BLACK TERN (*Chlidonias niger*) POPULATION LEVELS AND NEST SITE SELECTION IN VERMONT, 1994.

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INTRODUCTION

As part of ongoing research into the population status of the black tern (Chlidonias niger) in Vermont, two projects were undertaken in 1994. These consisted of a complete census of known breeding areas in Vermont, and a preliminary assessment of habitat preferences within the marshes where black terns nest. The census was part of a regionwide effort to monitor the population trends of this rare and declining marsh nesting bird. Black tern researchers in the Northeast agreed to perform a regionwide census every three years, starting in 1994.

Selection of nesting habitat by marsh-nesting birds in general, and black terns in particular, can occur at several different levels. Burger (1985) describes these levels as: general habitat, territory, and nest site, whereas Knutson (1991) uses four levels: regional, marsh, colony, and nest site. A more appropriate description for black terns might be:

regional: that portion of the species' range to which it returns to breed.
general habitat: selection of marsh habitat as compared to upland, montane, arboreal etc.
marsh: selection of the individual marsh where breeding will be attempted.
colony site: that portion of the marsh where the nest(s) will be constructed.
nest site: the specific location where suitable nest substrate is found and the nest is constructed.

Previous studies of black terns have described nesting habitat as follows: The marsh should be greater than five hectares (ha) if part of a marsh complex, or greater than 10.9 ha if an isolated marsh, and it should be in the "hemi-marsh state" meaning 40 to 60 percent open water (Brown and Dinsmore 1986). The major vegetation types vary from marsh to marsh, but they are generally emergent marshes dominated by one or more of the following: cattail, bulrush, or burreed. Open water and emergent vegetation should each comprise about 50 percent of the marsh, with large pools and plentiful perches (Novak 1990). The nest should be located at least 25m from shore, less than 4m from open water, in relatively less dense and shorter vegetation, in water less than 2m deep, and with plentiful muskrats (Bailey 1977,

Cuthbert 1954, Dunn 1979). The nest itself is usually a shallow cup built about 3-8 cm above water level of whatever vegetation is in the immediate vicinity. The nest substrate is usually an old muskrat lodge, floating mat of dead vegetation, floating cattail rootstalks, or log (Bailey 1977, Bergman et al. 1970, Cuthbert 1954, Knutson 1991).

This research proceeds from the assumption that black terns are marsh nesters, and that they will return to the same marsh where they were born or where they have nested previously, if the conditions are suitable. This study aims to address the question of whether there are large-scale structural characteristics within a given marsh for which the black terns are searching when they select a colony or nest site. This could have important implications with regards to vegetation and water level manipulations if one is interested in managing for this species. The difficulty with describing the colony characteristics is the inaccessibility of these marshes. In order to describe vegetation structure within a marsh the preferred technique is generally to use transects or random plots throughout the marsh. Accomplishing this during the nesting season would be extremely disruptive to the terns and other nesting species present. An alternative would be to do the vegetation assessment either before or after the nesting season, but because the vegetation changes drastically throughout the summer in these marshes the results probably would not be representative of the conditions during nest selection. In order to avoid the above problems aerial photographs taken at the time of nest selection were used to assess landscape level colony site selection. This technique provides an overall view of the marsh, its' vegetation structure, and the interspersion of vegetation types and open water. Actual nest sites located on the photos would be compared with random points within the vegetation of the marsh. In this way actual versus potential nest site characteristics can be compared, the hypothesis being that black terns are selecting nest sites non-randomly with respect to potential sites within each marsh.

STUDY AREAS

The study areas for the black tern census are made up of all of the known black tern nesting areas in Vermont. The locations of these areas have been described in detail elsewhere (Shambaugh 1992); the general locations can be found in Figure 1.

The study areas photographed from the air for the habitat assessment were those within the Lake Champlain basin: Dead Creek Wildlife Management Area (WMA), Little

Otter Creek, Cranberry Pool (Missisquoi National Wildlife Refuge (MNWR)), Goose Bay (MNWR), Charcoal Creek, and Mud Creek WMA. These areas contain greater than 90 percent of the known black tern nests in Vermont. They cover the range from essentially pure cattail marshes (Dead Creek, Mud Creek) to mixed emergent marshes (Charcoal Creek, Little Otter Creek, and Goose Bay) to buttonbush swamps (Cranberry Pool). They also range from lakeshore marshes (Goose Bay), to riverine marshes (Little Otter Creek, Charcoal Creek), to actively managed impoundments (Cranberry Pool, Mud Creek, Dead Creek). Because of this variability of wetland types it was hoped that some generalization could be made about nesting habitat preferences. Unfortunately, as described below, due to the unusually high water levels in Lake Champlain during the summer of 1994 most of the normal black tern nesting areas in the Champlain Basin were under water during much of the nesting season. Therefore, the only aerial photographs which were suitable for the present study were those at Dead Creek WMA and Cranberry Pool, both impoundments not directly influenced by lake levels.

The Dead Creek nesting area is made up of a stretch of Dead Creek in Addison County Vermont dominated by the Dead Creek WMA. The portion of the WMA where black terns nest is about a six km stretch of the main channel of Dead Creek bordered in places by dense cattail beds. It is bisected by the Stone Bridge Dam, a small dam which serves to keep upstream water levels elevated by several feet. The upstream section is managed at optimal depths for waterfowl, while the downstream section is unmanaged and the water levels fluctuate naturally. The cattail beds in the managed portion are very dense, essentially single species stands, presumably because cattails proliferate under the more constant water level regime. Emergent vegetation in the unmanaged portion is also dominated by cattails, but the beds are somewhat less dense, presumably because the water levels do fluctuate more. The Vermont Dept. of Fish and Wildlife plans to drain the area above the Stone Bridge Dam at some point during 1995. The purpose of this drawdown is to reduce the cattail growth by drying out the beds and then crushing them with a bulldozer. This will hopefully lead to less dense cattail stands with a better interspersion of open water and improve the habitat not only for migratory waterfowl, but also for nesting birds such as black terns.

Cranberry Pool is a 220 ha marsh/swamp at the mouth of the Missisquoi River in Franklin County within the Missisquoi NWR. This area was created in its current form in 1970 when a series of dikes were built around a portion of swamp bordering Cranberry Creek. The open portion of this wetland

is dominated by buttonbush, burreed, and wildrice while part of it is still maple swamp. This wetland is managed to maintain a 0.5-1.0m water depth for waterfowl production. Cranberry Pool is currently managed on a five-year cycle, such that every fifth year the water level is maintained at a greater depth in order to give the emergent vegetation a rest from waterfowl grazing (Gallegos 1986).

METHODS

The census techniques utilized are the same as those described previously (Shambaugh 1992). In brief, all areas are censused by canoe during the incubation period, nests are located when possible, if not then the number of adults are counted.

Color infra-red aerial photos were taken of Dead Creek WMA, Little Otter Creek, Mud Creek WMA, Charcoal Creek, Cranberry Pool, and Goose Bay at a scale of 1:5000 (1cm = 50m) on June 4, 1994 by James Sewall & Co. (Old Town, ME). Nine by nine inch prints were made and delivered to the author on June 14, 1994. All areas were then censused with photos in hand. Nest locations, vegetation types, and any observable landmarks such as muskrat and beaver lodges, and duck blinds were marked on the photos while the census was taking place. Photos were taken of each nest, and vegetation within a two meter radius circle was described.

After the census was complete, adjacent photos were spliced together to make a composite photo of each marsh. At Dead Creek and Cranberry Pool, where detailed habitat descriptions were performed, clear acetate overlays were made with the location of each nest marked. Using a random numbers generator, random spots were located on each overlay. The random points were located by using two random numbers to determine percent distance from the south and west sides of the marsh respectively. Only those points within or immediately adjacent to vegetation were deemed to be potential nest sites and included in the analysis (40 for Dead Creek, and 50 for Cranberry Pool).

At each spot on the overlay, both nest site and random point, a series of measurements were made as described in Table 1. These parameters were chosen to gather as much information as possible from the photos about the distribution of distinguishable habitat characteristics. When more than one vegetation type was distinguishable each was assessed separately. Measurements were made with either a ruler or illuminated lupe with contact reticle (Peak model no. 2028), depending on the distance (ruler for greater than 1cm, lupe for less than 1cm). The percent composition of

vegetation and water were estimated by eye within different diameter circles around each point using a circle template (Berol Rapidesign R-140 Template). Due to the small number of nests, and skewed distribution of the measurements, non-parametric statistics were used to assess differences among populations. The Kolmogorov-Smirnov (K-S) test for the difference between two distributions was chosen. This test is sensitive to differences not only in the mean, but also variance, distribution, skewness, etc. (Sokal and Rohlf 1981).

Cover maps were made identifying marsh perimeter, water, and major vegetation types at each marsh on clear acetate overlays. That portion of each marsh made up of water was further segregated into open water and other water. Open water was defined slightly differently at the two marshes. At Dead Creek, open water is made up of the main channel of Dead Creek, all side channels and pools within the vegetation were defined as other water. At Cranberry Pool open water is defined as that portion of the original Cranberry Creek channel which stays open the longest during the summer, based on personal experience and the aerial photos (see Figure 5). The areas making up each vegetation type, open water, and other water were cut out and weighed to estimate the percent distribution of these cover types for each marsh as a whole. Attempts were made to determine the amount of interspersion between vegetation and water, but it was deemed not feasible without a computerized GIS system due to the large number of small patches of water and vegetation.

Shortly after the June 4 photos were taken, the Charcoal Creek area developed suitable nesting habitat, and a large number of black terns built nests there. Therefore on June 23, the author flew over the Missisquoi National Wildlife Refuge area in an effort to get useable 35 mm pictures of Charcoal Creek during nesting. These photos were sufficient for identifying nest sites and general descriptive analysis, but not for making measurements of habitat because the scale is unknown (see Figure 2).

RESULTS AND DISCUSSION

Lake Champlain water levels during the spring and summer of 1994 were unusually high. The lake crested May 1, at near record levels of over 101 ft. It then gradually decreased until it was at about 99 ft. on June 1, approximately 1.5 ft. higher than average for the beginning of June (Gallegos 1986). Starting in mid-May weekly visits were made to various nesting areas to observe when the terns would start to nest given the unusual water conditions. Since the

Vermont Dept. of Fish and Wildlife was interested in gathering as much information as possible about Dead Creek before the planned drawdown, it was decided to concentrate on this area. Black tern nesting generally starts in late May in Vermont, and when the Route 17 area of Dead Creek was visited on June 1, eggs were found. As nesting was clearly underway, the color infra-red photography flight was scheduled to proceed as soon as possible. The flight occurred on June 4.

When the photos were received on June 14, it was immediately clear that many of the tern nesting areas in the Champlain Basin were still totally under water and that terns would not be nesting at these sites soon. In fact, black terns did not nest at Little Otter Creek until early July, about a month later than normal, and did not nest at all below the Stone Bridge Dam on Dead Creek. At Charcoal Creek there was no available nesting habitat at the time the photos were taken but by June 15 nesting had started. Because of this an attempt was made to take additional aerial photos of Charcoal Creek to gather at least some vegetation information for this area. By June 26 there were about 31 active nests at Charcoal Creek North. These nests were located on the photo taken the week before (see Figure 2) but no statistical analysis is possible because distances could not be measured.

CENSUS RESULTS

As can be seen from Table 2 the overall numbers of breeding pairs in Vermont dropped by about 20 percent from the last complete census in 1992, to a total of approximately 74 pairs. This is probably due to the high water levels as discussed above. Of the areas showing a significant decline, all are directly under the influence of lake fluctuations. It is possible that some black terns shifted to new, unknown nesting areas so this population count may be an underestimate. At Mud Creek, the black terns nested within cattails which were inaccessible, as occurred in 1993 so the number of breeding pairs had to be estimated. Again this is presumably due to the high water levels, as there was no available nesting habitat in the main pool when the photos were taken, and when nesting was initiated.

If one looks at individual colonies, it is clear that Charcoal Creek North, Mud Creek, and Cranberry Pool are the major breeding areas for black terns in Vermont. There appears to be some shifting among areas from year to year, but these three colony sites generally account for more than 50 percent of Vermont's nesting pairs. Again it is important to note that the Panton Rd, West Rd, and Goose Bay sites had

no suitable nesting areas during the whole month of June and were not utilized during the 1994 breeding season. The one nest found at Goose Bay was actually not within the bay at all, but on the other side of the dike in Goose Bay Pool. This was not a confirmed nesting attempt because no eggs or young were observed. There had obviously been a nest built and a pair of terns defending it, but no eggs had been laid at the time of the visit.

The South Bay colony size decreased to just two breeding pairs, and appears to be headed towards elimination. It is possible that the terns have moved their nesting area elsewhere within the Lake Memphremagog area and I have not yet found it. This possibility will be investigated in more detail in 1995. If the breeding population at Lake Memphremagog is eliminated it will probably not be re-established easily because there are no other known colony sites nearby. The nearest known site is at Missisquoi National Wildlife Refuge, approximately 70 aerial kilometers away.

As mentioned above, the total Vermont black tern population appears to have declined by about twenty percent in two years. It is hoped that this is simply due to the high water levels in 1994 causing either displacement or lack of nesting in a significant numbers of terns. The five year trend for the Dead Creek population unfortunately suggests a long term decline. As can be seen in Table 2, the total number of nesting pairs at the south end of Lake Champlain has declined from 18 pairs in 1990 to nine pairs in 1994. The major portion of this drop was in 1994, so again it may simply be due to the water levels, but further monitoring is warranted.

GENERAL HABITAT DESCRIPTION

The aerial photos taken for this study were color infra-red at a scale of 1:5000; this scale was selected to maximize the amount of detail and for ease of matching with ortho-photo maps. As is the case with most aerial photography the photos were taken with sufficient overlap to enable stereoscopic viewing, although this was not necessary for most of the current study because the habitat is essentially two-dimensional. The scale was sufficient to identify with ease individual muskrat lodges and other objects with a diameter larger than about 2m. Different vegetation types could clearly be discriminated by their spectral signature.

The two nesting areas which were utilized by black terns for nesting at Dead Creek in 1994 were above the Stone Bridge

Dam (at West Rd.), and therefore not directly influenced by Lake Champlain water levels (see Figure 3). These colonies: Route 17 North, and Route 17 South are on either side of Route 17 as the name implies. This portion of Dead Creek consists of a narrow, winding main channel bordered on one or both sides by dense stands of cattails. There is a large amount of muskrat activity in this area, with muskrat lodges clearly visible on the photos. The study area encompassed by this project extends from the dams creating the Brilyea ponds in the south, downstream to the end of the cattail beds about 1.4 km north of Route 17 (see Figure 4). From this point downstream to Stone Bridge Dam at West Rd., there are no more significant beds of emergent vegetation. The Route 17 South colony site extends about 1.2 km, and contains approximately 24% open water (defined as the main channel and adjacent water), 56% cattail beds, and 20% other water (defined as side channels and openings within the cattails). The Route 17 North area extends about 1.4 km, and has similar composition, being 31% open water, 52% vegetation, and 17% other water. Vegetation (cattails) makes up 54% of the total Dead Creek study area with water making up the remainder (28% of which was open water overall).

Cranberry Pool is quite different from Dead Creek in many ways, being an impoundment with essentially no cattails present, surrounded by swamp. The wetland as a whole measures about 220 ha (Gallegos 1986) with part being maple swamp, part buttonbush/snag margin, part open wetland. The portion defined as Cranberry Pool for the purpose of this study is that visible as wetland from aerial photos, i.e., excluding the maple swamp. The character of this wetland changes dramatically during the summer months. In May it almost looks like an open pond, with no emergent vegetation and some buttonbush apparent. By June the buttonbush is starting to green up and emergent vegetation, primarily burreed, is starting to appear. By July the emergent vegetation, burreed and wildrice, has proliferated and open water is not obvious. By August, the whole wetland looks like a wet meadow, dominated by tall wildrice, with very little water visible.

At the time of nest-site selection, late May and early June, open water and buttonbush are the dominant features, but burreed mats are becoming common in certain areas. At the time the aerial photos were taken the marsh consisted of approximately 82% water (of which 22% is open water), and 18% vegetation (15% buttonbush, 3% burreed). While it is clear that this is a very different type of wetland than Dead Creek, both are suitable for, or at least useable by, black terns.

Individual nests, when located, were plotted on the photos during the census, and these locations can be seen on Figures 4 and 5. It can be seen that there were not large numbers of nests at either location, but that most of the nests cluster at Route 17 North, and in the eastern part of Cranberry Pool.

DEAD CREEK

From Table 3 it can be seen that at Dead Creek the only significant difference ($p=0.05$) between nests and random locations is in the distance to open water. Nests are much closer to the main channel than is the case for random points. The maximum distance to open water from any nest was 30m, while for random points it was 300m. Some interior portions of the cattail vegetation were impenetrable by canoe because they were so dense, so it is possible that the nest results are biased. I am convinced this is not the case because there were few enough black terns present in the area that I believe I accounted for all nesting pairs. Figure 4 shows the vegetation distribution within the Route 17 study area and which areas were found to be suitable nesting habitat by this analysis. Suitable nesting area at Dead Creek is defined as that portion of the cattail mat within 30m of open water, the maximum distance of any nest to open water, and is depicted in red in Figure 4.

CRANBERRY POOL

Cranberry Pool has a much more interesting set of results of the habitat analysis as can be seen in Table 3. The distance to the nearest nest is much closer for nests, as compared to random points (mean = 49m vs. 767m), as would be expected of a semi-colonial species. The distance to the nearest marsh edge is also significantly different, being about twice as far for nests (mean = 358m vs. 179m). This may be an indication that black terns prefer to nest in the center of marshes, or it may be due to the fact that they prefer burreed, which is found primarily in the center of the marsh. There is insufficient data to distinguish these two possibilities.

At several levels it is apparent that the presence of burreed is important for black terns at Cranberry Pool. Nests are closer to burreed than random, and have a greater percent burreed present at both the 45m and 70m circle scales. Burreed is not present at all nest sites, but it is always nearby. On the other hand, buttonbush was found to be present at all nest sites, even though this is not illustrated by the statistical analysis. It therefore appears, at the

resolution of these photos, that burreed must be present in the vicinity, although nests are actually built in a buttonbush patch. The information collected at the nest sites backs up this data. All eight nests were within buttonbush patches, but they were either associated with small patches of burreed, or burreed debris which had drifted amongst the buttonbush. Based on this data one can make an estimate of the suitable nesting area within Cranberry pool (see Figure 5). In Figure 5 that portion of the buttonbush which is within 33m of burreed (the maximum distance from any nest to burreed) is deemed suitable and colored in red. Of course this is a rough estimate because of the very limited number of nests.

Based on the characteristics of the marsh as a whole, and the known biology of black terns, it is possible to explain this relationship. Because black terns use only vegetation available in the immediate vicinity of the nest site for nest building, they must build somewhere near burreed which is the only major source of suitable nesting material in the area. Buttonbush is a woody plant so it is not suitable nesting material. Because the marsh has such a high percentage of water, debris and dead vegetation tends to be pushed by the wind until it gets tangled up in buttonbush, the predominant plant form. The windblown debris makes an excellent nest substrate and is often where black tern nests are found within Cranberry Pool.

MARSH COMPARISON

Using the habitat characteristics measured at nests and random points at the two marshes, a comparison was made of the two areas. In this analysis similarities were looked for rather than differences by using the K-S statistic to determine which parameters were significantly different, any parameter not significantly different can be defined as similar. The only variable which was not significantly different between the random points at the two marshes, was distance to open water, again defined as the main channel or that portion which remains open the longest during the summer. All other parameters used to compare random points at the two marshes showed a significant difference and were therefore not similar. This information, in conjunction with the percent open water at the two areas (28% at Dead Creek, and 22% at Cranberry Pool), indicates that both the amount and dispersion of open water at the two areas is similar. Everything else about the two marshes is quite dissimilar. At Dead Creek, vegetation makes up a majority of the rest of the area, while Cranberry Pool is dominated by an interspersion of water and buttonbush.

A comparison of nest-site parameters at the two marshes

finds several similarities. The distance to open water and to the nearest water are both not significantly different. The percent of water and vegetation at the 45m and 70m diameter levels were also similar. For both of these size circles, the terns appeared to be selecting for areas with about equal amounts of vegetation and water. At Dead Creek they selected areas with less vegetation than average, while at Cranberry Pool they selected areas with more than average. This indicates that it is not just distance to water but also interspersion of water and vegetation which is important in nest site selection. It is clear from this that having water nearby is very important, that dense homogeneous stands of any vegetation are selected against. The fact that having water very nearby is important is clearly seen in the photo of Charcoal Creek as seen in Figure 2. The nests are not necessarily right next to the open water, but most of them are at the edge of the mat and therefore near some water. This is the case even though the vegetation on most of these mats is relatively sparse and less than 25cm tall. Presumably this is because the birds are selecting areas with easier egress for themselves and their young later in the nesting season, when the vegetation is much taller and more dense. This is also apparent at Dead Creek, where the portion of the marsh where black terns historically have nested in highest numbers (the northernmost nests in 1994), is an area of relatively more water and less dense cattails. The young leave the nest within several days of hatching and spend considerable time swimming, so access to water would be important.

The interspersion of water and vegetation appears to be very important in the selection of nest sites. This information is available on the photos taken for this study, but it proved impractical to try to measure it without the aid of a computer.

CONCLUSIONS

1994, being an unusually high water year in the Lake Champlain Basin, limited the usefulness of the aerial photography for this study to the marshes at Dead Creek and Cranberry Pool. Because of this high water many of the traditional black tern nesting areas were unavailable in 1994. A decrease in the number of breeding pairs found in Vermont to about 74 pairs is an indication that either the birds are not nesting, or that they found other areas which were not surveyed. Data from 1993 indicate that large numbers of birds may not nest during high water years (Shambaugh 1993).

The comparison of nesting habitat indicates that the amount and dispersion of water in a marsh is critical in the choice of nesting area. Open water must be available nearby, but it may not need to be as close if there is a lot of other water nearby. This is indicated by the fact that the distance to open water was five times greater at Cranberry Pool than at Dead Creek. Tern nests are preferentially found at or near the edge of vegetation mats. This is presumably for ease of access by both adults and young later in the season when the vegetation can get very dense and tall. Therefore any management activities which increase the interspersion of water with vegetation, or decrease the density of dense vegetation should benefit black terns. The vegetation type at the various areas investigated was very dissimilar. Dead Creek was almost entirely cattail, Cranberry Pool was a mix of buttonbush and burreed, while Charcoal Creek had a combination of river bulrush, wildrice, arrowhead, and marsh cinquefoil. The ratio of water to vegetation varied greatly as well, but open water to vegetation was not significantly different. This indicates that the vegetation structure, interspersion of water/vegetation, and location of open water are all critical, whereas species of vegetation appears to be not as important. At Cranberry Pool the presence of burreed was found to be important, but it may not be the burreed itself which is important. Burreed is the emergent vegetation which is found in significant amount earliest in the season. Any management activities at Cranberry Pool which increase the presence of burreed or other emergents early in the summer (June) may increase the usefulness of this area for black terns.

Because the overall marsh characteristics at the two colonies studied appear to be quite different, it seems that the birds may be selecting for different things at the two areas. It is possible that the nest site selection process is based on a hierarchy of criteria which must be met. A hypothetical hierarchy might be as follows:

The initial decision of what marsh to investigate would be based on whether the individual nested or was born there, or if other terns are already present. At that point it would be important to determine if there are any potential nest sites. After that the decision must be made as to where the optimum nest site would be. In an area such as Dead Creek where possible nest sites are abundant but the vegetation is dense, it would be important to find a nest site in relatively less dense vegetation and near to open water so the young can leave the nest easily. At Cranberry Pool, where potential nest sites are less common and the vegetation is much less dense, the need to be near open water

is less important, and finding a suitable nest platform may be the highest priority.

RECOMMENDATIONS

When the Vermont Department of Fish and Wildlife performs its vegetation management at Dead Creek in 1995, I suggest that a series of trial plots be established. Different management strategies could be utilized at these plots and followed through time. For instance, some areas could have all of the cattail mat flattened while others could be selectively flattened, with different ratios and patterns of water versus cattails. In this way, different patterns of interspersion of water and vegetation could be created, and black tern response followed. This would necessitate tracking both vegetation changes and tern nesting for several years following the management activities because the response may not be immediate. In addition, any lowering of the water levels at Dead Creek should either be essentially complete by June 1, or not be initiated until after July 15 in order to minimize the disturbance to black terns and other marsh nesting species.

Related to this is the recommendation that this type of habitat assessment by aerial photography be repeated in 1996. One could then interpret the management techniques used at Dead Creek and their effect on black terns. This would also make it possible to track vegetation changes at all of the marshes over time and the tern's response to them. It would also be possible to confirm the conclusions of this year's study and identify more patterns in nest site selection.

It is not warranted based on this year's photos alone, but if this study is repeated, a more rigorous analysis of this year's and any future years' photos by GIS time series analysis would be appropriate and highly recommended.

Because of the possible decline in black tern numbers both statewide and within two of the three populations in Vermont, it is recommended that a statewide census be performed periodically until long term trends are better understood. The states of the Northeast where black terns nest have agreed to perform censuses every three years to monitor this species. I recommend that the states involved consider changing this to every other year so that useable trend information can be obtained in a more timely fashion.

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TABLE 1.

HABITAT PARAMETERS

NEAREST NEST: Distance to the nearest nest.
OPEN WATER: Distance to the nearest open channel.
NEAREST WATER: Distance to the nearest visible water.
NEAREST LODGE: Distance to the nearest muskrat lodge (at Dead Creek only).
NEAREST BUTTONBUSH: Distance to the nearest visible buttonbush (at Cranberry Pool only).
NEAREST BURREED: Distance to the nearest visible burreed (at Cranberry Pool only).
NEAREST UPLAND: Distance to the nearest upland or other marsh boundary.
15m % BUTTONBUSH: Percent buttonbush in 15m diameter circle.
15m % BURREED: Percent burreed in 15m diameter circle.
15m % CATTAIL: Percent cattail in 15m diameter circle.
15m % WATER: Percent water in 15m diameter circle.
25m % BUTTONBUSH: Percent buttonbush in 25m diameter circle.
25m % BURREED: Percent burreed in 25m diameter circle.
25m % CATTAIL: Percent cattail in 25m diameter circle.
25m % WATER: Percent water in 25m diameter circle.
45m % BUTTONBUSH: Percent buttonbush in 45m diameter circle.
45m % BURREED: Percent burreed in 45m diameter circle.
45m % CATTAIL: Percent cattail in 45m diameter circle.
45m % WATER: Percent water in 45m diameter circle.
70m % BUTTONBUSH: Percent buttonbush in 70m diameter circle.
70m % BURREED: Percent burreed in 70m diameter circle.
70m % CATTAIL: Percent cattail in 70m diameter circle.
70m % WATER: Percent water in 70m diameter circle.
15m % VEGETATION: Percent buttonbush + burreed + cattail in 15m circle
25m % VEGETATION: Percent buttonbush + burreed + cattail in 25m circle.
45m % VEGETATION: Percent buttonbush + burreed + cattail in 45m circle.
70m % VEGETATION: Percent buttonbush + burreed + cattail in 70m circle.

TABLE 2.

BLACK TERN COLONY SIZES AND LOCATIONS

COLONY	POPULATION	NUMBER OF BREEDING PAIRS 1990	1991	1992	1993	1994
CHARCOAL CR. N.	MISSISQUOI	15	24	22	15*	31
CHARCOAL CR. S.	MISSISQUOI	5	13	11	2*	2
CRANBERRY POOL	MISSISQUOI	17	6	5	5	13
BIG MARSH	MISSISQUOI	UNK.	0	0	15	1*
GOOSE BAY	MISSISQUOI	UNK.	UNK.	13	6	1*
MUD CR. WMA	MISSISQUOI	UNK.	7	24	20*	15*
SOUTH BAY	MEMPHREMAGOG	4	4	4	UNK.	2
PANTON RD. N.	DEAD CREEK	1	2	1	2*	0
PANTON RD. S.	DEAD CREEK	0	4	3	UNK.	0
ROUTE 17 N.	DEAD CREEK	6	0	0	UNK.	5
ROUTE 17 S.	DEAD CREEK	5	0	0	UNK.	2
WEST RD.	DEAD CREEK	0	2	4	UNK.	0
LITTLE OTTER CR.	DEAD CREEK	6	9	8	UNK.	2
TOTAL		59	71	95	UNK.	74

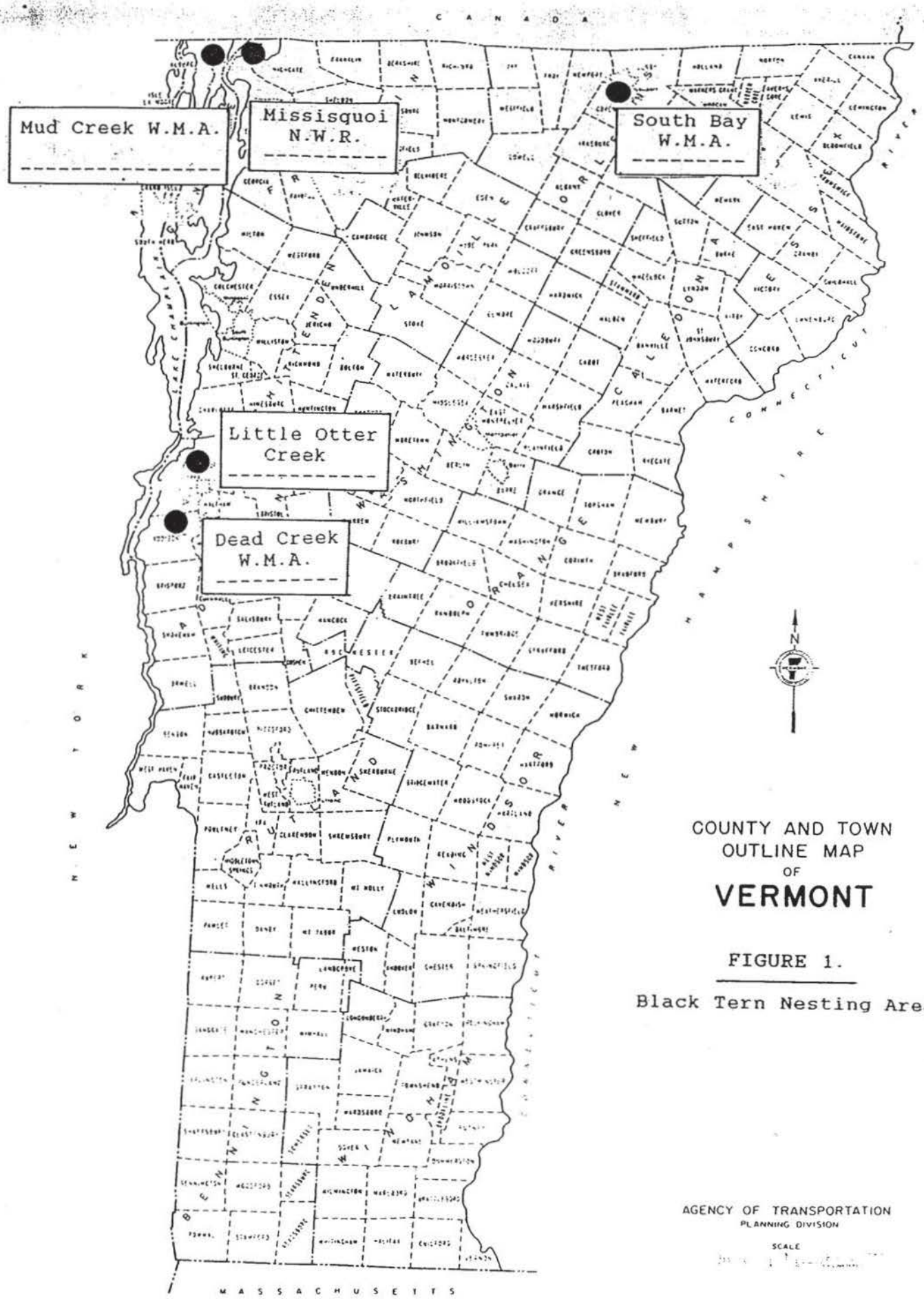
UNK. = unknown

* = estimated

TABLE 3. STATISTICAL SUMMARY OF HABITAT MEASUREMENTS (mean (S.D.)).

* indicates a significant difference between random and nest values by K-S statistic (p=0.05).
# indicates no significant difference by K-S statistic between colonies when comparing nest data or random points (p=0.05).

PARAMETER	CRANBERRY POOL		DEAD CREEK	
	NEST (n=8)	RANDOM (n=50)	NEST (n=7)	RANDOM (N=40)
NEAREST NEST (m)	49.4 (52.1) *	767.3 (562.9) *	245.0 (216.3)	183.8 (120.0)
OPEN WATER (m)	52.0 (55.1) #	141.5 (121.1) #	9.2 (10.8) *#	82.4 (75.9) *#
NEAREST WATER (m)	2.0 (2.1) #	5.9 (15.9)	2.0 (1.6) #	6.8 (7.1)
NEAREST LODGE (m)	N/A	N/A	24.1 (10.9)	38.0 (26.3)
NEAREST BUTTONBUSH (m)	2.0 (1.9)	14.6 (30.8)	N/A	N/A
NEAREST BURREED (m)	11.8 (11.6) *	178.1 (192.1) *	N/A	N/A
NEAREST UPLAND (m)	358.2 (84.7) *	179.1 (101.6) *	97.4 (28.4)	69.8 (41.8)
15m % BUTTONBUSH	26.3 (23.1)	13.8 (18.6)	N/A	N/A
15m % BURREED	5.6 (7.3)	5.8 (15.0)	N/A	N/A
15m % CATTAIL	N/A	N/A	66.4 (25.1)	75.5 (24.8)
15m % WATER	68.1 (20.3)	68.5 (27.0)	33.6 (25.1)	24.5 (24.8)
25m % BUTTONBUSH	25.6 (13.2)	16.8 (17.4)	N/A	N/A
25m % BURREED	8.8 (12.2)	5.5 (12.2)	N/A	N/A
25m % CATTAIL	N/A	N/A	58.6 (23.4)	71.8 (21.0)
25m % WATER	65.6 (14.7)	64.9 (24.1)	41.4 (23.4)	28.0 (20.7)
45m % BUTTONBUSH	30.6 (14.2)	20.1 (16.7)	N/A	N/A
45m % BURREED	14.4 (5.0) *	6.5 (12.7) *	N/A	N/A
45m % CATTAIL	N/A	N/A	59.3 (20.9)	66.8 (18.2)
45m % WATER	55.0 (13.1) #	61.5 (22.0)	40.7 (20.9) #	32.0 (17.0)
70m % BUTTONBUSH	31.2 (9.5)	21.7 (15.8)	N/A	N/A
70m % BURREED	17.5 (6.6) *	6.8 (12.5) *	N/A	N/A
70m % CATTAIL	N/A	N/A	55.7 (20.9)	65.6 (14.8)
70m % WATER	51.2 (12.5) #	60.6 (21.7)	44.3 (20.9) #	31.1 (14.1)
15m % VEGETATION	31.9 (20.3)	19.6 (20.5)	66.4 (25.1)	75.5 (24.8)
25m % VEGETATION	34.4 (14.7)	22.3 (17.3)	58.6 (23.4)	71.8 (21.1)
45m % VEGETATION	45.0 (13.1) *#	26.6 (16.0) *	59.3 (20.9) #	66.8 (18.2)
70m % VEGETATION	48.8 (12.5) *#	28.5 (15.4) *	55.7 (20.9) #	65.6 (14.8)



COUNTY AND TOWN
OUTLINE MAP
OF
VERMONT

FIGURE 1.

Black Tern Nesting Areas

AGENCY OF TRANSPORTATION
PLANNING DIVISION

SCALE

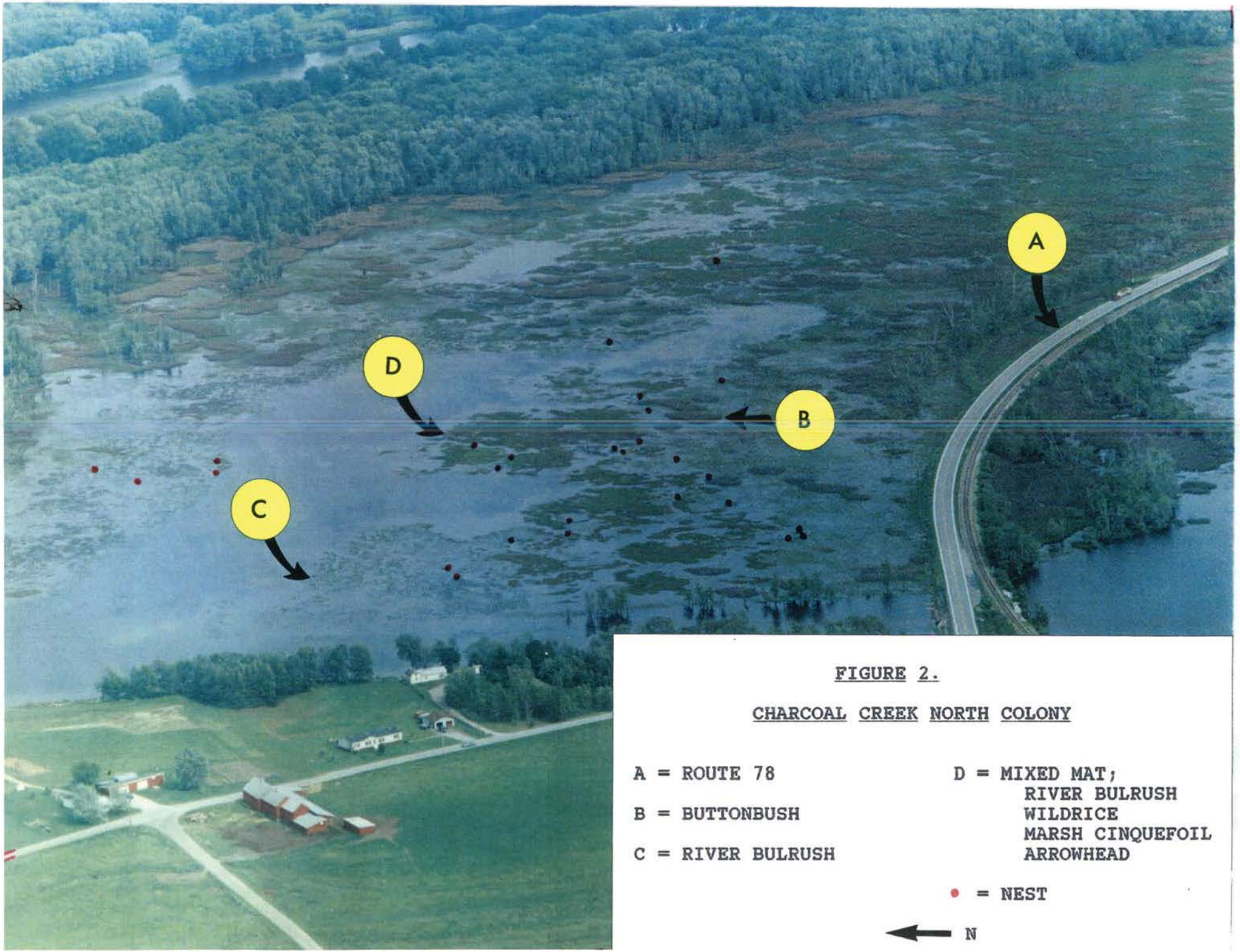


FIGURE 2.

CHARCOAL CREEK NORTH COLONY

A = ROUTE 78

B = BUTTONBUSH

C = RIVER BULRUSH

D = MIXED MAT;
RIVER BULRUSH
WILDRICE
MARSH CINQUEFOIL
ARROWHEAD

● = NEST

← N

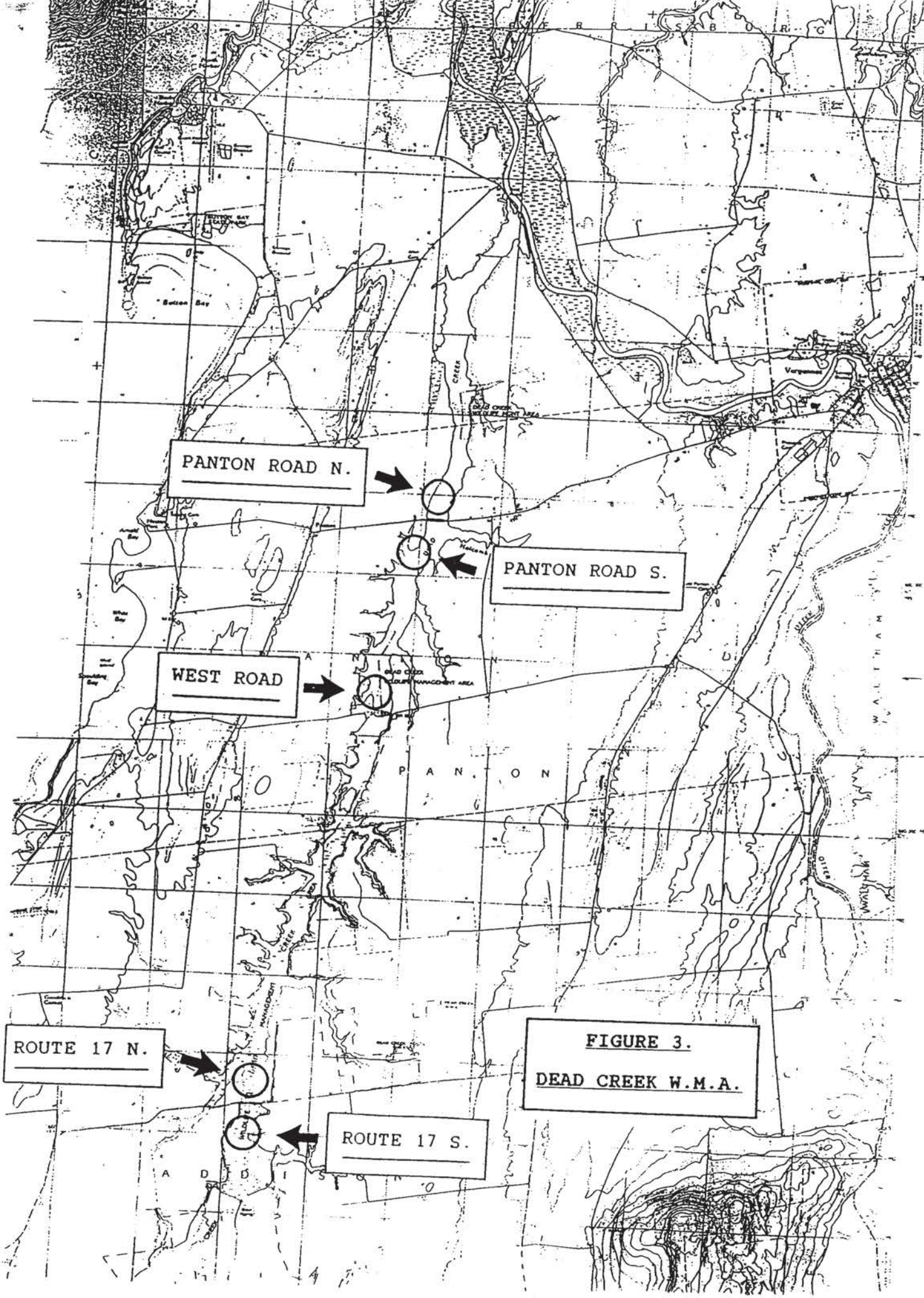


FIGURE 3.

DEAD CREEK W.M.A.

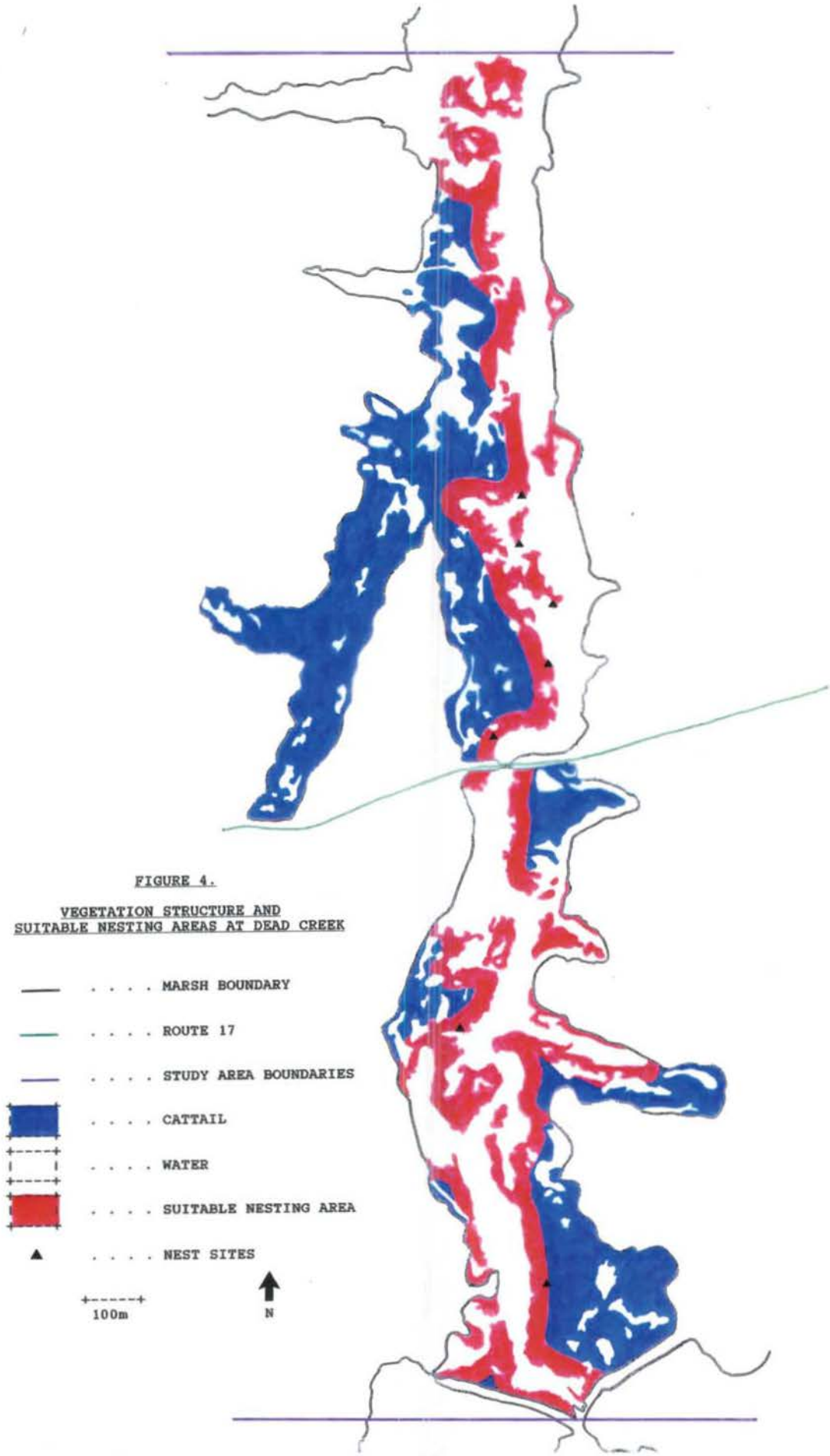


FIGURE 4.

VEGETATION STRUCTURE AND
SUITABLE NESTING AREAS AT DEAD CREEK

FIGURE 5.

VEGETATION TYPES AND
SUITABLE NESTING AREAS AT CRANBERRY POOL