GROUND BROOD COUNTS TO ESTIMATE DUCK PRODUCTION ON TWO HABITATS IN WESTERN ALASKA

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Abstract: Between July 17 and 24, 1989, duck brood surveys were conducted on the Pah River Flats, in interior Alaska, and McCarthy's Marsh, on the Seward Peninsula. Ten plots, 2.6 square kilometers (km^2) in size, on the Pah Flats and 13 plots on the Seward were surveyed, yielding duck production estimates of 2.12 and 5.22 young/km^2 respectively. Observed production differed significantly ($P < .0005$) between the two habitats, and is presumed to be low in 1989 due to weather influences. Species composition of adults also differed markedly between the two habitats. It is difficult to obtain precise estimates of variable populations from small-scale surveys and in remote areas. Methods to reduce the variance of estimates of waterfowl brood density include stratification, use of the finite population correction factor in computations, and ratio estimation using an auxiliary variable (number of waterbodies).

Alaska's public wetlands are becoming an increasingly valuable resource as continental waterfowl breeding habitat diminishes because of development, drought, and pollution. Low populations of certain species--pintails (*Anas acuta*) for example--have caused concern among sportsmen and management agencies. In 1989, it was estimated that Alaska hosted about 60% of the breeding population of pintails (R. Pospahala, pers. comm.). Inventories will help identify important waterfowl habitat on Bureau of Land Management (BLM) land in the Kobuk District. Such baseline data is essential to determine the potential impacts of settlement, oil and gas leasing, and mineral exploration and development (BLM 1983, 1986).

King and Lensink (1971) estimated 60 breeding ducks per square mile of waterfowl habitat on the Seward Peninsula. Prior to our survey, no intensive waterfowl inventory had been attempted on the Seward Peninsula, although ground brood survey counts have been conducted by U.S. Fish and Wildlife Service (FWS) on other wetlands areas in interior and northwestern Alaska.

Intensive ground surveys to estimate duck production have been conducted on the Selawik and Koyukuk National Wildlife Refuges (NWR) since 1985 (Brubaker and Witmer 1989, Rost 1988). Their studies attempt to estimate waterfowl production based on the number and size of broods counted by observers on the ground. Although there are some studies in progress on helicopter surveys, most managers in Alaska rely on walking or canoe surveys for accurate counts and identification of broods. The present study follows the methodology used there to obtain comparisons of wetlands habitat value to waterfowl and duck productivity.

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STUDY AREAS

The Pah River flats, located in north-central Alaska between the Kobuk and the Koyukuk rivers, is a basin covering about 728 km^2 (Fig. 1). The lowlands include numerous lakes, ponds, marshes and streams. Individual lakes are less than 60 ha in size. The vegetation types include treeless marshes, sedge meadows, open spruce (*Picea mariana*) forests, closed spruce forests, low shrub, high shrub, and alpine tundra. Forested types with small openings for ponds and meadows predominate. Most of the ponds support a border of emergent vegetation characterized by sedges (*Carex* sp.), buckbean (*Menyanthes trifoliata*), marsh fivefinger (*Potentilla palustris*), and water hemlock (*Cicuta mackenzieana*). On average, about 10% of the water surface is covered by floating or aquatic species. Chief among these are yellow pond lily (*Nuphar polysepalum*), dwarf pond lily (*Nymphaea tetragona*), bur reed (*Sparganium* sp.), scouring rush (*Equisetum* sp.), pondweeds (*Potamogeton* sp.), and bladderwort (*Utricularia vulgaris*).

McCarthy's Marsh lies just south of the Bendeleben Mountains, in the neck of the Seward Peninsula. The basin containing McCarthy's Marsh is drained by the Fish River and its tributaries. This study area also included Death Valley, a small basin which lies northeast of McCarthy's Marsh, across the Darby Mountains. McCarthy's Marsh is a pond-

canoes or walked around the margins, close to the edge. When it was necessary to land on a lake within the plot, that lake was surveyed last to allow time for waterfowl behavior to return to normal. All waterbodies lying within or mostly within the plot were surveyed in entirety. Waterbodies are defined to lie within the plot if their centers lie within the plot. Priority was given to duck broods while conducting the survey, but attempt was made to identify and enumerate all waterfowl seen. Birds were observed with the aid of binoculars, and recorded by species, age class, and number of young, when possible. Duck broods were classified as age class I, II, or III according to Bellrose (1976).

Stratification of waterfowl habitat was done from USGS maps, using criteria developed from those used on the Koyukuk NWR. Three strata were defined: poor, moderate, and key habitat. Poor habitat was defined as a section with numerous small bog lakes, with no single bog lake over 24 ha either partially or wholly within the plot. Poor habitat may have non-bog lakes totaling more than 6 ha but less than 24 ha. Bog lakes and marshes were defined as those not containing flowing streams which would provide regular nutrient exchange. Marshes were classified as bog unless drained by a stream intersecting the plot. Moderate habitat was defined as having at least 24 ha, but not more than 40 ha of water in non-bog lakes, sloughs, or marsh areas. Plots having at least 24 ha but less than 49 ha of an 81-ha or larger bog lake within the plot were also classified as moderate. Key habitat was defined as containing more than 40 ha of non-bog lakes, sloughs, and marshlands, or containing more than 49 ha of an 81-ha or larger bog lake. In order to be classified as key, the plot had to have at least some open water showing on the map (could not be all marsh).

Each section identified as potential waterfowl habitat was assigned a number. Plots to be surveyed were then selected using a random numbers table. The highest density of sample units were taken from the key stratum to reduce the variance of the stratified mean broods/plot (McDonald et al. 1989). An average number of young of all species per plot was calculated for each stratum. The product of the average young per plot and the number of plots in the stratum estimates total young produced in each stratum. Summing these gives a total duck production estimate for each study area. For production estimates, four young were included for each broody hen seen, rounding to the nearest whole number after Rost (1988). Standard errors of the sample means were computed according to Cochran's (1977) formulae for stratified random samples which use the finite population correction factor, (N - n)/N, where N is the population size and n is the sample size. Differences between brood densities on the two habitats were compared using a Student's t-test.

RESULTS

Based on the map stratification, key habitat constituted 8% of the Pah River study area and 12% of McCarthy's Marsh (Table 1). Although key habitat comprised only 10% of the land area on the combined study areas, it contributed about 78% of the observed production. All production estimates are based on ducks and do not consider the production of other waterfowl.

Pah River Flats

Ten plots were surveyed by a combined BLM/FWS crew of five persons. About 16% (427 ha) of the surface area was water. Key and moderate strata together comprised 95% of the water surface area surveyed; 69% was contained in the key strata alone. A total of 59 waterbodies were surveyed, yielding 56 duck broods or broody hens of six species. The dabbler:diver ratio for 242 adults observed was 159:83, or 66% dabblers (Table 2). Of 117 adult geese, 94% were white-fronted geese, mostly observed in flocks of molting adults. Six broods of geese were observed--four Canada geese (*Branta canadensis*), and two white-fronts (*Anser albifrons*). No tundra swans (*Cygnus columbianus*) or arctic loons (*Gavia arctica*) were observed in this habitat, but one common loon (*G. immer*) was seen.

The estimates of mean broods per plot and young per plot are given in Table 3 along with their standard errors (SE). In the key stratum, 15.4 young/km^2 were produced and in the moderate stratum, 5.4 young/km^2 were produced. No young

Table 1. Estimated waterfowl habitat from map stratification (km^2).

	Habitat (km^2)			
	Key	Moderate	Poor	Total
Pah River	23.4	46.8	218.4	288.6
McCarthy's Marsh	46.8	104.0	249.6	400.4
Totals	70.2	150.8	468.0	689.0

Table 4. Duck brood summary table for Pah River Flats, Alaska, 1989.

Broods:	Class I		Class II		Class III				
Species	No.	Avg size	No.	Avg size	No.	Avg size	Broody hens	Total broods	Avg. size
Dabblers:									
Mallard	3	1.3	0	-	0	-	0	3	1.3
Wigeon	12	4.1	1	1.0	0	-	4	17	3.8
G.w.teal	3	6.0	5	4.0	3	4.3	6	17	4.6
Shoveler	0	-	0	-	0	-	0	0	-
Pintail	0	-	2	5.0	1	3.0	3	6	4.3
Subtotal	18	3.9	8	3.9	4	4.0	13	43	3.9
Divers and seaducks:									
Scaup	11	5.5	1	5.0	0	-	0	12	5.4
Scoters	1	7.0	0	-	0	-	0	1	7.0
Subtotal	12	5.6	1	5.0	0	-	0	13	5.5
Total	30	4.7	9	3.9	4	3.0	13	56	4.4

dabbler:diver ratio was 315:92, or 77% dabblers. In general, there was a smaller percentage of American wigeon (*A. americana*) and green-winged teal (*A. crecca carolinensis*) seen on the open tundra habitat of McCarthy's Marsh, but a higher percentage of pintails. Pintails also comprised 28% of the the dabbler broods observed in the McCarthy's Marsh survey compared to 14% on the Pah Flats.

Table 5. Estimated duck production for McCarthy's Marsh, Alaska, 1989.

	Stratum			
	Key	Moderate	Poor	Total
Plots surveyed (*n*)	5	4	4	13
Observed young	189	10	19	218
Broody hens	23	13	0	36
Broods[a]	73	18	5	96
Broods[a]/plot	14.60	4.50	1.25	3.65
SE (broods)	5.538	2.584	0.616	1.008
Young[b]/plot	56.2	15.5	4.8	13.6
SE (young)	22.175	9.202	2.508	3.856

[a]Includes broody hens.
[b]Broody hens assigned 4 young each.

DISCUSSION

The mean density of young ducks produced on the Pah River flats was 2.12/km^2, which differs significantly from the mean of 5.22/km^2 produced on McCarthy's Marsh (t = 6.325, P < .0005). The mean number of broods also differed significantly between survey areas (t = 6.935, P < .0005). These results indicate that the Seward Peninsula habitat supported higher production per unit area for 1989. Future surveys will be required to determine whether this result is consistent over time. These productivity levels are low compared to production estimates obtained by Rost and Bertram on the Koyukuk NWR in 1988 (14.23 young/km^2). However, results from other areas suggest that 1989 was a very poor season for duck production in western Alaska. The Koyukuk NWR reported a 67% decline in production from 1988, with 4.54 young/km^2 in their 1989 survey (P. Liedberg, pers. commun.). Early results from the Selawik NWR indicated a 70+% decline in production from a 4-year average. About 4.46 young/km^2 were produced on the Selawik NWR in 1989 (R. Brubaker, pers. commun.). Thus, observed production for the BLM study areas in 1989 may be presumed to be lower than normal. It appears that these areas may both support nesting densities comparable to those on nearby refuges and a significant number of pintails may be produced on the open tundra habitat of the

Table 6. Duck brood summary table for McCarthy's Marsh, Alaska, 1989.

Broods:	Class I		Class II		Class III				
Species	No.	Avg size	No.	Avg size	No.	Avg size	Broody hens	Total broods	Avg. size
Dabblers:									
Mallard	3	1.7	1	2.0	2	1.5	6	12	1.7
Wigeon	4	3.2	3	2.3	4	1.8	1	12	2.5
G.w.teal	8	5.0	1	2.0	1	7.0	11	21	4.9
Shoveler	1	3.0	1	3.0	0	-	2	4	3.0
Pintail	2	2.5	5	2.8	2	5.0	13	22	3.2
Unknown	1	5.0	2	4.5	3	2.3	1	7	3.5
Subtotal	19	3.7	13	2.8	12	2.8	34	78	3.2
Divers and seaducks:									
Scaup	2	4.0	0	-	4	5.0	0	6	4.7
Scoters	1	8.0	0	-	1	3.0	1	3	5.5
Oldsquaw	5	5.4	2	4.0	0	-	0	7	5.0
Unknown	0	-	1	2.0	0	-	1	2	2.0
Subtotal	8	5.4	3	3.3	5	4.6	2	18	4.5
Total	27	4.2	16	2.9	17	3.3	36	96	3.6

Seward Peninsula.

The reasons for poor duck production in western and interior Alaska in 1989 are unknown. However, a late spring thaw with below normal temperatures was generally observed, which may have reduced early nesting success. A combination of heavy spring rainfall and late thaw caused very high water conditions early in the breeding season, which probably flooded some nests and nest sites, as well as submerging littoral vegetation and mud flats used for feeding. Local inhabitants from the Selawik area reported water levels this spring to be the highest since 1962 (R. Brubaker, pers. commun.).

The higher percentage of class III broods observed in McCarthy's Marsh (18% vs. 7%, Tables 4 and 6) indicates that the chronology of nesting was more advanced than in the Pah River flats. This may be due to a larger fraction of early-nesting pintails, or to climate influences. Rost (1988) gives the mean hatching date for pintails on the Koyukuk NWR as June 6--about two weeks earlier than any other dabbler. Since the young may be capable of flight in six weeks (Bellrose 1976), a late July survey might be expected to miss many broods. Thus, the number of pintails actually produced in McCarthy's Marsh probably exceeds our estimate. It is interesting that average brood size did not differ significantly between the two areas, since mortality loss usually reduces the size of older broods. This might indicate better survival of broods in McCarthy's Marsh, but could also be an artifact of the small sample sizes or differences in sightability between the two habitats.

A major difficulty in waterfowl brood surveys is the high variability among samples, which lowers the precision of population estimates. The present study had CV's from 23% to 28%. The stated goal

Table 7. Using waterbodies to estimate production on McCarthy's Marsh.

	Stratum			
	Key	Moderate	Poor	Total
Ponds sampled	72	31	16	119
Number of ponds in stratum	171	339	539	1,049
Mean ponds/plot	14.4	7.8	4.0	6.2
Mean broods/plot	14.60	4.50	1.25	3.65
Broods[a]/waterbody				0.590
Total broods produced				619
Standard deviation (br)				160

[a]Includes broody hens.

of the FWS for their brood surveys in Alaska is a 12.5% CV, which would allow detection of changes of 25% in the total population with 90% confidence (McDonald et al. 1989). A larger sample size, even over an expanded study area, would reduce the variance. Provided the sampling fraction remains low, the finite population correction factor is close to unity, and the size of the population as such has little effect on the SE of the sampling mean (Cochran 1977). To see why this is so, one need only review the equation for the variance of the sample mean: $var(y) = (S^2/n)(1-f)$, where S is the SE of the sample, n is the sample size, and f is the sampling fraction. As an example, the Koyukuk NWR achieved an overall CV of 15% using almost identical methods in their 1987 survey. They sampled 31 plots of 2.6 km^2 to estimate the population on the 8,000 km^2 refuge. Notice that the sampling density of 1% is less than that used on the BLM study areas (8-9%), and yet, variance is halved. Expanding the study area and the number of samples is the preferred method to reduce variance as it increases both the quantity and quality of information, however it also increases the cost.

Most of the variation in the stratified mean broods for the Pah Flats survey came from the moderate stratum (80%) while in the McCarthy's Marsh survey, the moderate and key strata each contributed about 40%. The values obtained for variation within strata this year will allow better allocation of samples among strata next year. Using the Neyman allocation formula gives:

$$n_i = n(N_i o_i / \Sigma N_i o_i) \qquad \text{(Scheaffer 1986)}$$

where n_i is the sample size for stratum i, N_i is the number of plots in stratum i, n is the combined sample size from all strata, and o_i is the standard deviation of stratum i, estimated by the SE of the sample. This formula assumes the cost of sampling is the same for each stratum, which is not strictly true in this case, but the cost of access varies more between individual plots than between strata. Using this method, equal numbers of samples should be taken from key and moderate strata in the Pah Flats, if there are no other changes in the design or the population. Of course the population of broods is likely to vary considerably between years, so this must be used as an approximate guide. It appears that optimal allocation of samples for McCarthy's Marsh would be 6 key, 5 moderate, and 2 poor, if sample size remains the same. By using this allocation, it is theoretically possible to obtain a CV of 12.5% with only 13 samples, if the mean number of broods remained constant.

A third method for reducing variation concerns the sample units themselves. It may be that there is too much natural variation among plots, in spite of stratification efforts, when sample sizes are small. The number of waterbodies on a plot was correlated with the number of broods (r = 0.75). Therefore, a combined ratio of broods/waterbody may be used to produce a more precise estimate of total broods. Regressing number of broods against number of waterbodies with the McCarthy's Marsh data produced the regression equation: broods = (0.797) waterbodies, with P = .002 (t = 3.89). When brood numbers are expanded using waterbodies, the result is 619 broods produced in McCarthy's Marsh with a SE of 160 broods, CV 26% (Table 7). All pond numbers shown here are based on map interpretation. Use of aerial photos, or other techniques, might provide better approximation of ponds and a stronger relationship with number of broods. Use of broods/unit shoreline might prove to be a more satisfactory correlation with a smaller variance than broods/pond. Thus, it may be possible to obtain a more reliable population estimate without changing the survey scope, using a combined ratio estimate of the total.

There were numerous observations of "broody" hens, i.e., single hens exhibiting aggressive or decoy behavior but a brood was not seen. We assumed all such hens to have a hidden brood of four young. Ideally, the brood size assigned to broody hens should be the average size observed in a specific locale and year for the particular species. However, in a small study, average brood sizes are subject to wide variation and may not be representative (see Results). Also, the brood size is highly dependent on the age of the brood, as mortality is much higher early in brood-rearing. The amount of error introduced by the treatment of broody hen observations is unknown. The reasons for large numbers of broody hen observations might include cover type, time of day, weather influences, or experience of the observers.

In considering the population estimates derived from this type of brood survey, several limitations must be kept in mind. There is no consideration for young raised before or after the date of survey, nor for mortality of observed young. Sightability is assumed to be 100%, although we know that it is considerably less. Such factors as wind, time of day, vegetation type, the observer's experience and cloud cover all affect sightability.

Estimation of sightability by intensive survey (overnight observation) of selected plots was undertaken by the the Koyukuk NWR staff in 1989 and 1990 (Mark Bertram, pers. commun.).

In conclusion, inventories are perhaps the single most important waterfowl management tool available to BLM Alaska at present. Baseline data on breeding grounds, including production and habitat characteristics, are essential to determine the effects of resource development, including mining, grazing, and oil exploration, as well as to understand the effects of natural phenomena such as flooding and fire. Because waterfowl breeding populations are highly variable, careful consideration must be given to design of surveys so that they can be accomplished efficiently and economically.

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