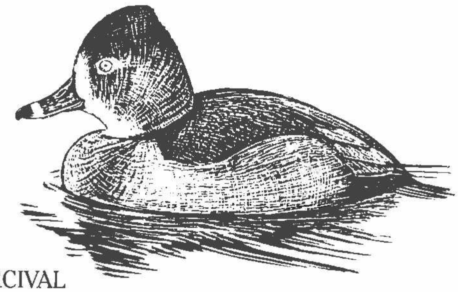
Time and energy budgets of wintering Ring-necked Ducks *Aythya collaris* in Florida, USA



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We developed a time budget from 220.5 hours of observations of Ring-necked Ducks wintering on four wetlands in north central Florida. Foraging and resting were the dominant activities occupying 30-40% and 39-42% of the 24-hour period, respectively. Most foraging occurred during the three hour periods following sunrise and preceding sunset. Maintenance behaviour composed 4-9%, swimming 4-8% and alert behaviour 4-7% of diel activities. Other behaviours, including flying, aggression and courtship, were less than 1%. No differences in behaviour partitioning were detected among years or months, or between sexes, but time budgets differed among time periods. Time males spent in alert behaviour was associated with wind direction and habitat type, and time males spent swimming was associated with habitat type. Two methods were used to estimate daily energy expenditure (DEE), which varied from 123 to 169 kcal/bird/day. Ring-necked Ducks would need to consume 3,370-4,170 Hydrilla verticillata tubers per day to meet these energy requirements.

Key words: Energy Budget, Florida, Ring-necked Duck, Time Budget, Wintering

More than half the Ring-necked Ducks *Aythya collaris* in the Atlantic flyway winter in Florida (Bellrose 1980) and they provide more than 30% of the state's annual waterfowl harvest (Novara *et al.* 1981). Population status of Ring-necked Ducks in the southeastern United States appears stable (Montalbano *et al.* 1985), but limited biological data preclude use of specific management programmes other than harvest regulation. The rapid human population increase in Florida (Terhune 1983) will place further demands upon the state's wetlands. Therefore, if Florida is to remain an important wintering area for Ring-necked Ducks, information on how and why these ducks use Florida wetlands will be vital for future management.

Time and energy budgets are methods which can be used to provide biological data for management. Our study objectives were to determine diel time budgets and to estimate energy bugets of Ring-necked Ducks wintering in Florida from arrival in November to departure in March.

Study area

Observations of Ring-necked Ducks were obtained on four wetlands in north central Florida: Rodman Reservoir in Putnam County, Orange Lake in Alachua County, Paynes Prairie in Alachua County and Lake Sampson in Bradford County. Most observations were made at Rodman Reservoir, which was formed by damming the Oklawaha River as part of the Cross Florida Barge Canal. Rodman Reservoir has developed into a 3,500 ha wetland that can be classified (Cowardin *et al.* 1979) as a lacustrine, limnetic, aquatic bed system which contains four deep marsh areas. Deep marsh areas were characterised by dense stands of submergents, including Hydrilla *Hydrilla verticillata*, a pondweed *Potamogeton illinoensis*, Hornwort *Ceratophyllum demersum*, while Spatterdock *Nuphar lutea* and Pickerelweed *Pontederia cordata* were the dominant emergents. Orange Lake is a large (4,921 ha), lacustrine, aquatic bed lake (Cowardin *et al.* 1979) of which approximately 30% is deep marsh, similar to the deep marsh at Rodman Reservoir. Limited observations were also obtained from deep marsh areas at Paynes Prairie (1,737 ha) and Lake Sampson (826 ha).

Methods

Time budget

A 24-hour time budget was developed from observations of individual Ring-necked Ducks and flocks as large as 320 birds, during 141 hours of observation from early November to mid-March 1983-84, and 66.5 hours from early November to mid-March 1984-85. Groups were scan sampled (Altmann 1974) every ten minutes. Flock size was assumed to be the maximum number of males and females encountered during all the scans. We recorded sex and behaviour of each bird encountered during the scan on cassette tape. These data were later transcribed and coded. Recorded behaviours included dive (submerged or submerging), dive pause (on the water surface between dives), loaf (resting with head drawn low so the lower mandible rested on the breast feathers), preen (any feather maintenance activities), sleep (resting with mandibles tucked under the scapular feathers), alert (neck outstretched), fly, swim, aggression (bill thrusts or actual grabbing of another bird), courtship (displays as reported by Johnsgard (1965)), flight intention movements (head pumping), dabble, comfort activities (stretch, shake, or wing-flap), drink, or bathe. Numbers of birds joining or leaving the flock were recorded as they were observed.

Observations were made from an airboat, a jonboat with a seat mounted on a 2 m stepladder, and from a canoe. Prior to all observations, the boat was anchored in an area known to be used by Ring-necked Ducks, and birds allowed to settle for at least 30 minutes. A 15 x 60x spotting scope and a night vision scope were used for diurnal and nocturnal observations, respectively.

The day was divided into four periods: 04.00-10.00, 10.01-16.00, 16.01-22.00 and 22.01-04.00. During the 1983-84 field season, the dates and periods for data collection were predetermined using a random number table. During January and February 1983 and the 1984-85 field season, entire days rather than periods were predetermined from a random numbers table. Days rather than periods were chosen to obtain maximum data, because disturbances often resulted in little or no data taken during the chosen periods in the previous year. At the beginning and end of each observation period, ambient temperature, wind direction, wind velocity, moon phase and the two dominant plants in the area were recorded. During January and February 1983, dive and dive-pause times were recorded as well as water depth where Ring-necked Ducks were foraging.

The original periods were changed for analysis. Because Ring-necked Ducks exhibited different diurnal and nocturnal activity patterns, periods one and three were divided into diurnal portions (from 06.00-10.00 and 16.00-18.030, respectively) and nocturnal portions (from 04.00-06.00 and 18.30-22.00, respectively). Nocturnal portions of periods one and three were combined with period four to produce the nocturnal portion of the time budget, as well as estimates of the hours per day spent foraging.

Activities were pooled for analysis of time budget and development of energy budgets. Categories used included foraging (dive, dive pause, drink, dabble), swimming, flying (fly, flight intention movements), resting (sleep, loaf), comfort activities (preen, comfort, bathe), courtship, aggression and alert behaviour. The number of observations in each behaviour class for each sex was converted to percentage of the total observations. The UNIVARIATE procedure (SAS Inst., Inc. 1982a) was used to test the normality of distributions of percentages and arcsine transformations of percentages. Not all variables were normally distributed in either test, therefore behavioural differences among years, months, time periods and sexes were evaluated statistically by ranking the mean monthly percentage of time devoted to different behavioural categories and then using a one way analysis of

Table 1. Multiples of the basal metabolic rate (BMR) used to estimate energy expenditure of waterfowl activities, and sources, used in Equation 1 to estimate daily energy expenditure.

Activity	Coefficient (multiple of BMR)	Source
Swimming	2.2	Prange & Schmidt-Nielson (1970)
Foraging	3.5	Woakes & Butler (1983)
Rest	1.2	Wooley & Owen (1978)
Flying	14.0	Tucker (1969)
Maintenance	2.0	Wooley & Owen (1978)
Courtship and aggression	2.1	Prange & Schmidt-Nielson (1970)
Alert	2.0	Wooley & Owen (1978)

variance that approximates a Kruskal-Wallis test (SAS Inst., Inc. 1982b). Significance level was set at $\propto = 0.05$ for all statistical tests.

Energy budget

Energy expenditure was estimated by two equations:

$$DEE = (BMR) \sum_{i=1}^{k} (AC_i)(PD_i), \qquad (1)$$

where DEE is daily energy expenditure, BMR is basal metabolic rate (65.64 and 69.33 kcal/bird/day for males and females, respectively [C.W. Jeske, unpubl. data]), AC_i is the activity coefficient (multiple of BMR reported in **Table 1**), PD_i is percentage of the day spent in this activity. The activity coefficient represents the energy expenditure, expressed as a multiple of BMR, required for that activity.

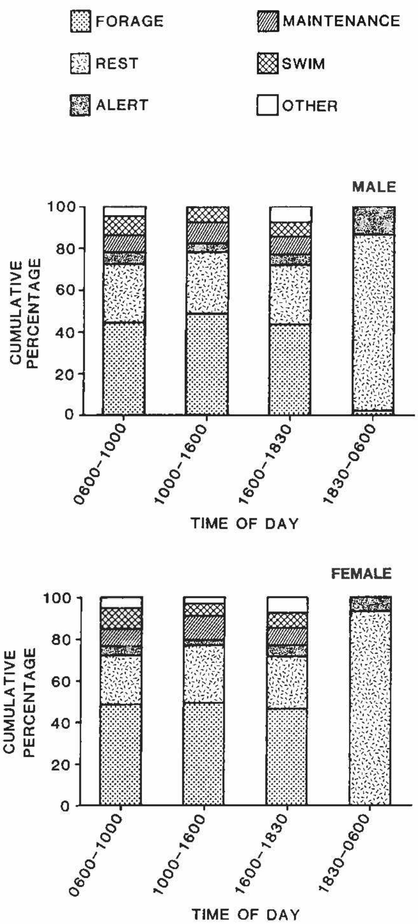

Figure 2. Cumulative mean percent of time periods spent in foraging, rest, alert, maintenance, swim, and other behavioural categories for male and female Ring-necked Ducks.

Table 2. Body mass of wintering Ring-necked Ducks; mean monthly temperature maxima (T_a) and minima (T_{na}) for Gainesville, Florida (National Oceanic and Atmospheric Administration 1983); photoperiod; and Existence (EM_{ta}) and Standard Metabolism (SM_{na}) values were used to estimate DEE by Equation 2.

	Sex	Body Mass (g)	Maxima and Minima Temperature T_a (C)	T_{na} (C)	Photoperiod P (%)	Metabolism[1] EM_{ta} (kcal)	SM_{na} (kcal)
Nov	M	762	23.4	10.2	43	184.52	70.31
	F	672	23.4	10.2	43	173.41	65.23
Dec	M	739	22.2	9.4	41	179.71	70.83
	F	665	22.2	9.4	41	170.52	66.46
Jan	M	750	18.3	5.9	44	174.38	79.35
	F	674	18.3	5.9	44	161.28	66.46
Feb	M	764	21.1	7.4	47	180.76	76.80
	F	710	21.1	7.4	47	174.32	73.49
Mar	M	760	23.7	9.2	50	184.77	72.42
	F	690	23.7	9.2	50	176.30	68.50

[1] Calculated from equation in Peters (1986).

The second method used to estimate DEE was modified from Koplin *et al.* (1980), where:

$$DEE = NSA\ (EM_{ta}) + SA[(BMR)(P)(SC)] + (1\text{-}P)(SM_{tna})\ (2)$$

NSA is the percentage of the day spent in non-swimming activities (**Figure 2**), EM_{ta} is existence metabolism of non-passerine birds for the mean diurnal ambient temperature (**Table 2**), SA is percentage of the day spent in swimming and foraging activities (**Figure 2**), BMR is basal metabolic rate, P is mean monthly photoperiod for 28°N latitude (**Table 2**; Woodbury 1954), SC is the activity coefficient for swimming (3.0 was used because swimming activity included swimming and foraging), and SM_{tna} is standard metabolism of non-passerine birds for the mean nocturnal ambient temperature (**Table 2**).

Mean monthly body masses were determined from 621 wintering Ring-necked Ducks collected between November 1979 and March 1982 (C.W. Jeske & J. Thul, unpubl. data) were used to calculate the standard metabolic rate. We used percentage of day spent in swimming activities instead of flight time because less than 1% of the observations were of birds in flight, but 30% were of swimming and foraging birds.

Observations were missing for period one for December and period four for December, February and March. Consequently, percentages of time spent in various activities for period one in December were estimated as the mean, by sex, of other period values (Jeske 1985). For missing period four values, mean percentages from all observations were used because period four samples were small (total of eight hours observation on four birds).

Results

Time budget

Most of the observations were recorded at Rodman Reservoir. No differences in activity between study sites were observed. Like Hohman (1984b) and Bergan *et al.* (1989) reported, foraging and resting were the dominant activities during the 24-hour cycle (**Figure 2**). (P=0.05). The proportion of activities between periods was different (P=0.05) in the one way analysis of variance using mean ranked percentages, but no difference was detected between years (P=0.54), months (P=0.17), or sexes (P=0.37) contrary to the sex-related difference found by Bergan *et al.*(1989).

Daily patterns of Ring-necked Duck activity did not vary throughout the winter (**Figure 2**). They arrived at diurnal foraging areas approximately 30 minutes before sunrise. The birds settled into small, scattered groups, were alert and preened for a few minutes, then rested until sunrise. Between sunrise and sunset, the birds spent most of their time foraging and resting, with maintenance activities commonly occurring as a transition between those activities. Foraging was most intense in the three hour periods after sunrise and before sunset (**Figure 2**) as reported by Bergan *et al.* (1989). At sunset, most birds ceased foraging, bathed and preened for short periods while forming tightly grouped flocks, and rested until about 30 minutes after sunset. The flocks then became active, swimming and preening for about 15 minutes, and departed for roosts. In 1983-84 and 1984-85, Ring-necked Ducks departed for roosts from Rodman Reservoir toward the southeast or west. We were not able to identify the roost used by most of the birds using Rodman Reservoir, although some of the birds probably did roost on Paynes Prairie or Orange Lake.

We observed arrival at a small roost twice, once on Orange Lake and once on Paynes Prairie. In both cases, single birds and small flocks, smaller than departing flocks, arrived and settled on the water in the vicinity of the roost and swam to the actual roost site. Resting was the most common nocturnal activity. The only other nocturnal activities observed were alert behaviour (generally in response to American Coot *Fulica americana* alarm calls) and drinking or dabbling behaviour.

Courtship, other than isolated "head-throws" (Johnsgard 1965), was not observed until early February 1984 and late January 1985, when formation of pairs was obvious. The intensity of courtship, as measured by the number of pairs engaged in courtship, increased until the birds departed in mid- to late March. Courtship began earlier in 1984-85 than 1983-84, probably as a result of the milder temperatures in December and January 1984-85. The only copulation observed was on 26 February 1985.

Flight activity was underestimated as a result of our inability to follow movements between the foraging areas and the roosts as well as our recording flock activities rather than individual activities. Ring-necked Ducks in this area of Florida probably spend one hour a day in flight. The dominance of foraging and resting in the daily activity cycle overshadows trends in maintenance activities, aggression, courtship and alert behaviour.

The relation (P=0.04) between the primary habitat type and the percentage of time that males spend alert may result from a differential habitat preference between the sexes. Males spent less time alert in Hydrilla habitats than in Spatterdock and Fanwort habitats, where visibility is more limited. Flocks using the exposed Hydrilla sites tended to have a higher percentage of males (77.2 and 79.4 in January and February, respectively). Only 55% of the observations on Paynes Prairie were of males, where the deep marsh is dissected by many floating islands.

Percentage of diurnal hours spent alert by males also was largest when winds were from the east (P=0.01), but were not affected by wind speed (P=0.10). Because most observations were made on Rodman Reservoir, the birds may have been responding either to the wave action of the greater fetch for easterly winds or, more likely, our inability to observe flocks in exposed areas during high winds because only birds in protected sites, primarily Spatterdock habitats, were observed.

Males spent comparatively more time swimming in open water habitats than in other habitat types. Flocks in open water habitats contained mostly males, and the tendency to drift from foraging sites would be greater in open water habitats.

Mean (+SE) dive times and the interval between dives were 18.6 + 4.1 seconds (n=32) and 13.1 + 7.0 seconds (n=32), respectively, for males and 18.3 + 4.5 seconds (n=30) and 14.0 + 7.4 seconds (n=30), respectively, for females. Ring-necked Ducks spent about 32 seconds per dive (dive + dive pause), which converted to a foraging rate of 112.5 dives/hour. Therefore, in the 5.2 to 7.1 hours per day they spend foraging, they dived from 584 to 795 times.

Discussion

Nilsson (1970) defined day-active wintering waterfowl species as mainly diurnal foragers and night-active species as nocturnal foragers. Our results clearly indicate that Ring-necked Ducks wintering in north central Florida are day-active. However, Thornburg (1973) reported few observations of diurnal foraging by fall migrating diving ducks *Aythya* spp., including Ring-necked Ducks, on the Mississippi River. Hohman (1984a) reported incubating female Ring-necked Ducks taking nocturnal recesses, presumably to forage.

Waterfowl wintering along the Swedish coast which foraged mainly on active prey were reported to be day-active, while species which fed primarily on sessile prey were mainly night-active (Nilsson 1970). During extremely cold periods, these latter species also foraged diurnally, probably to compensate for an increased thermoregulatory energy requirements. Percentages of the day spent foraging reported by Nilsson (1970) for Tufted Ducks *Aythya fulgula* and Pochard *A. ferina* on inland lakes were similar to those we found for Ring-necked Ducks. Klima (1966) also found Pochard to be day-active on inland waters.

Several authors (e.g. Hochbaum 1944, Nilsson 1970, Thornburg 1973) believe nocturnal foraging is a response to diurnal human disturbance. Pedroli (1982) argued that nocturnal foraging is not a response to human disturbance, rather, it is a winter adaptation to conserve energy by resting during the warmest part of the day and foraging during the coldest part. Heat produced by foraging activity would compensate for thermoregulatory losses. Tamisier (1976) thought nocturnal foraging by Green-winged Teal *Anas crecca* and Northern Pintail *A. acuta* was a response to avoid avian predation.

Avian predators, including Northern Harriers *Circus cyaneus* and Bald Eagles *Haliaeetus leucocephalus*, frequently hunted waterfowl on Orange Lake and Rodman Reservoir. Most Bald Eagle attacks were directed toward coots. Ring-necked Ducks usually flushed and moved to another site when eagles approached. No avian predation on Ring-necked Ducks was observed, although we observed two coots being captured by Bald Eagles.

Energy budget

Daily energy expenditure (DEE) estimates from **Equation 1**, varied from 123 to 132 kcal/bird/day for males and 134 to 138 kcal/bird/day for females (**Table 3**). Because no significant differences exist among months or the sexes in the daily activity budget, the DEE may be estimated as the mean of the male and female values, or 131 + 5 kcal/bird/day. **Equation 2** produced higher (t=31.2, 18 df, P=0.01) DEE estimates than **Equation 1**. Male DEE estimates varied from 162 to 169 kcal/bird/day and female estimates from 156 to 165 kcal/bird/day (**Table 3**). The mean DEE estimate from **Equation 2** is 162 + 5 kcal/bird/day.

Koplin *et al.* (1980) compared DEE/BMR values from **Equation 2** with estimates from six other studies using **Equation 1**. They found that **Equation 2** produced a DEE/BMR ratio of 3.33. In our study the ratios were 2.5 and 2.3 for males and females, respectively. In six studies that used **Equation 1**, the ratios varied from 1.7 to 3.2. Based on our result, **Equation 1** produced ratio estimates of 1.9 for males and 2.4 for females, which are within the range reported by Koplin *et al.* (1980).

Because scan sampling underestimates flight time, a more accurate DEE estimate may be obtained by assuming that an individual spends one hour a day flying (40 minutes per day spent flying to and from the roost and 20 minutes of flight during the day). **Equation 1** produces DEE values of 161 and 168 kcal/bird/day (using the mean percentages in **Figure 2**), for males and females, respectively. These estimates are similar to those produced by **Equation 2**, which does not separate flight from other activities.

The mean DEE estimates of 131 and 162 kcal/bird/day seem to be met easily by wintering Ring-necked Ducks in north central Florida. The major foods of wintering Ring-necked Ducks on Rodman Reservoir and Orange Lake are Hydrilla tubers and turions, Spatterdock seeds, snails, and dragonfly nymphs (C.W. Jeske *et al.*, in press). Hydrilla tubers, an important food, are an abundant, renewable resource in Rodman Reservoir with an estimated density of 580 tubers/m^2 at water depths of 60 cm (Miller 1975). Ring-necked Ducks would need 3,370 to 4,170 tubers/day (tuber composition in **Table 4**) or 4-6 to 6-8 per dive to meet the mean DEE estimates produces by **Equations 1** and **2**, respectively, if they have an 87% conversion coefficient (Miller 1984). Inclusion of other energy dense foods, such as Spatterdock seeds, would lower this efficiency requirement. Ring-necked Ducks may winter in Florida because of the ease of

Table 3. Daily energy expenditure estimates (from Equations 1 and 2) for Ring-necked Ducks wintering in north central Florida for November through March.

	Daily energy expenditure (kcal/bird/day)			
	Equation 1		Equation 2	
	Male	Female	Male	Female
Nov	132	134	164	159
Dec	128	138	163	156
Jan	123	136	162	153
Feb	123	136	168	163
Mar	128	134	169	165

Table 4. Nutrient composition (Miller 1975) and energy content (Robbins 1983:9) of Hydrilla tubers, a major food of Ring-necked Ducks wintering in north central Florida.

Nutrient	Dry weight (%)	Energy content (kcal/g)
Starch	46.80	4.23
Crude protein	5.30	5.65
Lipids	1.00	9.45
Sucrose	4.17	3.96
Other sugars	0.39	3.75
Ash	42.34	0.00

acquiring energy-rich foods, such as Hydrilla tubers and Spatterdock seeds, in a mild climate.

Management implications

Human disturbances probably influence diurnal activity patterns and habitat selection of Ring-necked Ducks. The Florida waterfowl season opened the third Wednesday in November and closed the third Sunday in January with a five day hiatus in early December. Rodman Reservoir and Orange Lake are heavily hunted when Ring-necked Ducks are present. Low Ring-necked Duck populations on Orange Lake during the 1983-84 and 1984-85 seasons resulted in lower hunting intensities than in previous years. In both years, waterfowl and hunters concentrated on Rodman Reservoir. In 1983-84, most Ring-necked Ducks left Rodman Reservoir during early December because increased hunting pressure excluded them from most of the available foraging sites. In 1984-85, hunting pressure on Rodman Reservoir again was high, but the spread of Hydrilla to areas that were not hunted heavily nor fished north of the dam provided secure resting and foraging areas. By the end of the hunting season, about 26% of the Ring-necked Ducks on Rodman Reservoir were using that area. Ring-necked Ducks apparently will remain on a lake with intense hunting pressure if refuge areas are available.

Wintering Ring-necked Ducks are often disturbed by fishermen, who are common on Florida lakes throughout the winter. Although Ring-necked Ducks may develop a tolerance for fishing boats, we believe that fishing activity increases the amount of time that Ring-necked Ducks spend flying, as well as reducing their use of certain areas for foraging and resting. Waterfowl use of a South Wales lake was influenced by winter recreation and suggests that exclusion of boats from a quarter of the lake was sufficient to encourage the birds to remain on the lake without affecting the recreational opportunity Tuite *et al.* (1983).

Chemical treatment of submerged vegetation, particularly Hydrilla, may be detrimental to Ring-necked Duck populations. Hydrilla reduces wave action and discourages boaters, as well as being an important component in the diet of Ring-necked Ducks wintering in Florida. A balance between the needs of recreational boaters and wintering waterfowl may be to treat boat channels, or specific areas, rather than attempting to eradicate submergents from the lake. For example, on Rodman Reservoir, the Barge Canal Channel could be treated for Hydrilla, but the four areas used heavily by Ring-necked Ducks (**Figure 1**), as well as coots and Pied-billed Grebes *Podilymbus podiceps*, should not be treated if managers want these species to continue wintering on the Reservoir. Although Hydrilla is an exotic plant and thought of by many as a pest, it may mitigate some attributes lost by drainage and man-induced alterations of Florida wetlands.

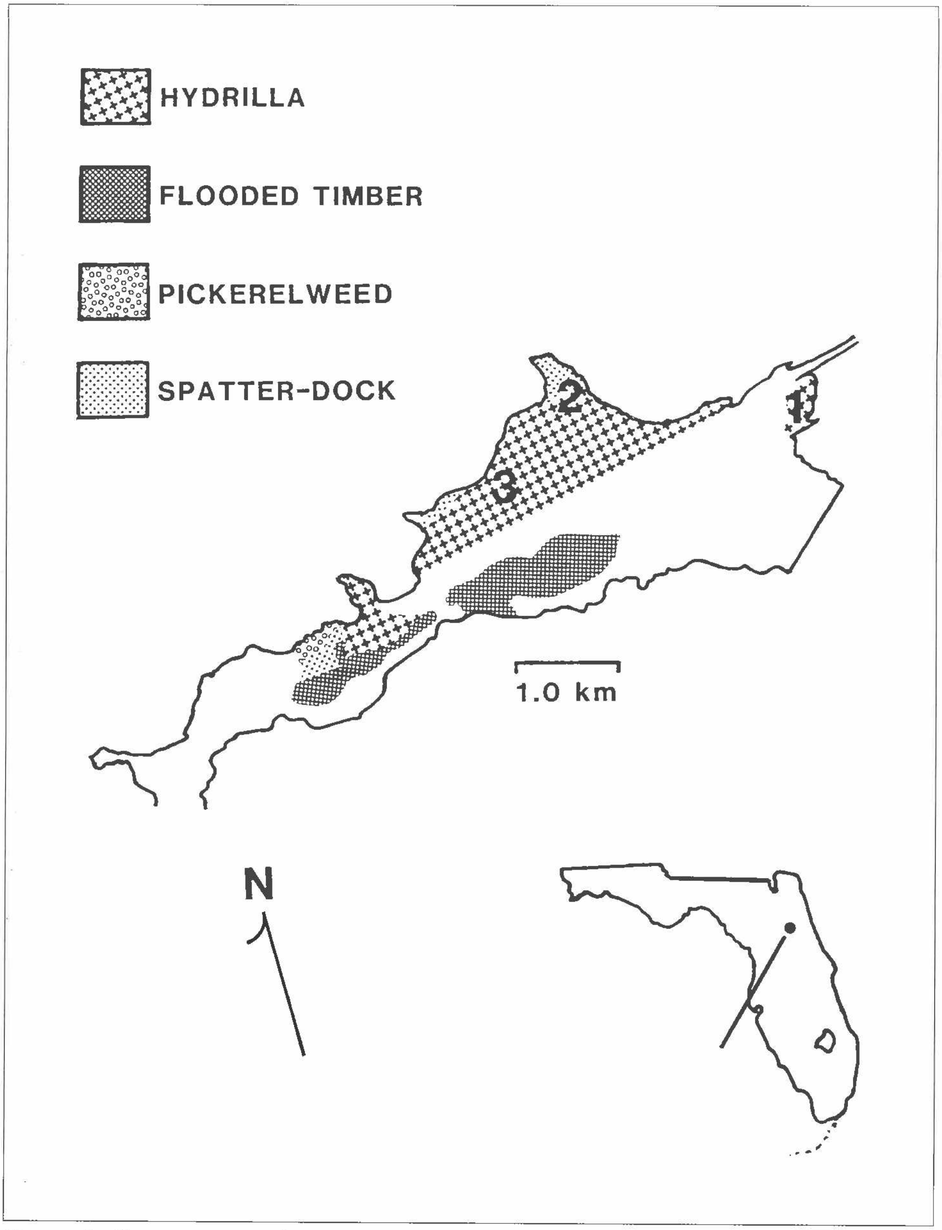

Figure 1. Cover types and areas traditionally used by Ring-necked Ducks on Rodman Reservoir, the main study area.

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