumstances permit.

Ground counts are not always designed to be complete counts. The number seen may be used to estimate the number present by multiplication. Techniques for counting some of the population and estimating the total population have been devised for other species and applied to wild ruminants. The Petersen or Lincoln Index is one, the Leslie index is another.

The Petersen or Lincoln Index is relatively simple in theory, but more comlpex in its use. It is a method involving the marking and releasing of individuals, after which the ratio of marked animals to unmarked animals seen is the basis for estimating the population. For simplicity, suppose 10 animals were marked and released. Later 5 marked and 5 unmarked were seen regularly. One might conclude that the fraction of animals seen that were marked (5/10 = 0.5) is a good estimater of the total in the population by: 10 marked/0.5 = 20 total. In proportion form:

$$\frac{\text{number marked observed}}{\text{total number observed}} : \frac{\text{total number marked}}{\text{total population}}$$

Thus:

$$\frac{5}{10} : \frac{10}{N}$$

so 5N = 100 and N = 20.

There are a number of assumptions underlying this estimate, including such things as proportional mortality in both the marked and unmarked groups, no lost marks, marked animals are no more conspicuous, etc. More detailed treatments of the assumptions and calculations may be found in Overton and Davis (1969 433).

The Leslie Method (Overton and Davis 1969:450) is similar to the Lincoln Index in the sense that repeated observations are made, but with the Leslie Method they are recaptures. The frequency of recaptures becomes the basis for estimating N. There are assumptions to be met and conditions to be heeded when using any method for estimating N. Additional methods and further discussions are found in Overton and Davis (1969).

LITERATURE CITED

Overton, W. S. and D. E. Davis. 1969. Estimating the numbers of animals in wildlife populations. Chapter 21, Pages 403-456 In: Giles, R. H., Jr. (Ed.). Wildlife Management Techniques. The Wildlife Sociey, Washington, D. C. 623 p.

Tester, J. R. and K. L. Heezen. 1965. Deer responses to a drive census determined by radio tracking. BioScience 15(2):100-104.

REFERENCES, UNIT 1.2

DIRECT ESTIMATES; GROUND COUNTS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	7---2	217	220	od--	tech red man-pow, driv cen	morse,ma	1943
JWMAA	28--1	27	34	od--	factors, spotlighti counts	progulske,dr; due	1964
NAWTA	24---	457	464	od--	deer drive vs track census	tyson,el	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
FLSCA	38...	157	167	odvi	popula, everglades, florid	schemnitz,sd	1974
ICNSA	7---4	30	30	odvi	1948 deer survey, iowa	faber,lf	1948
JWMAA	4---1	15	18	odvi	census meth, spring, summe	erickson,ab	1940
JWMAA	5---4	412	415	odvi	cruising meth, cens, oklah	krefting,lw; flet	1941
JWMAA	7---2	217	220	odvi	reduc man-power, drive cen	morse,m	1943
JWMAA	32--4	760	764	odvi	attempt, leslie censu meth	lewis,jc; farrar,	1968
JWMAA	43--1	258	261	odvi	impr meth, cen dec con for	floyd,tj; mech,l/	1979
NAWTA	3----	280	286	odvi	tagging, pop studies, minn	olson,hj	1938
NAWTA	4----	221	230	odvi	devel, use game drives, pa	mccain,r	1939
NAWTA	9----	150	154	odvi	roadsid count, emerg, minn	schrader,ta	1944
NAWTA	21---	555	566	odvi	large-scale dead deer surv	whitlock,sc; eber	1956
NYCOA	11--2	4	4	odvi	live-trapping white-t deer	bromley,aw; sever	1956
PCGFA	19---	26	30	odvi	cens tech, enclos, georgia	downing,rl; moor/	1965
PCGFA	20---	56	63	odvi	compar, cens methods, tenn	lewis,jc; safley,	1966
PSAFA	1962-	162	165	odvi	census tech, the southeast	johnson,fm; downi	1962
WCDBA	7----	1	32	odvi	wint hab, census meth, wis	kabat,c; collias/	1953

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFGA	41--3	225	228	odhe	compar, 4 cens meth, calif	dasmann,rf; taber	1955
JOMAA	37--3	457	458	odhe	mule deer record for iowa	sanderson,gc	1956
JOMAA	40--1	148	149	odhe	addi mule de records, iowa	kline,pd	1959
JWMAA	18--4	537	538	odhe	use deer cal, locate fawns	diem,kl	1954
JWMAA	21--1	33	37	odhe	comp air, groun count, col	gilbert,pf; grieb	1957

odhe continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
NAWTA	8----	369	380	odhe	cens meth, appl, managemen	rasmussen,di; dom	1943
NAWTA	11---	349	354	odhe	census herd, sampling meth	cronemiller,fp; f	1946
NEXAA	567--	1	32	odhe	ft stanton hrd, ecol, n mx	wood,je; bickle,/	1970
NOSCA	34--4	118	126	odhe	differ range use, spruce-f	white,kl	1960

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JRMGA	5---2	76	80	ceel	odhe, wint-rang util, wash	buechner,hk	1952
JWMAA	24--3	279	290	ceel	migrat pattrn sun rivr elk	picton,hd	1960
NPOAA	1974-	83	88	ceel	air and ground surv, norwy	gossow,h; thorbjo	1972
WMBAA	6----	1	25	ceel	surveys, wildlif, manitoba	colls,dg	1952

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	18--3	403	404	alal	compar, aerial ground cens	edwards,ry	1954
NCANA	101-1	615	629	alal	moose inventor meth, revie	timmermann,hr	1974
OUOKA	25--3	8	15	alal	wapiti roundup	lowry,d III	1969

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFGA	30--4	221	224	anam	pronghorned antel in calif	mclean,dd	1944

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
ATICA	24--3	157	161	obmo	distr, abund, gr bear lake	kelsall,jp; hawl/	1971
JWMAA	35--1	103	108	obmo	pop characs, nrth wst terr	freeman,mmr	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFNA	81--1	1	22	oram	obser, kootenay nat pk, bc	holroyd,jc	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BIOKA	38---	293	306		est size mobil pops, recap	bailey,ntj	1951
ECOLA	33--4	441	450		exp meth popul dyn, critiq	smith,fe	1952
JFUSA	34--5	467	471	wldl	wildl cens meth, n england	hosley,nw	1936
JOMAA	22--2	148	157	anim	techns study animal populs	blair,wf	1941
JWMAA	2---2	131	134	biga	carrying capacity of range	young,va	1938
JWMAA	4---4	313	314	anim	intersection meth of count	graham,sa	1940
JWMAA	5---4	357	370	biga	early historicl rec, monta	koch,e	1941
NAWTA	3----	407	414	biga	wildl cens, counts vs esti	mccutchen,aa	1938
NAWTA	10---	234	241	biga	meths deter numbers & rnge	hunter,gn	1945

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	31--4	643	651	caca	reliabi petersen meth, pop	strandgaard,h	1967

UNIT 1.3: INDIRECT ESTIMATES

Indirect estimates of populations are often the only reasonable ways to come up with working numbers for decision-making. There are several ways to make such estimates. Fecal and pellet groups may be counted and population estimates or animal-days of use derived by dividing the total count by the defecation rate per day. This was proposed by Bennett et al. (1940), and has been used by investigators in many states in the last 40 years. The technique is based on a number of assumptions. These are discussed by Eberhardt and Van Etten (1956) for white-tailed deer in evaluating two enclosed areas in Michigan. The biological assumptions are:

(1) that all groups are found and correctly identified,

(2) all pellet groups deposited since leaf-fall will be available and counted, and

(3) that a known number of pellet groups are defecated per day.

All of these assumptions are subject to error, of course. If the errors are committed at a constant rate from year to year, their effects are less serious than if the error rate fluctuates from year to year.

The formula for estimating the number of deer present per square mile from pellet counts, with 640 acres per square mile, 1/50 acre circular sample plots, and 13 pellet groups defecated per day is:

$$DPSM = [(APGP)(50)(640)]/(DYLF)(13)$$

where DPSM = deer per square mile,
APGP = average number of pellet groups per plot, and
DYLF = days since leaf fall.

Eberhardt and Van Etten (1956) made pellet-count estimates (PECO) of known populations (KNPL) of DPSM for three years in each of two areas in Michigan. The data and the ratios of the two estimates (RTIO = ratio of PECO/KNPL) are:

	Cusino			George Reserve		
	PECO	KNPL	RTIO	PECO	KNPL	RTIO
1953	40.8	28.8	1.42	30.7	32.7	0.94
1954	25.5	25.0	1.02	28.4	36.1	0.79
1955	22.2	28.1	0.79	17.3	37.2	0.47

The pellet counts varied from 0.47 to 1.42 times larger than the known population. The "known" populations are thought to have been estimated accurately for these intensively-studied enclosed populations; variations in the ratios are then due almost entirely to the pellet counts. The amounts of the differences in the two values of DPSM suggest that other methods should be used to supplement these results.

Track and trail counts on transects may be made in snow or in ground vegetation to provide an index to the population. Roads may be used as the transects. If they are dragged at the same time twice each day, daily use can be measured. Trail counts provide an index to deer abundance with a minimal investment of man-days, and the results are useful for recognizing population changes from year to year and to relate to the results of other methods of estimation.

The use of late fall and early spring trail counts as indices to deer abundance in Wisconsin is described by McCaffery (1976). The results were positively related to other indices of deer abundance. Such trail counts also provide an index to habitat use when the numbers of trails encountered on transect lines are evaluated in relation to habitat types present along the lines.

Indirect population estimates are usually not good indicators of absolute population levels, and results of indirect estimates usually do not become meaningful until several years of data are obtained. Then, relative changes in indirect evidence may be used to draw conclusions on probable changes in the actual population. Sex and age ratios, reproductive data, and mortality data all become useful in making calculations of the likely numbers of animals, which in time may be rather reliable estimates.

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Bennett, L. J., P. F. English, and R. McCain. 1940. A study of deer populations by use of pellet group counts. J. Wildl. Manage. 4(4): 398-413.

Eberhardt, L. and R. C. Van Etten. 1956. Evaluation of the pellet group count as a deer census method. J. Wildl. Manage. 20(1):70-74.

McCaffery, K. R. 1976. Deer trail counts as an index to populations and habitat use. J. Wildl. Manage. 40(2):308-316.

REFERENCES, UNIT 1.3

INDIRECT ESTIMATES

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFGA	38--2	225	233	od--	meth, est deer pop, kill d	dasmann,rf	1952
JWMAA	20--1	75	78	od--	anal meths cens wintr-lost	robinette,wl; jo/	1956
JWMAA	26--1	50	55	od--	infl rain, pellet gr count	wallmo,oc; jacks/	1962
JWMAA	29--4	723	729	od--	error, pellet grou censusi	van etten,rc; ben	1965
JWMAA	32--3	592	596	od--	paint, marking pellet grou	kufeld,rc	1968
JWMAA	39--4	641	652	od--	dev distnc meth, pellet gr	batchelor,cl	1975
NAWTA	13---	431	441	od--	method measur od range use	mccain,r	1948
NAWTA	19---	511	525	od--	meths cens wintr-lost deer	robinette,wl; jo/	1954
NAWTA	21---	555	566	od--	large-scale dead deer surv	whitlock,sc; eber	1956
NAWTA	23---	411	425	od--	probl, pellet group counts	robinette,wl; fer	1958
NAWTA	24---	457	464	od--	deer drive vs track census	tyson,el	1959

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFNA	90--1	29	36	odvi	est popul, mortal, 1970-72	king,dr	1976
CNSVA	28--5	36	38	odvi	deer pop, wildl rollercoas	severinghaus,cw	1974
JWMAA	4---1	15	18	odvi	meth censusing, sprng, sum	erickson,ab	194?
JWMAA	4---4	398	403	odvi	stud pop, pellet gr counts	bennett,lj; engl/	1940
JWMAA	7---2	203	216	odvi	on aransas refuge, texas	halloran,af	1943
JWMAA	16--2	121	131	odvi	hunt statis rang cond, pop	gunvalson,ve; er/	1952
JWMAA	20--1	70	74	odvi	evalua, pellet-group count	eberhardt,l; van	1956
JWMAA	23--2	187	197	odvi	highway mor, index pop cha	jahn,lr	1959
JWMAA	29--2	381	387	odvi	esti pop, automa colle dat	sittler,od	1965
JWMAA	33--4	871	880	odvi	harv est, sampl surv, mich	hawn,lj; ryel,la	1969
JWMAA	37--2	212	216	odvi	road kills show trends in	mccaffery,kr	1973
JWMAA	40--2	308	316	odvi	trail counts, pop, hab use	mccaffery,kr	1976
JWMAA	41--4	779	782	odvi	freq dist pell gr, indiana	stormer,fa; hoek/	1977
MDCRA	2352-	1	64	odvi	techn data, pellet grp sur	ryel,la	1961
MFNOA	89...	1	2	odvi	count pellet gr, mult-rand	krefting,lw; shiu	1960
NAWTA	3----	287	295	odvi	census, kill rec, lake sta	adams,he	1938
NAWTA	24---	201	215	odvi	food habits, everglades de	loveless,cm; liga	1959
NFGJA	7---1	80	82	odvi	persist, wint pell gro, ny	patric,ef; bernha	1960

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
PCGFA	6----	1	15	odvi	estimat popula from tracks	tyson,el	1952
PCGFA	16---	29	31	odvi	track counts, meas pop siz	brunett,le; lambo	1962
PCGFA	19---	110	117	odvi	interp, trap data, alabama	lueth,fx	1965
PCGFA	21---	39	41	odvi	eval track census meth, se	harlow,rf; downin	1967
PCGFA	21---	69	73	odvi	determ unreport kill, tenn	legler,e,jr; hayn	1967
TNWSD	9----	1	5	odvi	che sta data, herd siz, nh	stevens,cl	1953
TNWSD	20---	1	37	odvi	gains & losses in pop, n y	free,s; hesselto/	1964
WSCBA	22--8	6	10	odvi	the deer unit: surv, manag	keener,jm; thomps	1957

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JRMGA	25--1	66	68	odhe	fecal gro coun rel site fa	anderson,ae; med/	1972
JWMAA	7---1	123	124	odhe	counts, bucks vs shed antl	hickel,mr; swift,	1943
JWMAA	11--1	103	104	odhe	prob error, samp meas,kill	cronemiller,fp	1947
JWMAA	22--2	193	199	odhe	pel-gr coun, cens, ran use	rogers,g; juland/	1958
JWMAA	28--3	435	444	odhe	defecation rates of mule d	smith,ad	1964
JWMAA	32--3	585	591	odhe	comp plots, pellet gr dens	smith,rh	1968
JWMAA	33--4	895	905	odhe	frequen distr, fec gr coun	bowden,dc; ander/	1969
NAWTA	15---	644	649	odhe	determin pop from the kill	lauckhart,b	1950
NAWTA	21---	487	498	odhe	fluctuations, popul, calif	dasmann,rf	1956
NOSCA	34--4	118	126	odhe	differ range use, spruce-f	white,kl	1960
UASPA	17...	65	69	odhe	estim pop, diff huntg mort	kelker,gh	1940
UASPA	32...	59	64	odhe	weath, persis, pellet grou	ferguson,rb	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	29--2	406	407	ceel	determinat defecation rate	neff,dj; wallmo,/	1965
JWMAA	34--1	29	36	ceel	od, frequen distrib pel gr	mcconnell,br; smi	1970
JWMAA	39--4	641	652	ceel	dev dis meth, pellet group	batcheler,cl	1975

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
NCANA	95--5	1153	157	alal	det # pell grps, bed areas	desmeules,p	1969
QSFRA	8----	1	12	alal	cens taking sta, 1971, can	potvin,c; guilber	1973

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
ATRLA	21-15	217	222	ungu	est num in for by trac cou	dzieciolowski,r	1976
BIOKA	42--3	279	290		pop est, chng comp, removl	chapman,dg	1955
ECOLA	33--4	441	450		exp meths in popu dynamics	smith,fe	1952
ECOLA	39--1	147	150	anim	nearst-neighbr distnc meth	blacklith,re	1958
JFUSA	34--5	467	471	wldl	wildl cens meth, n england	hosley,nw	1936
JOMAA	22--2	148	157	mamm	techniqs study anim populs	blair,wf	1941
JOMAA	32--3	318	328	anim	new techniq of anim census	maclulich,da	1951
JWMAA	13--2	145	157	anim	strip census method, estim	hayne,dw	1949
JWMAA	29--2	392	395	anim	schnabel est, removl anims	overton,ws	1965
JWMAA	30--1	173	180		shnabel est, diff pop levl	chapman,dg; overt	1966
JWMAA	32--1	82	88		preliminar appr, line tran	eberhart,ll	1968
JWMAA	32--3	597	614	biga	pellet group coun tech for	neff,dj	1968
JWMAA	42--2	441	444	herb	dung ph to diff herb speci	hansen,rm	1978
NAWTA	3----	407	414	wldl	wildl cens, counts vs esti	mccutchen,aa	1938
NAWTA	4----	542	545	wldl	region 8 tech, wildl inven	ruff,fj	1939
NAWTA	10---	234	241	biga	meths deter numbers & rnge	hunter,gn	1945
UASPA	20...	189	198	wldl	formulas deter pop, sx rat	kelker,gh	1948
XARRA	170--	1	7		rec, comp summ, pellet dat	patton,dr; casner	1970

UNIT 1.4. OBSERVED POPULATION DYNAMICS

Descriptions of population dynamics are necessary for good long-range management decisions. Some species, such as white-tailed deer, are very abundant in some areas and population dynamics need to be understood in order to set up adequate harvests and prevent range deterioration. Other species are absent or rare in potentially good habitat, and restocking efforts and subsequent protection are necessary to establish populations.

Some population changes are dramatic. The rise and fall of caribou on St. Matthew Island (Klein 1968) illustrates how a primary consumer relates to range resources in a rather simplified system over a period of several years. Population changes in more heterogenous habitats may not be as dramatic, but the same principles apply. Certain components of natural population dynamics have been eliminated in post-settlement times. Natural predators such as wolves, bears, mountain lions, bobcats, and others have much more restricted distributions than in pre-settlement times. Changes in the vegetation are also dramatic as farming and forestry practices result in plant communities quite unlike those in which wild ruminants spent the last several thousand years.

The reproductive potential of white-tailed deer is well known. A herd in New York State grew from less than 40 animals in 1949 to over 2500 in 1957 after 8 years of protection within the Seneca Army Depot fence. The increase in numbers was accompanied by decreases in body weight and reproductive rates. The population was reconstructed by aging the deer harvested, beginning in the late 1950's, and numbers and reproductive rates used to calculate mortality. The analyses by Moen and Sauer (1977) demonstrated the importance of accurately aging the deer.

There are many papers containing descriptions of the population dynamics of different species of wild ruminants. These papers contain estimates of N in different sex and age classes, and data on natality and mortality rates, useful in relation to discussions in UNITS 1.1, 1.2, and 1.3 and to the next TOPIC. References to population growth after restocking may be found in the list of SERIALS at the end of this UNIT, and in CHAPTER 22. Some of the references listed contain brief descriptions of observed numbers, and some contain extensive descriptions of population dynamics. The references will be useful when using natality and mortality rates for population predictions in CHAPTER 19. First, however, sex, age, and weight structures are discussed in TOPIC 2.

LITERATURE CITED

Klein, D. R. 1968. The introduction, increase, and crash of reindeer on St. Matthew Island. J. Wildl. Manage. 32(2):350-367.

Moen, A. N. and P. Sauer. 1977. Population predictions and harvest simulations. Pages 26-36 In: Proc. Joint Northeast-Southeast Deer Study Group Meeting, Blackstone, Va.

REFERENCES, UNIT 1.4

OBSERVED POPULATION DYNAMICS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
MANJA	20--1	24	26	cerv	pop tren, licen rep, malay	khan,m; khan,m	1967

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFGA	44--1	51	72	od--	surviv, forag trend, calif	dasmann,wp; hjers	1958
CAGRA	10--5	9	14	od--	population dynamics of dee	longhurst,wm	1956
CFGGA	4....	1	139	od--	jawbone deer herd, califor	; riney,t; /	1951
CFGGA	6----	1	316	od--	surv herds; rnge, mgt prob	longhurst,wm; le/	1952
NAWTA	12---	193	203	od--	9 yr observtn, problm area	einarsen,as	1947

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
AMFOA	74--4	32		odvi	white-tails: success story	randall,ce	1968
AMNAA	61...	230	238	odvi	historic view, ranges, wis	christensen,em	1959
CNSVA	28--5	36	38	odvi	deer pop, wildl rollercoas	severinghaus,cw	1974
ECOLA	41--4	706	715	odvi	popula ecology, ne alabama	adams,wh,jr	1960
FLSCA	38...	157	167	odvi	populations, florida everg	schemnitz,sd	1974
ICNSA	7---4	30		odvi	deer survey, 1948, iowa	faber,lf	1948
ICNSA	12--1	101	101	odvi	iowa's early deer story	madson,j	1953
INHNA	34---	1	22	odvi	white-t deer popu, illinoi	pietsch,lr	1954
JWMAA	5---2	182	190	odvi	prelim report, study, texa	sanders,e	1941
JWMAA	9---3	237	242	odvi	in the great plains region	cook,fw	1945
JWMAA	11--3	263	266	odvi	the huron mounta deer herd	manville,rh	1947
JWMAA	17--2	166	176	odvi	necedah refuge deer irrupt	martin,fr; krefti	1953
JWMAA	29--4	706	716	odvi	die-off, cent min reg, tex	marburger,rg; tho	1965
MDCRA	2282.	1		odvi	estim vital statistcs herd	eberhardt,l	1960
MDCRA	2395-	1	143	odvi	pop dyna, econ impac, mich	mcneil,rj	1962
MGQPA	31...	194	218	odvi	popula dynam 1954-67, minn	petraborg,w; idst	1972
MOCOA	18--6	1	3	odvi	two decades of deer	robb,d	1957

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
MRLTA	31--3	43	44	odvi	introduced dee, se washing	swanson,cv	1950
MRYCA	1942-	6	8	odvi	worcester county deer herd	wilson,ka; vaughn	1942
NAWTA	3----	280	286	odvi	tagging & popul stud, minn	olson,hf	1938
NAWTA	14---	543	553	odvi	whitetail deer, us & canad	bartlett,ih	1949
NAWTA	17---	472	479	odvi	exti, resto, 60 yr, georgi	jenkins,jh	1952
NAWTA	21---	487	499	odhe	fluct, popul, calif chapar	dasmann,rf	1956
NAWTA	26---	448	459	odvi	deer, bad river indian res	cook,rs; hale,jb	1961
NAWTA	28---	422	430	odvi	10 yr, enclosed herd, mich	arnoldl,da; verme	1963
NFGJA	3---1	80	87	odvi	hist, man, ecol, allegh pk	severinghaus,cw	1956
NFGJA	3---2	129	167	odvi	history of w-t d in n york	severinghaus,cw;	1956
NFGJA	12--1	17	30	odvi	popul dynamics, senec army	hesselton,wt; se/	1965
NFGJA	16--1	19	26	odvi	minimum deer populatio, ny	severinghaus,cw	1969
NYCOA	12--4	19	19	odvi	seneca ordnanc deer, pt II	severinghaus,cw	1958
NYCOA	20--2	28	32	odvi	deer facts, seneca depot	hesselton,wt; se/	1965
PCGFA	5----	1	18	odvi	deer restoration, se u. s.	barick,fb	1951
PCGFA	21---	15	23	odvi	overpop, hunt, ft knox, ky	dechert,ja	1968
PCGFA	21---	42	50	odvi	herd dynamics, pioneer pop	urbston,df	1967
PCGFA	27---	297	301	odvi	obs die-off, smoky mts prk	fox,jr; pelton,mr	1974
PMACA	10...	411	416	odvi	prelim surv, dee yrds, mic	bartlett,ih; step	1928
PMACA	19...	567	570	odvi	deer populations, michigan	bartlett,ih	1933
RRFBA	19...	66	75	odvi	status of w-t dee, tenness	schultz,v	1955
SLUMA	173..	141	142	odvi	w-t d, forest crop, arkans	read,ra	1946
TISAA	62--2	135	140	odvi	herd pop dynamics, illinoi	hawkins,re; montg	1969
TNWSD	8----	1	17	odvi	some aspects, de herd, n j	sweet,jc; wright,	1952
TNWSD	9----	1	5	odvi	chec sta dat, herd siz, nh	stevens,cl	1953
TNWSD	16---	1	19	odvi	pop census, 1959, n jersey	wright,cw	1960
TSASA	62--1	67	79	odvi	prelim survey, deer, kansa	taylor,dl; elder,	1959
TWASA	35---	351	366	odvi	deer irruptions, wisconsin	leopold,a	1943
TWASA	42---	197	247	odvi	w-t dee in early wisconsin	schorger,aw	1953
TWASA	48---	49	56	odvi	forest cov, pop dens, wisc	habec,jr; curtis,	1959
UKMPA	39---	1	36	odvi	status of deer in kansas	anderson,dd	1964
VIWIA	29--4	10	21	odvi	northwes virgini deer herd	thornton,je	1968
VIWIA	29--5	8	9	odvi	vital statistcs of va herd	carpenter,m	1968
VJSCA	13...	1	16	odvi	allegheny cty herd, virgin	giles,rh,jr	1962

odvi continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
WLMOA	67---	1	53	odvi	populat dynam, captiv herd	woolf,a; harder,j	1979
WSCBA	8---8	3	11	odvi	deer eruptions	leopold,a	1943
WSCBA	8---8	11	19	odvi	deer today, tomorrow, wisc	feeney,ws	1943
WSCBA	18--1	3	10	odvi	and the browse came back	deboer,sg	1953
WSCBA	26--3	17	19	odvi	how many deer?	keener,j	1961
WSCBA	32--5	14	15	odvi	dee explosion in the south	owen,d	1967
XFNCA	39---	11	18	odvi	deer popula in the midwest	nixon,cm	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BISNA	23--2	113	114	odhe	kaibab deer incident, myth	burk,cj	1973
CAFGA	33--4	287	314	odhe	populatio, interstate herd	interst committee	1947
CAFGA	49--1	4	15	odhe	abundance, scarcity, calif	dasmann,wp; dasma	1963
CAFGA	50--3	132	145	odhe	study, redwoo-doug fir for	browning,bm; laup	1964
DRCWD	11---	1	24	odhe	hist, curr stat, popu east	kufeld,rc	1979
ECOLA	38--2	233	246	odhe	dynam, 3 natural populatio	taber,rd; dasmann	1957
JAZAA	5....	43	44	odhe	transplanted odhe in arizo	mcculloch,cy	1968
JWMAA	15--2	206	208	odhe	dynamics, mule de populati	cronemiller,fp	1951
NAWTA	4----	236	243	odhe	range, popul studies, utah	rasmussen,di	1939
NAWTA	21---	159	172	odhe	nutri, popu dynam, n calif	taber,rd	1956
UASPA	32...	59	64	odhe	weath, persis, pellet grou	ferguson,rb	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
CAFNA	91--2	130	133	ceel	alal, pop fluctuat, manito	rounds,rc	1977
EKPOA	17...	709	718	ceel	reproduc, dynamics, poland	serafinski,w	1969
JAECA	38--2	425	457	ceel	pop dynami, red d, on rhum	lowe,vpw	1969
JWMAA	13--1	127	134	ceel	irruption, riding mt, mani	banfield,awf	1949
JWMAA	24--1	15	21	ceel	roosevelt elk, afognak isl	troyer,wa	1960
JWMAA	29--2	406	407	ceel	determinat defecation rate	neff,dj; wallmo,/	1965
JWMAA	31--2	304	316	ceel	pop cha, gallatin, 1932-65	peek,jm; lovaas,/	1967
JWMAA	33--3	465	481	ceel	popul ecol, summ, jacks ho	martinka,cj	1969
JWMAA	38--2	161	174	ceel	popul analyses, north utah	kimball,jf; wolfe	1974

ceel continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
NAWTA	3----	388	389	ceel	ann n yellowsto herd count	alane,vh	1938
NAWTA	14---	513	526	ceel	american elk today	rasmussen,dj	1949
NZFSA	5....	235	249	ceel	erup, deter, decli, nelson	clarke,cmh	1976
VILTA	3--3	177	376	ceel	ecol investiga, scandinavi	ahlen,i	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
EKPOA	17...	709	718	alal	reproduc, dynamics, poland	seraffinski,w	1969
JEVSB	4---1	39	51	alal	comput sim model, wolf dyn	zarnoch,sj; turne	1974
JOMAA	49--2	325	326	alal	status, moose, nova scotia	telfer,es	1968
JWMAA	26--4	360	365	alal	studies, mountains, montan	peek,jm	1962
MABIA	26--3	267	281	alal	wolf, diff equat model rel	hausrath,ar	1975
NAWTA	14---	492	501	alal	status of moose in n ameri	hatter,j	1949
NCANA	101-1	1	8	alal	moose, yesteday, today, to	peterson,rl	1974
NCANA	101-1	559	593	alal	pop fluct, 1950-72, alaska	bishop,rh; rausch	1974
NCANA	101-1	605	613	alal	pop dynam, forests, e ussr	filonov,cp; zykov	1974
PASCC	8----	41	49	alal	dynamics, railbelt populat	rausch,ra	1957
TRVIA	108-1	110	112	alal	note on the moose, sweden	curry-lindahl,k	1961
ZOLZA	54--5	752	762	alal	mathemat modeli, pop dynam	galantsev,vp; ki/	1975
ZOOLA	41--3	105	118	alal	ecol, behav, popul dynamcs	denniston,rh,II	1956

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
ATICA	14...	91	100	rata	pop dy, mackenzie, 1938-58	krebs,cj	1961
ATICA	27...	256	264	rata	ovmo, on banks island, nwt	kevan,pgK	1974
ATLPA	9---4	369	382	rata	pop dynam, reinde, svalbar	reimers,e	1977
BICOB	1---1	86	87	rata	caribo, southampt isl, nwt	macpherson,ah	1968
BPURD	1----	127	139	rata	alaska, u.s., canada herds	le resche,re	1975
BPURD	1----	155	161	rata	status, wild reindee, ussr	semenov-tian-shan	1975
BPURD	1----	162	169	rata	pop grow, movt pat, nelchi	hemming,je	1975
BPURD	1----	170	180	rata	popu status, nelchina herd	bos,gn	1975

rata continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
BPURD	1----	221	227	rata	status, selkirk mt caribou	freddy,dj; ericks	1975
BPURD	3----	1	8	rata	hist, curren status, alask	davis,jl	1978
BPURD	3----	9	19	rata	pop status, caribou,nw-ter	calef,gw	1978
BYMOA	81--1	132	133	rata	the altai reindeer	sobanskii,gg	1976
CAFNA	89--3	299	310	rata	disapp, reintrod, cap bret	dauphine,tc,jr	1975
CWLSB	1419-	1	11	rata	coats isla carib surv 1970	parker,gr	1970
CWPNB	3----	1	5	rata	popul esti, bg car, canada	thomas,dc; parke/	1968
CWOPA	10---	1	9	rata	trends popul, canada, 20 y	parker,gr	1971
CWPNB	56....	1	10	rata	ovmo, crash, popul, par is	_____; thomas,dc/	1975
CWPNB	64---	1	13	rata	peary car popul, can arcti	thomas,dc; russe/	1976
CWPNB	80---	1	14	rata	2 popul, peary carib, arct	thomas,dc; russe/	1977
CWRSB	9----	1	44	rata	popul estimate, bg caribou	thomas,dc	1969
CWRSB	20---	1	93	rata	total numb, mortal, recrui	parker,gr	1972
CWRSB	31---	1	88	rata	biol kaminuriak pop bar-gr	miller,fl	1976
CWRSB	40---	1	55	rata	ovmo, dist, movement, numb	miller,fl; russe/	1977
FUNAA	22...	253	264	rata	range, popu size, svalbard	norderhaug,m	1969
JOMAA	39--4	560	573	rata	prelim study ungava caribo	banfield,awf; ten	1958
JWMAA	32--2	350	367	rata	introd, incr, crash, st ma	klein,dr	1968
JWMAA	38--4	757	770	rata	decl in n am aftr settlmnt	bergerud,at	1974
NAWTA	29---	445	453	rata	invest woodl caribo, nw us	evans,hf	1964
NCANA	83...	225	234	rata	hstry, dist, anal pop, mgt	moisan,g	1956
NPMEA	99...	132	139	rata	distribut, svalbard, 1960s	norderhaug,m	1970
NPOAA	1969-	70	79	rata	popul densit, svalbard rei	norderhaug,m	1970
NPOAA	1970-	53	58	rata	distr of svalbard reindeer	norderhaug,m	1972
NPOAA	1977-	243	248	rata	counts, popu est, svalbard	larsen,t	1976
PCZOA	16---	206		rata	prelim invest bar-gr carib	banfield,awf	1954
SYLVA	4----	17	23	rata	status, woodl carib, ontar	de vos, a	1948
WLMOA	25---	1	55	rata	popul dynam, newfound cari	bergerud,at	1971
WMBAA	10a--	1	79	rata	prelim invest, barren-gr c	banfield,awf	1954
WMBAA	10b--	1	112	rata	prelim invest, barr-gr, II	banfield,awf	1954
WMBAA	12---	1	147	rata	continued barre-gr studies	kelsall,jp	1957
WMBAA	15---	1	145	rata	co-op stud barr-gr 1957-58	kelsall,jp	1960
ZOLZA	50--1	117	125	rata	wild reindeer pop, novosib	kishchinskii,aa	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
JOMAA	25--1	43	46	anam	distrib, status in montana	beer,j	1944

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
JOMAA	48--1	145	146	bibi	present number, bison, tex	jackson,aw	1967
OFBIA	27---	29	32	bibi	plains bison, nort ontario	young,om	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
EXJOA	49...	17	28	ov--	wild sheep, brooks range	kilham,wh,jr	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
CAFGA	43...	103	111	ovca	surv, santa rosa mts, cali	jones,fl; flittn/	1957
CAFGA	43--3	179	191	ovca	surv, santa rosa mts, cali	jones,fl; flittn/	1957
CGFPA	24---	1	11	ovca	liter review, popul dynami	streeter,rg	1970
JOMAA	27--1	3	28	ovca	ecol stud, rocky mt nat pa	packard,fm	1946
JWMAA	28--2	381	390	ovca	popul dynam, wildhorse isl	woodgerd,w	1964
JWMAA	31--4	693	706	ovca	populat, desert game range	hansen,cg	1967
SCBUB	35--6	29	76	ovca	survey of sierr nevad bigh	jones,fl	1950

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
EXJOA	46...	297	304	ovda	dall she count, mackenzies	kilham,wh,jr	1968
JWMAA	40--4	597	609	ovda	dall sh demog, murie, alas	murphy,ec; whitte	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS	AUTHORS	YEAR
ATICA	30--1	52	60	obmo	s range, abund, e greenlan	ferns,pn	1977
CWPNB	33...	1	9	obmo	rata, prelimi surveys, nwt	miller,fl; russel	1973

obmo continued on the next page

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JOMAA	39--3	398	408	obmo	distribu of muskox in cana	tener,js	1958
JOMAA	55--4	824	828	obmo	dist, numbers, arctic cana	miller,fl; russel	1974
JWMAA	35--1	103	108	obmo	pop char, jones sound, nwt	freeman,mmr	1971
MAMLA	22--1	168	174	obmo	the muskox, east greenland	vibe,c	1958
NPOAA	1974-	159	174	obmo	muskox populatio, svalvard	alendal,e	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
JWMAA	19--4	417	429	oram	two-year stud, crazy mount	lentfer,jw	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS----------	AUTHORS----------	YEAR
AJZOA	2---1	9	65	anim	outlin of dynamics of pops	nicholson,aj	1954
AMBOC	7---3	130	131	many	endangered animals, sweden	anonymous	1978
ATICA	6....	91	148	seve	status of some arctic mamm	rausch,rl	1953
CWOPA	4----	1	50	game	queen eliz isl game survey	tener,js	1963
ECOLA	51--1	53	72	ungu	eruption of popultions, nz	caughley,g	1970
ECOLA	56--4	855	967		stabil, growth, pred, prey	tanner,jt	1975
FPWTA	32---	35	40	many	big gam mackenzie mts, nwt	simmons,nm	1968
MABIA	4---1	129	136		pop gro rat, lif cy pertur	demetrius,l	1969
NAWTA	12---	437	447	biga	status, big gam herds, mex	leopold,as	1947
NAWTA	15---	644	649	biga	determ, big game pop, kill	lauckhart,b	1950
NAWTA	43---	311	322	ungu	eval pop and range, b colu	bunnell,fl; elli/	1978
NAWTA	43---	351	357	ungu	popul in rel to wilderness	martinka,cj	1978
PZESA	15...	25	30	mamm	comp resp artif contro pop	batcheler,cl	1968
QRBIA	29--2	103	137		pop conseq, life hist phen	cole,lc	1954
SGGMA	40--4	321	331	many	stat, prosp, lrg mamm, can	anderson,rm	1924
XFWLA	342--	1	1	biga	inventory, u. s., 1950-51	us fish, wildl se	1952