Final 7/17/2006

Preliminary report on the distribution and abundance of four-toed salamanders (*Hemidactylium scutatum*) at Cape Cod National Seashore, with emphasis on the Herring River drainage.

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Introduction

The four-toed salamander (*Hemidactylium scutatum*) is a MA species of special concern known for its association with sphagnaceous wetlands (Petranka 1998). Although its presence on Cape Cod was documented by Lazell (1976), its presence on outer Cape Cod and Cape Cod National Seashore (CACO) was not documented until the mid-1980's, when several individuals were recorded during night time road surveys on Cole's Neck Road, Prince Valley Road, and Long Nook Road in Wellfleet and Truro (Seipt 1986, 1987). Through subsequent incidental encounters, road surveys, and sampling with coverboards, 31 additional individuals were recorded through 2005, ranging from Fresh Brook in South Wellfleet up to Long Nook Road in Truro (Appendix 1).

Because the majority of four-toed salamanders (HESC) recorded at CACO thru 2005 are in or adjacent to wetlands associated with the Herring River in Wellfleet, a tidally restricted system proposed for restoration (Portnoy and Reynolds 1997), and HESCs commonly use similar situations elsewhere on Cape Cod (Oxbow Associates 2004), questions were raised about potential impacts of tidal flow restoration to HESC on outer Cape Cod. This survey was conducted to provide data to assist in planning for and analysis of proposed tidal restoration of the Herring River, Wellfleet, MA. Its goals were;

1. Determine the distribution and relative abundance of HESC within the Herring River system of Wellfleet,

2. Determine the distribution and relative abundance of HESC throughout outer Cape Cod and compare abundance with the Herring River system.

Materials and Methods

HESC were surveyed by active search in wetlands during the spring nesting season. Nests and nesting females were located by careful manual search in clumps and hummocks of *Sphagnum* and other mosses along ditches, streams, pond margins and within ponds, at the interface with standing water (Harris et al. 1995, Corser and Dodd 2004, Oxbow Associates 2004).

Within the Herring River system, the area below High Toss Road was not considered potential habitat for HESC, due to the current extent of tidal influence and salinity. Above High Toss Road, we used year 2000 color orthophotos to identify broad areas of marsh and/or tributaries, generally delineated by roads and the abandoned railroad bed, as survey sites. Each site was surveyed for one hour of search effort. Because the riverine marshes contain an extensive system of ditches and, at Sagamore, Cape Cod, HESC nesting is concentrated along ditches (Oxbow Associates 2004) we selected sections of ditching to sample using Time Constrained Search (Corn and Bury 1990). Ten areas within the Herring River System were sampled, with three large enough to be divided into sub-sections (Appendix 2). These were Bound Brook East (four sub-sections), Bound Brook North (two sub-sections), and Upper Herring River (four subsections) (Figure 1). Thus, there were a total of 17 one-hour surveys conducted within the Herring River.

Nineteen sites not associated with the Herring River were also sampled. Seventeen are isolated wetlands and the remaining two, Fresh Brook and Salt Meadow, are riparian, i.e. part of other river systems. These sites were selected from among all the known wetlands at CACO. Based on our knowledge of wetland vegetation and hydro-periods and HESC life history requirements, we considered vernal ponds, bogs, marshes, swamps, and inter-dune ponds to be potential habitat for HESC. We excluded the ephemeral dune slack wetlands of the Province Lands and the larger, deeper kettle ponds. From among over 150 potential sites we chose sample sites based on the following criteria:

1. provide complete geographic coverage of CACO, from Eastham up to Provincetown,
2. include all sites where HESC were previously recorded,
3. include all sites known to have an abundance of *Sphagnum* moss, the preferred nesting micro-habitat for HESC.

Thus, rather than being a random sample, sites selected were those thought most likely to support HESC in each of the four principal towns of the park. Prior to conducting a survey, the sample site was reconnoitered so the survey team had a sense of how much and where the *Sphagnum* and other mosses were located. Moreover, prior to conducting a survey, all members of the survey team had seen nests of HESC at CACO and were familiar with the nesting micro-habitat. In carrying out the survey, search effort at a site was focused on the micro-habitat most likely to be used by nesting HESC. Most surveys were conducted by teams of two where one person actively searched and verbally conveyed findings to the second, who recorded data and obtained nest coordinates with a Garmin GPS III plus. This ensured that search time was actually spent searching and that search effort remained standardized.

In the course of searches, nests were found with or without a brooding female, and individuals without any association with a nest were also found. Because only females are known to migrate to wetland margins to nest (Harris 2005), all individuals encountered were assumed to be females. For each nest, the number of eggs present was counted. For each site sampled, abundance can be expressed as total number of records, number of nests, number of eggs, number of individuals recorded, and number of nesting females. Numbers of nesting females were calculated similar to Corser and Dodd (2004).

For each individual nest, the number of females present was considered the number of nesting females, except when no females were present, or the number of eggs exceeded 65. Because HESC are known to nest communally (Petranka 1998) and a female can lay up to 65 eggs (Harris 1995), nests with from 66 to 130 eggs counted as two nesting females, etc. Although all of these metrics were highly correlated, number of nesting females/search hour is probably the most direct index of breeding population size and is the measure of abundance used in this report.

Fisher's exact test (two-tailed) was used to compare frequency of occurrence and analysis of variance was used to compare abundance. Comparisons were made between sites within the Herring River versus all others, between isolated wetlands versus riparian wetlands, and between Herring River sites versus isolated wetlands. Analysis was based on data from each site surveyed, with mean values (number of nesting females/search hour) used for the three sites that were divided into sub-sections and sampled more than one search hour.

In addition to animals encountered during time constrained surveys, animals were encountered incidentally, in course of site reconnaissance or nighttime road surveys in 2006, and in previous years, in the course of road surveys and coverboard surveys.

Results

Based on the standardized surveys, HESC were detected in seven of 10 sites within the Herring River system, 11 of 19 sites outside of the Herring River, 9 of 12 riparian sites, and 9 of 17 isolated wetlands (Tables 1, 2). There were no significant differences in the frequency of occurrence of HESC between Herring River v. all other sites, riparian v. isolated sites, and Herring River v. isolated sites. Mean abundance was 7.575 nesting females/search hour at Herring River sites, 3.37 at all other sites, 8.31 at riparian sites, and 2.35 at isolated wetlands. Differences in mean abundance between Herring River sites and all other sites were not significant, but there were significant differences in abundance between Herring River v. isolated sites and between riparian v. isolated sites (Table 2).

In addition to HESC recorded during time constrained surveys, there were 29 incidental records of HESC in 2006, representing 21 nests, 24 nesting females, and 22 individuals. Most of these records are for sites included in the standardized surveys (Appendix 3).

Discussion

Based on all available data, HESC at CACO ranges from Eastham to Salt Meadow in North Truro (Figure 2). In spite of the occurrence of wetlands with an abundance of vertical *Sphagnum* adjoining standing water in Provincetown, HESC was not found there during this survey, nor during the many road surveys conducted there on rainy nights in recent years (R. Cook, pers. obs.). This distribution is quite similar to that of spotted salamanders (*Ambystoma maculatum*), which extends to High Head, Truro (Cook at al.2006). Lazell (1976) found amphibian and reptile species richness to be greater on upper Cape Cod than on the outer Cape, and hypothesized a model of post-glacial colonization of Cape Cod in which species were still actively dispersing distally onto outer Cape Cod. Based on the data to date, the distribution of these two salamander

species seems consistent with this model, with the dune system of the Province Lands appearing to act as a dispersal barrier.

Within this known distribution, HESC appears to be fairly widespread, occurring in both riparian and isolated wetland habitats. Since half of the sampling effort of this survey was focused on Herring River sites, sampling elsewhere at CACO was not as intense. Considering the existing records immediately north and south of the Pamet River, it is likely that HESC occurs in the ditched marshes of the Pamet River above Route 6. Similarly, the 1987 record from Long Nook Road suggests that HESC likely breeds in the ditched, upper reaches of the Little Pamet River as well. In addition, only 17 isolated wetlands were sampled, perhaps 10-15% of what is present in the glacially deposited outwash landscape south of High Head. Although we selected these isolated wetlands as sites most likely to produce records of HESC, it is highly likely that sampling at the remaining isolated wetlands would produce many additional occurrence records.

While it is clear that HESC is widespread throughout most of outer Cape Cod, and utilizes both isolated and riparian wetlands, the significantly greater mean number of nesting females in Herring River sites, and riparian sites in general suggest that riparian habitats provide higher quality breeding habitat and support higher population densities than isolated wetlands (Table 2). In many riparian sites we found freshwater marshes where there is a deep carpet of *Sphagnum*, with a ditch running through it, and in some cases, freshwater inflow into the ditches. These ditches are deep (typically 30-60 cm), provide a vertical face of moss with water right below, and an open body of fresh water for the downstream emigration of larvae if water level drops. In Upper Pole Dike Marsh, however, the site where HESC were most abundant (Table 1), S*phagnum* was not associated with ditching and the nests were located at the upper edges of the wetland, just below the uplands, where freshwater inflow was occurring.

In contrast, most of the topographically isolated vernal ponds and red-maple swamps we surveyed are shallow with short hydroperiods, probably limiting HESC reproductive success. In isolated wetlands, the highest counts were from sites (such as T22 and T28) with a deep central pool of open water and where *Sphagnum* enshrouded shrub hummocks extended to the edges of the deep water. In contrast, sites with shallow water only (e.g. W17), or where sphagnum was not close to deep water (e.g. T20), or where sphagnum grew as a thin veneer on the base of clumps of *Clethra alnifolia* or *Decadon verticillatus* (e.g. W16) were not as productive.

These results, though preliminary, show that HESC is widespread at CACO. The species is more abundant in riparian systems than in isolated wetlands, except for the relatively few that have well developed mosses in close proximity to deep water. At CACO, the riparian habitats used by HESC occur in the upper reaches of diked salt marshes, where tidal restrictions have blocked seawater and impounded discharging freshwater. Hydroperiod is further prolonged in diked marshes by undersized culverts through road crossings and deeply dug ditches. Although harmful to native estuarine biota, these conditions appear to contribute to high densities of HESC, e.g. in sites such as Lombard Hollow, Upper Herring River, and Upper Pole Dike Marsh. HESC was possibly present in these areas prior to tidal restriction, though perhaps in lesser numbers because of greater saltwater excursion. On the other hand, the removal of tidal restrictions could increase hydroperiod and improve HESC breeding habitat, albeit above the reach of seawater, because of increased wetland water levels (Nuttle & Portnoy 1992) and

hydroperiod wherever fresh groundwater discharges directly into the wetland surface-water system.

Management Considerations Vis-à-vis Salt Marsh Restoration

Considering their widespread occurrence and abundance within tidally-restricted wetland systems such as the Herring River and Fresh Brook, and their likely occurrence in other tidally-restricted systems, restoration of tidal flow in the Herring River and other, similar systems will likely have some effect on HESC populations. The extent of that effect will depend, of course, on the degree or extent of tidal restoration, saltwater excursion, and consequent changes in hydroperiod above the upstream extent of seawater. Given the Special Concern status of HESC in Massachusetts, it may be desirable to balance tidal restoration at CACO with maintaining some of the most important riparian sites for HESC. Such an approach is likely possible either by controlling the extent of tidal flow at the primary obstruction (in this case the Herring River Dike) and/or by making use of the roads and culverts that sub-divide the Herring River to retain some wetland areas as freshwater. Controlling tidal flow at the river mouth has the disadvantage of limiting the restoration of natural tidal range and salinity distribution throughout the entire flood plain, whereas protecting more remote upstream HESC may be as effective in conserving this species without severely limiting estuary-wide recovery. Since the important sites for HESC in the Herring River are mainly in the upper reaches, it would be possible to restore tidal flow to the lower portions of the river while keeping selected upper reaches fresh.

For example, by using weirs or fish ladders to block the upstream flow of salt water through existing culverts, HESC habitat in Upper Pole Dike Marsh, Upper Herring River, Ryder Beach, Lombard Hollow, and Prince Valley could be retained. Under this scenario, roughly 211 of 1165 acres or 18% of Herring River wetlands would be excluded from restoration. Including Upper Pole Dike Creek and the wetlands above it in the restoration would mean excluding 33.7 acres or 3% from restoration.

In evaluating these alternatives, it might also be useful to take a broader perspective. Analysis of restoration effects on a particular species requires knowledge of the species use of both the restoration site and elsewhere on the local and regional landscape. The Herring River is not the only tidally restricted wetland system that supports populations of HESC, it is not the only such system that has been or is being proposed for restoration of tidal flow, and HESC also occurs in isolated wetlands. Rather than evaluate each system proposed for restoration individually, it might be preferable to look at all of them collectively from the perspective of restoration and HESC impacts. To do this however, additional surveys for HESC in the Pamet River, Little Pamet River, and isolated wetland sites would be needed.

Acknowledgements

We would like to thank Kelly Boland, Leslie Brown, and William Walton for their field assistance and Mark Adams and Jim Chapman of Cape Cod National Seashore for guidance on map preparation. Brian Butler and Scott Smyers of Oxbow Associates greatly facilitated this work by sharing their data and prior experience with Cape Cod four-toed salamanders

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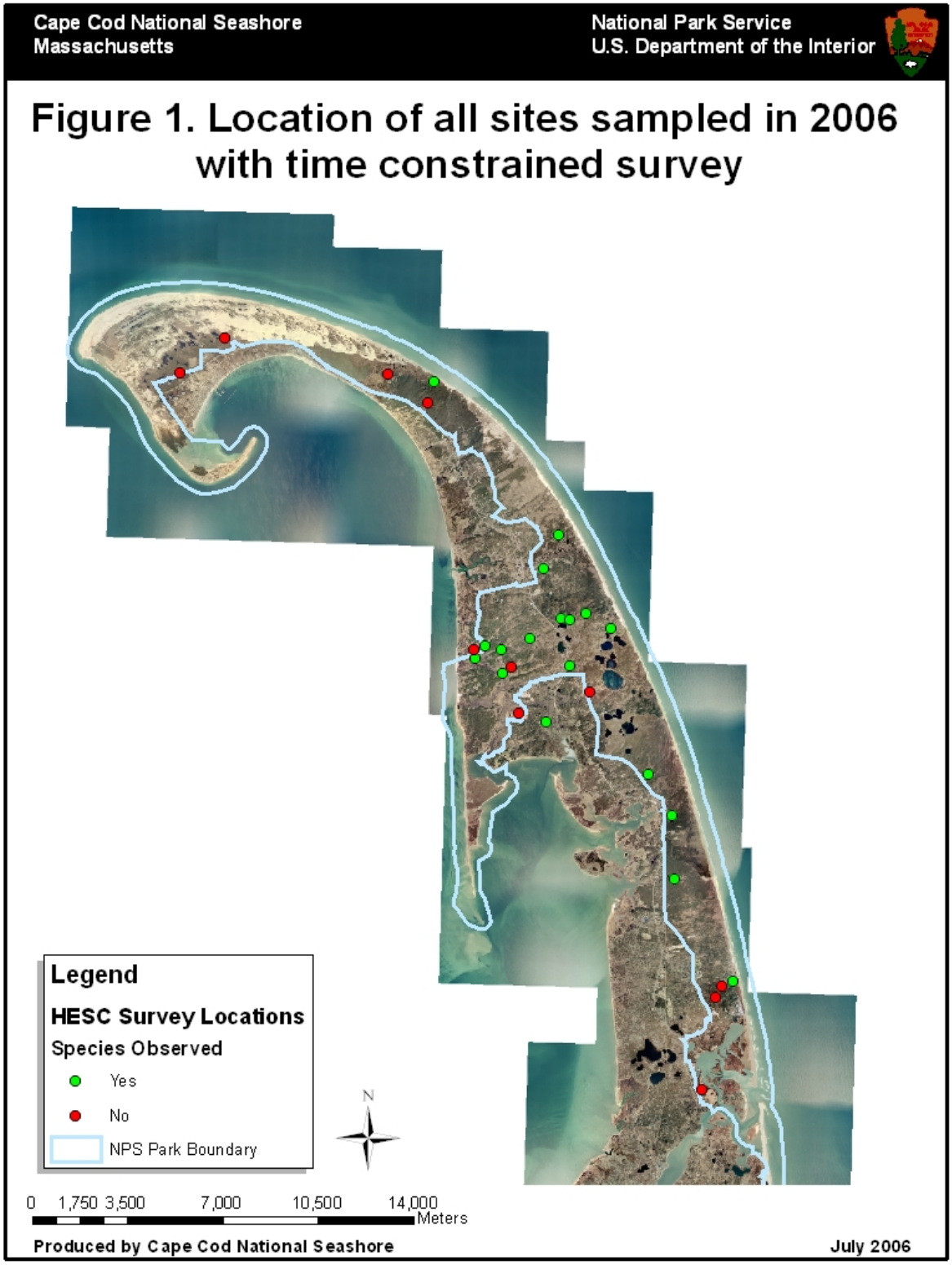
Cape Cod National Seashore
Massachusetts
National Park Service
U.S. Department of the Interior
Figure 1. Location of all sites sampled in 2006 with time constrained survey
Legend
HESC Survey Locations
Species Observed
Yes
No
NPS Park Boundary
N
0 1,750 3,500 7,000 10,500 14,000
Meters
Produced by Cape Cod National Seashore
July 2006

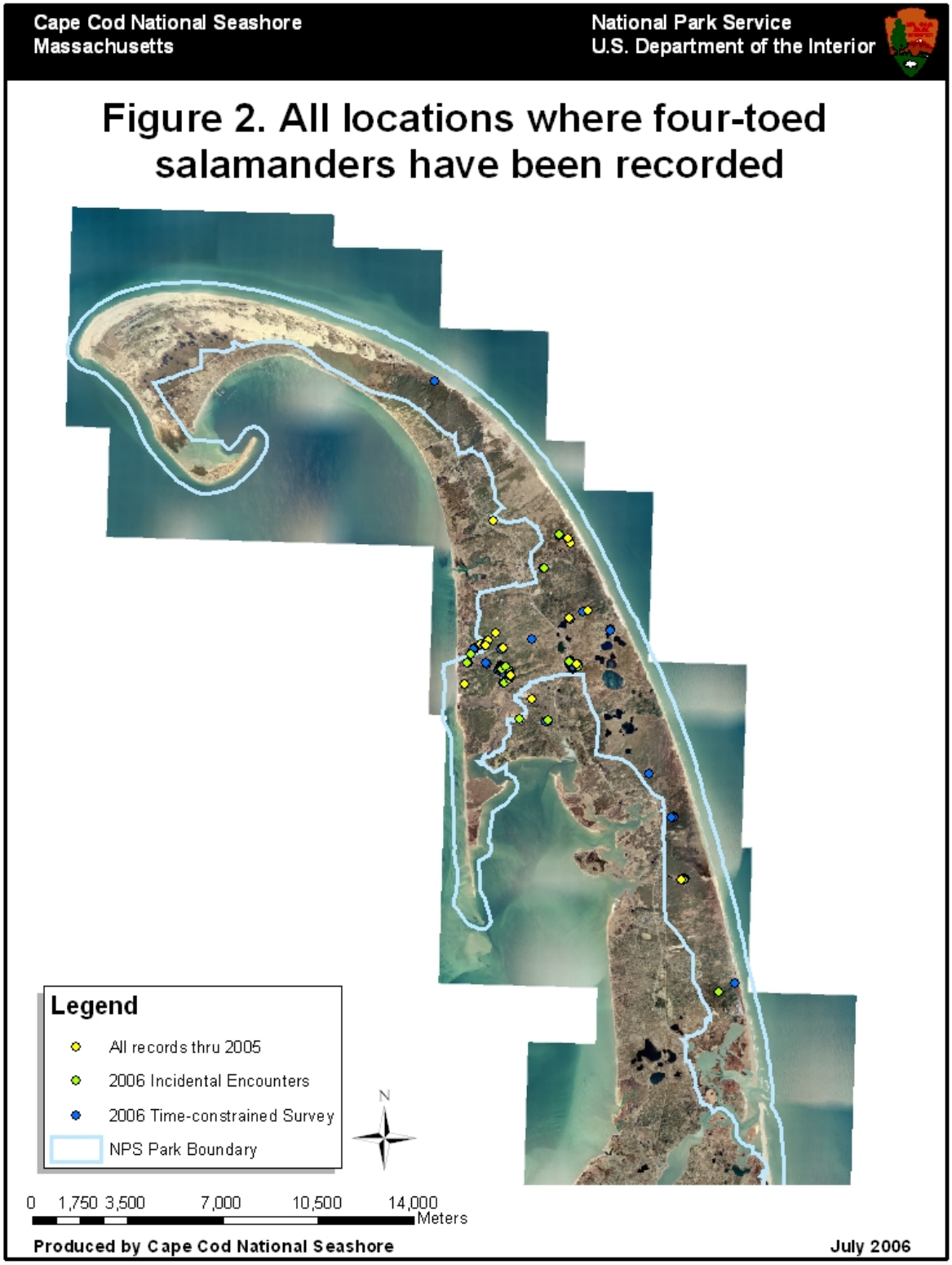
Cape Cod National Seashore
Massachusetts
National Park Service
U.S. Department of the Interior
Figure 2. All locations where four-toed salamanders have been recorded
Legend
All records thru 2005
2006 Incidental Encounters
2006 Time-constrained Survey
NPS Park Boundary
N
0 1,750 3,500 7,000 10,500 14,000
Meters
Produced by Cape Cod National Seashore
July 2006

Table 1. Summary of all measures of HESC abundance from all 2006 time constrained surveys. All measures are numbers found/search hour. Females=estimated number of nesting females.

Site	Code	Drainage	Date	Records	Nests	Eggs	Inds Obs	Females
Lower Pole Dike	LPD	Herring River	4/25/2006	0	0	0	0	0
Upper Pole Dike	UPD	Herring River	5/19/2006	19	19	1030	11	27
Bound Brook East 1	BBE1	Herring River	4/28/2006	1	0	0	1	0
Bound Brook East 2	BBE2	Herring River	5/5/2006	5	5	159	3	5
Bound Brook East 3	BBE3	Herring River	5/5/2006	12	12	358	11	12
Bound Brook East 4	BBE4	Herring River	5/5/2006	7	7	244	5	7
Bound Brook East-mean	BBE	Herring River		6.25	6	190	5	6
Bound Brook North 1	BBN 1	Herring River	5/16/2006	1	0	0	2	2
Bound Brook North 2	BBN2	Herring River	5/18/2006	2	1	33	2	2
Bound Brook North-mean	BBN	Herring River		1.5	0.5	16.5	2	2
Ryder Beach	RB	Herring River	5/15/2006	8	6	266	5	9
Paradise Hollow	PH	Herring River	5/18/2006	0	0	0	0	0
Lombard Hollow	LH	Herring River	5/16/2006	13	13	302	10	13
Prince Valley	PV	Herring River	5/15/2006	6	6	201	6	7
Portnoy Bog	PB	Herring River	5/19/2006	0	0	0	0	0
Upper Herring River 1	UHR1	Herring River	4/21/2006	3	3	102	1	3
Upper Herring River 2	UHR2	Herring River	4/21/2006	15	15	604	7	18
Upper Herring River 3	UHR3	Herring River	4/21/2006	12	11	242	11	12
Upper Herring River 4	UHR4	Herring River	4/21/2006	15	13	361	15	14
Upper Herring River-mean	UHR	Herring River		11.25	10.5	327	8.5	11.75
E02	E02	isolated	5/18/2006	0	0	0	0	0
E08 north	E08N	isolated	5/18/2006	0	0	0	0	0
E15	E15	isolated	5/17/2006	0	0	0	0	0
E16	E16	isolated	5/17/2006	1	0	0	2	2
Featherbed Swamp	FeB	isolated	5/3/2006	5	5	286	3	7
Grassy 3	Grassy 3	isolated	5/8/2006	0	0	0	0	0
P14	P14	isolated	5/8/2006	0	0	0	0	0
T05	T05	isolated	4/21/2006	0	0	0	0	0
T06	T06	isolated	5/15/2006	1	1	29	0	1
T13	T13	isolated	5/19/2006	1	1	25	0	1
T20	T20	isolated	5/16/2006	0	0	0	0	0
T22	T22	isolated	5/4/2006	7	7	199	8	9
T28	T28	isolated	5/16/2006	10	10	236	4	10
T31 (Small's Swamp)	T31	isolated	5/19/2006	0	0	0	0	0
T47	T47	isolated	5/15/2006	5	2	55	5	5
W16	W16	isolated	5/16/2006	2	1	20	1	2
W17	W17	isolated	5/18/2006	3	3	64	2	3
Salt Meadow	SM	East Harbor	5/22/2006	1	1	32	1	1
Fresh Brook	FrB	Fresh Brook	5/17/2006	21	21	648	16	23

Table 2. Comparisons of mean abundance of nesting female HESC and frequency of occurrence between sites classified by location and type (i.e. riparian or isolated).

Sites	Mean Females	ANOVA	Frequency Occurrence	Fisher's Exact Test	n
HR	7.58	$F_{1,27}=2.56$, $p=0.121$	70%	$p=0.7657$	10
all others	3.37		58%		19
riparian	8.31	$F_{1,27}=6.21$ $p=0.019$	75%	$p=0.7634$	12
isolated	2.35		53%		17
HR	7.58	$F_{1,25}=5.29$, $p=0.03$	70%	$p=0.7521$	10
isolated	2.35		53%		17

Appendix 1. Records of four-toed salamanders at Cape Cod National Seashore through 2005. All records are of adults.

SITE	DATE	EASTING	NORTHING	COUNT	DOCUMENTAT	METHOD	OBSERVER
Cole's Neck Road	8/18/1986	413542	4644695	1	CAP	Road Cruise	Irene Seipt
Prince Valley Road	8/18/1986	411718	4646704	1	OBS	Road Cruise	Irene Seipt
Longnook Road	3/31/1987	412132	4651233	3	OBS	Road Cruise	Irene Seipt
Old County Road	9/4/1992	411638	4646708	1	OBS	Road Cruise	Kyle Jones
Old County Road	3/24/1999	412732	4645596	1	OBS	Road Cruise	Brett Still
North Pamet Road	3/30/2001	414944	4650428	1	PH	Road Cruise	R. Cook, T.Tupper, B.Timm
Prince Valley Road	3/30/2001	412203	4647145	1	OBS	Road Cruise	R. Cook, T.Tupper, B.Timm
Prince Valley Road	3/30/2001	411828	4646731	1	OBS	Road Cruise	R. Cook, T.Tupper, B.Timm
Prince Valley Road	3/30/2001	411871	4646791	1	VS	Road Cruise	R. Cook, T.Tupper, B.Timm
Prince Valley Road	3/30/2001	411920	4646867	1	OBS	Road Cruise	R. Cook, T.Tupper, B.Timm
Prince Valley	4/27/2001	411807	4646663	1	CAP	SalBoard	Stan Kot
Prince Valley	4/27/2001	411807	4646663	1	CAP	SalBoard	Stan Kot
Prince Valley	5/8/2001	411807	4646663	1	CAP	SalBoard	Stan Kot
Prince Valley	6/5/2001	411807	4646663	1	CAP	SalBoard	Stan Kot
Lombard Hollow	6/8/2001	412492	4646590	1	CAP	SnkBoard	Stan Kot
Lombard Hollow	9/27/2001	412492	4646590	1	CAP	SnkBoard	Stan Kot
Prince Valley	3/15/2002	411807	4646663	1	CAP	SalBoard	K. Boland, R. Cook
Featherbed Swamp	3/20/2002	415565	4647938	1	CAP	SalBoard	Kelly Boland
Prince Valley	3/20/2002	411807	4646663	1	CAP	SalBoard	Kelly Boland
T06	4/2/2002	414914	4647695	1	PH	SalBoard	Kelly Boland
Prince Valley	4/17/2002	411839	4646692	1	CAP	SalBoard	K. Boland, J. Borgmeyer
Prince Valley	4/17/2002	411839	4646692	1	CAP	SalBoard	K. Boland, J. Borgmeyer
Prince Valley	4/23/2002	411807	4646663	1	CAP	SalBoard	James Borgmeyer
Prince Valley	6/14/2002	411839	4646692	1	CAP	SalBoard	James Borgmeyer
Prince Valley	7/1/2002	411839	4646692	1	CAP	SalBoard	J. Borgmeyer, S.Michehl
Prince Valley	7/8/2002	411807	4646663	1	CAP	SalBoard	J. Borgmeyer, S.Michehl
Pamet Bog	7/18/2002	414834	4650612	1	CAP	SalBoard	J. Borgmeyer, S.Michehl
Prince Valley	8/12/2002	411839	4646692	1	CAP	SalBoard	J.Borgmeyer, B. Strong
Herring River Upper Meadows	8/29/2002	415187	4645984	1	CAP	SnkBoard	J.Borgmeyer, B. Strong
Fresh Brook	9/24/2002	419005	4638075	1	CAP	SnkBoard	B. Strong. K. Boland
Herring River Upper Meadows	10/3/2002	415187	4645984	1	CAP	SnkBoard	J.Borgmeyer, B. Strong
Pamet Bog	10/3/2002	414834	4650612	1	CAP	SalBoard	J.Borgmeyer, B. Strong
Herring River Upper Meadows	10/24/2002	415187	4645984	1	CAP	SnkBoard	Brandon Strong
W01	4/7/2005	411081	4645243	1	PH	SnkBoard	Robert Cook

Appendix 2. Outline of areas searched during time constrained search in 2006.

Appendix 2-A.E15 search area
Appendix 2-B. E02, E08N, and E16 search areas
Appendix 2-C. Fresh Brook search area
Appendix 2-D. W17 search area
Appendix 2-E. W16 search area
Appendix 2-F. Portnoy's Bog search area
Appendix 2-G. Upper and Lower Pole Dike search areas
Appendix 2-H. Upper Herring River 1-4 search areas
Appendix 2-I. Paradise Hollow and BBE 1-4 search areas
Appendix 2-J. Bound Brook North 1 and 2 search areas
Appendix 2-K. Lombard Hollow, Ryder, and Prince Valley search areas
Appendix 2-L. T13 search area
Appendix 2-M. T28 search area
Appendix 2-N. T05 and T06 search areas
Appendix 2-O. Featherbed Swamp search area
Appendix 2-P. T47 search area
Appendix 2-Q. T22 search area
Appendix 2-R. T20 search area
Appendix 2-S. Salt Meadow search area
Appendix 2-T. T31 Smalls Swamp search area
Appendix 2-U. Grassy 3 search area
Appendix 2-V. P14 search area

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Appendix 2-A. E15 search area

0 10 20 40 60 80
Meters

Produced by CACO

July 2006

Cape Cod National Seashore
Massachusetts

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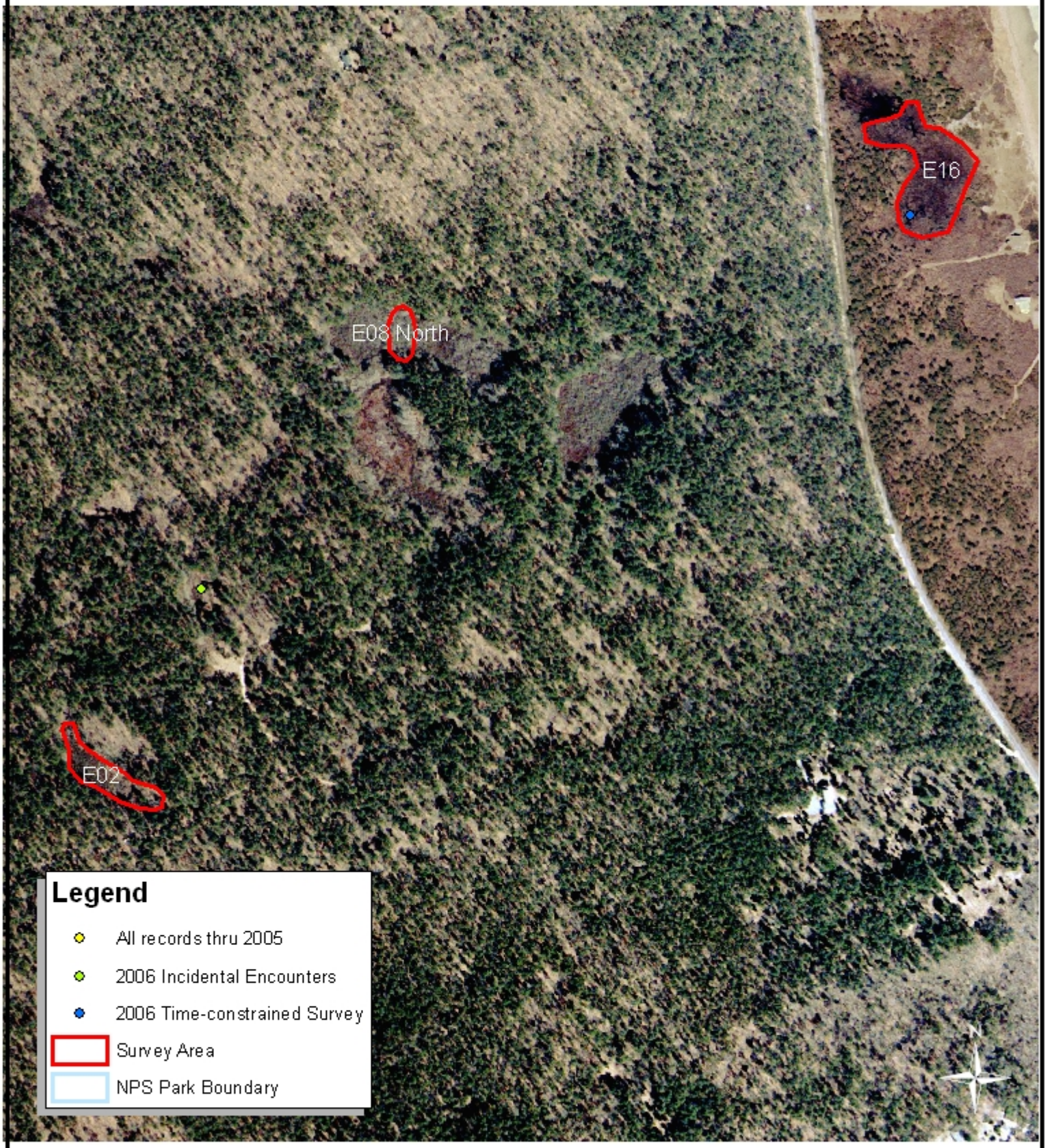
Appendix 2-B. E02, E08N, and E16 search areas



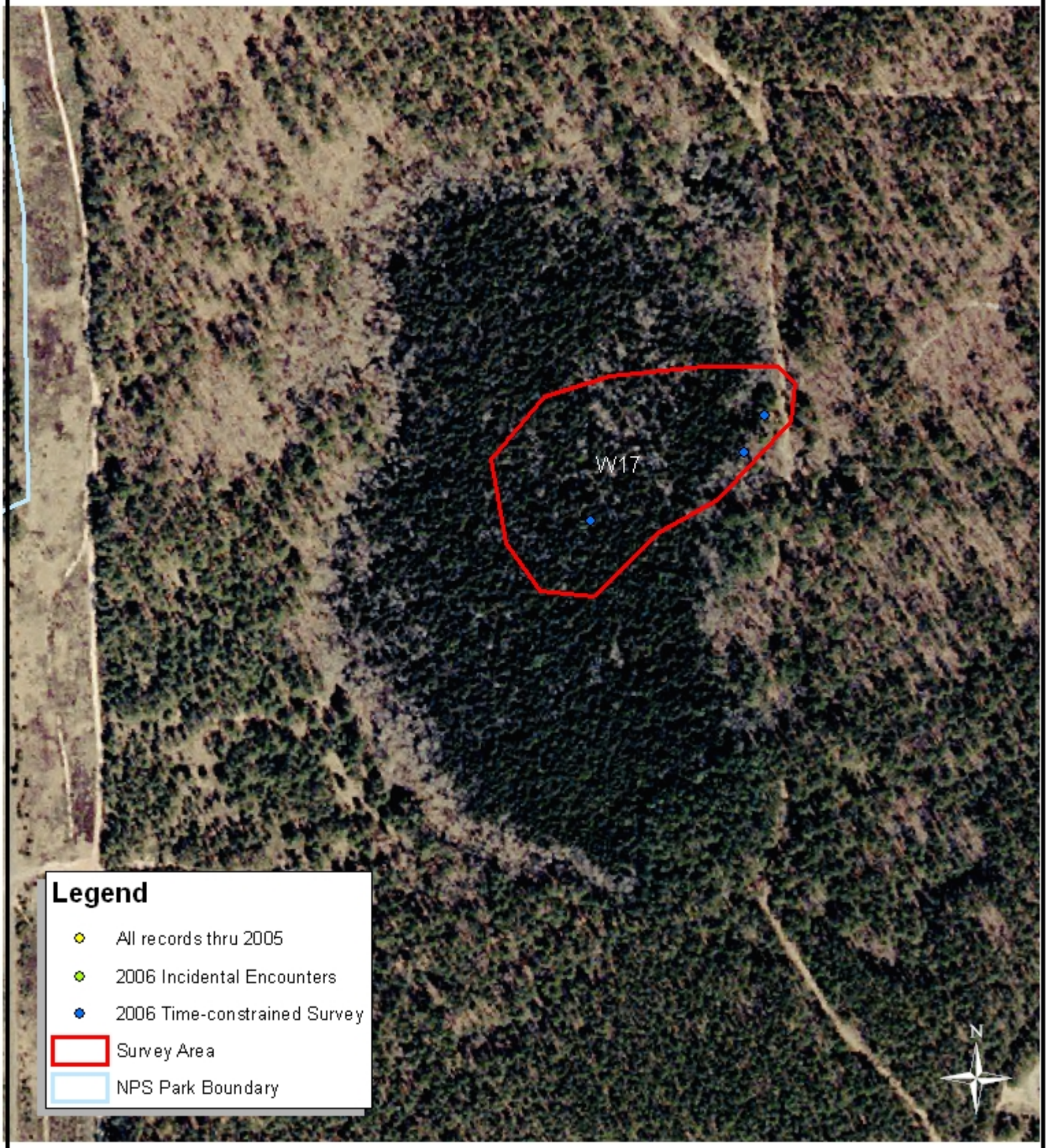
0 25 50 100 150 200
Meters

Produced by CACO

July 2006

Appendix 2-C. Fresh Brook search area

Appendix 2-D. W17 search area



Appendix 2-E. W16 search area

0 1 2 4 6 8
Meters

Produced by CACO

July 2006

Cape Cod National Seashore
Massachusetts

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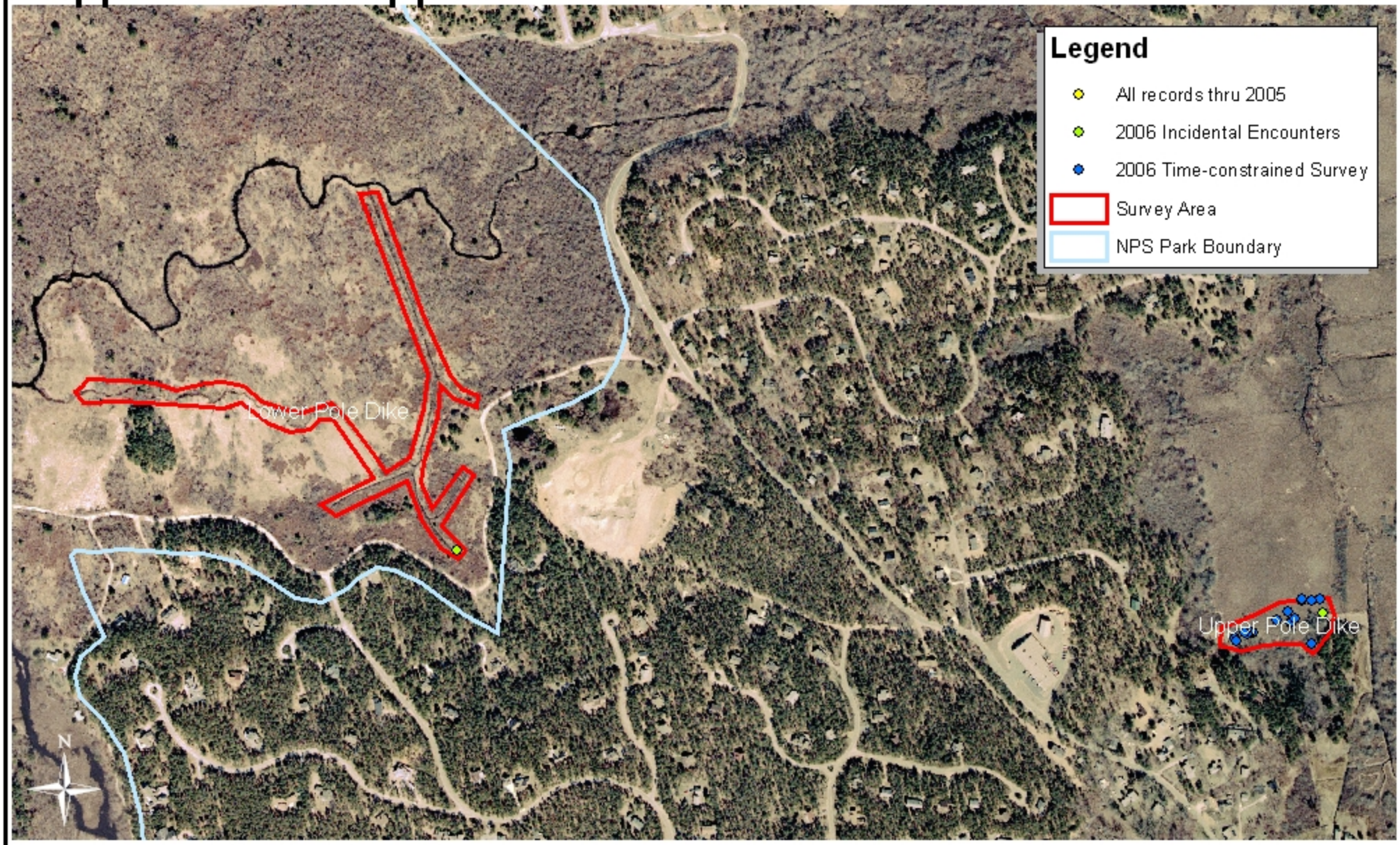
Appendix 2-F. Portnoy's Bog search area

0 24 8 12 16
Meters

Produced by CACO

July 2006

Appendix 2-G. Upper and Lower Pole Dike search areas



0 60 120 240 360 480 Meters

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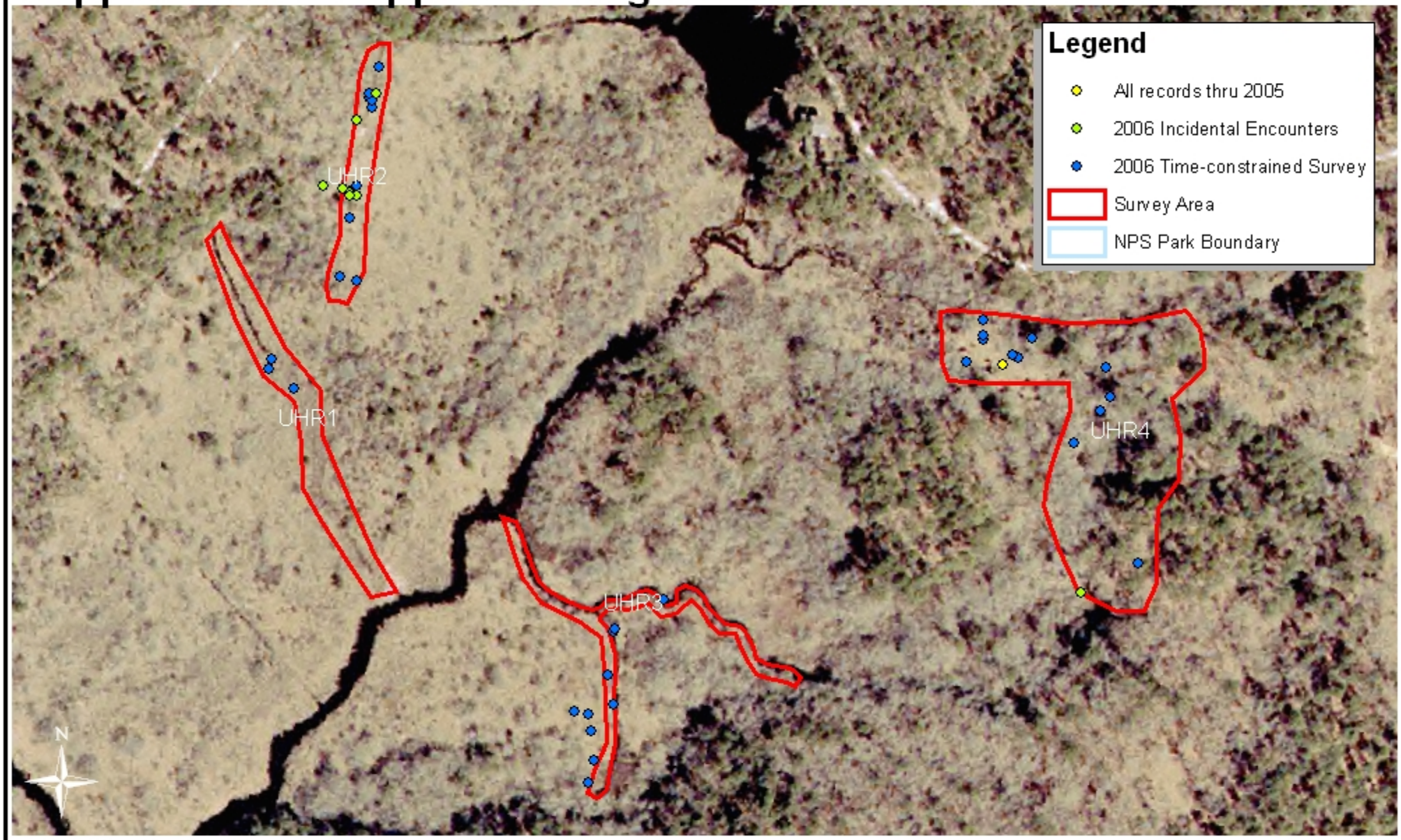
Appendix 2-H. Upper Herring River 1-4 search areas



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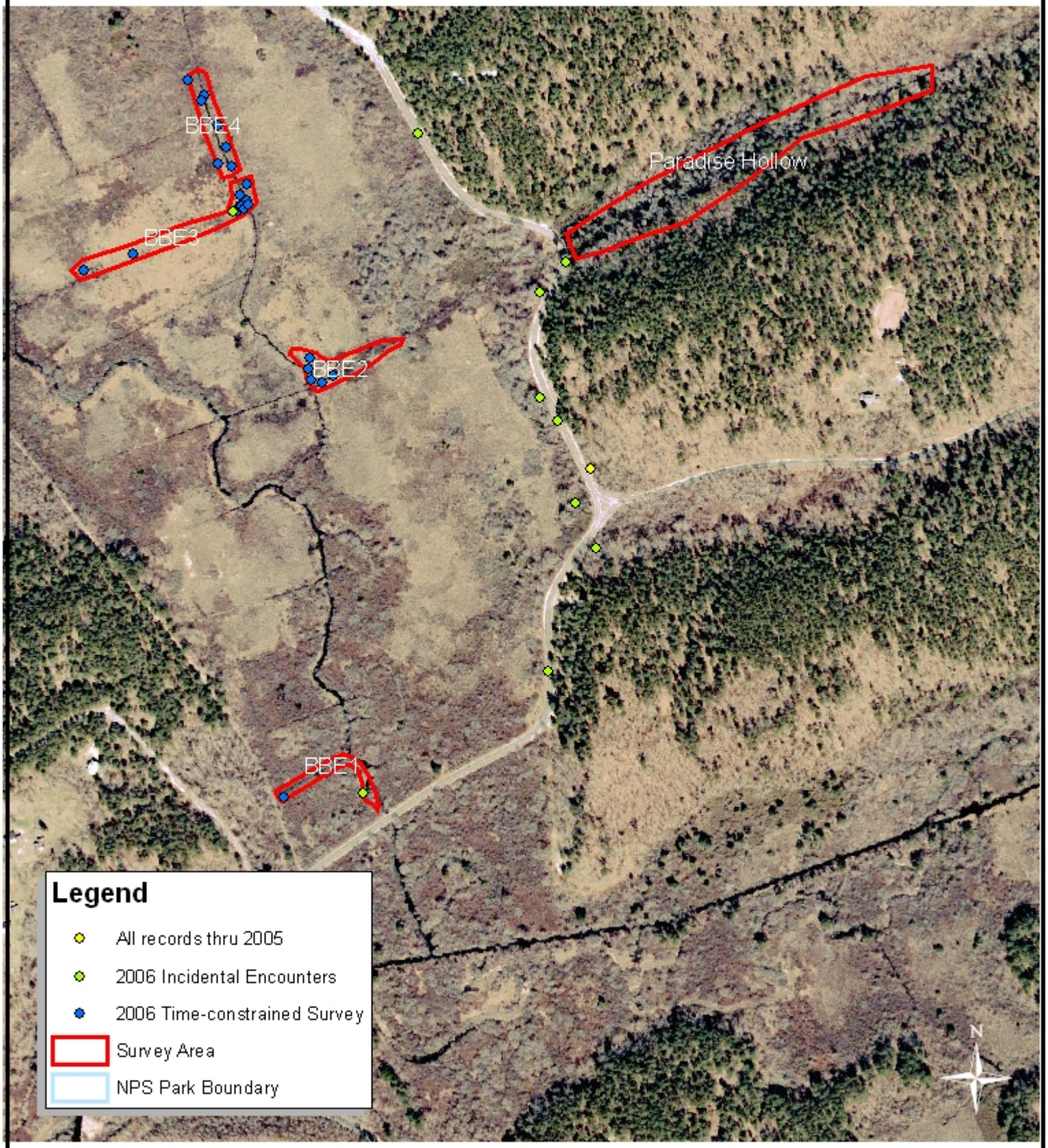
Appendix 2-I. Paradise Hollow and BBE 1-4 search areas



0 200 400
Meters

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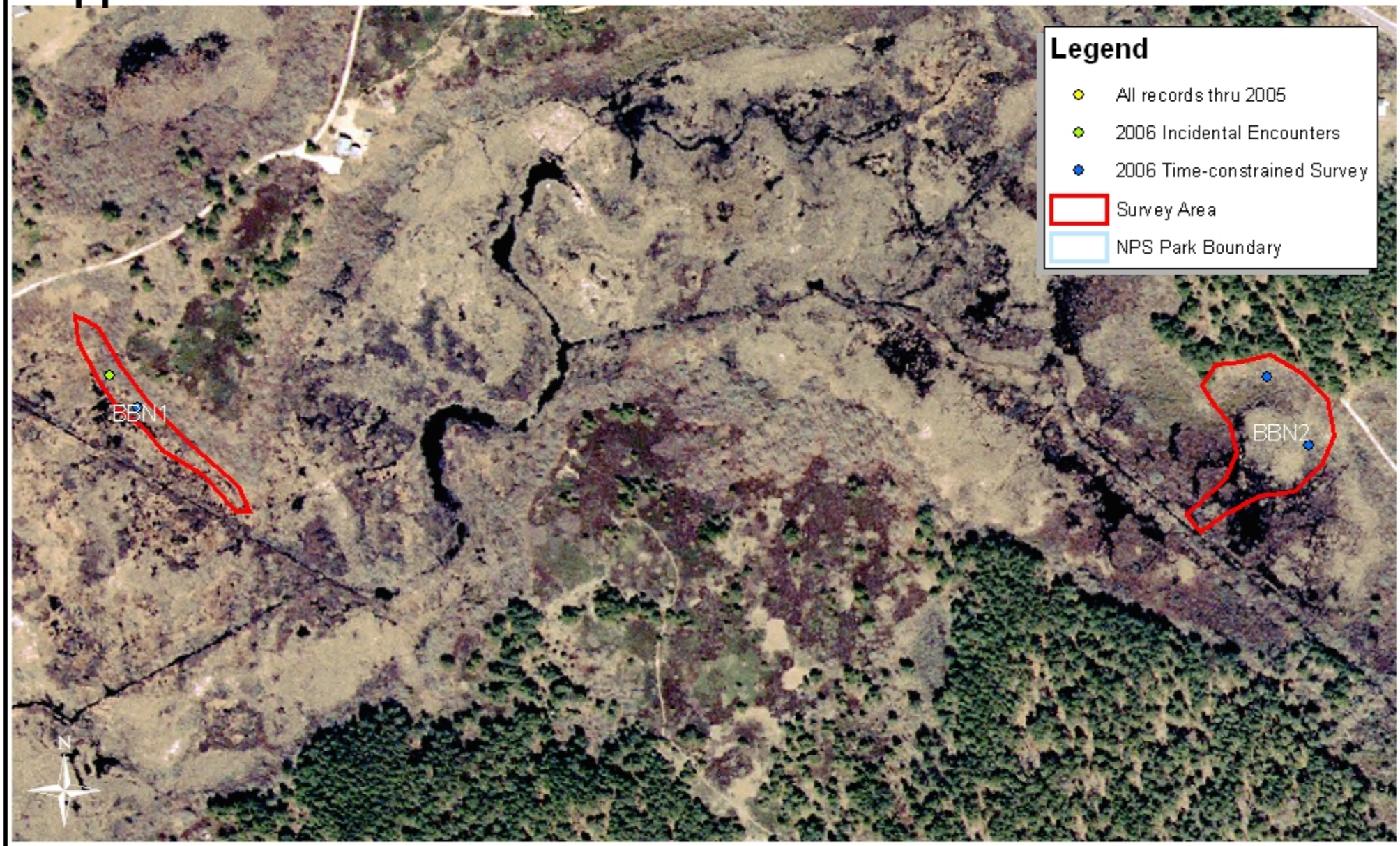
Appendix 2-J. Bound Brook North 1 and 2 search areas



0 30 60 120 180 240 Meters

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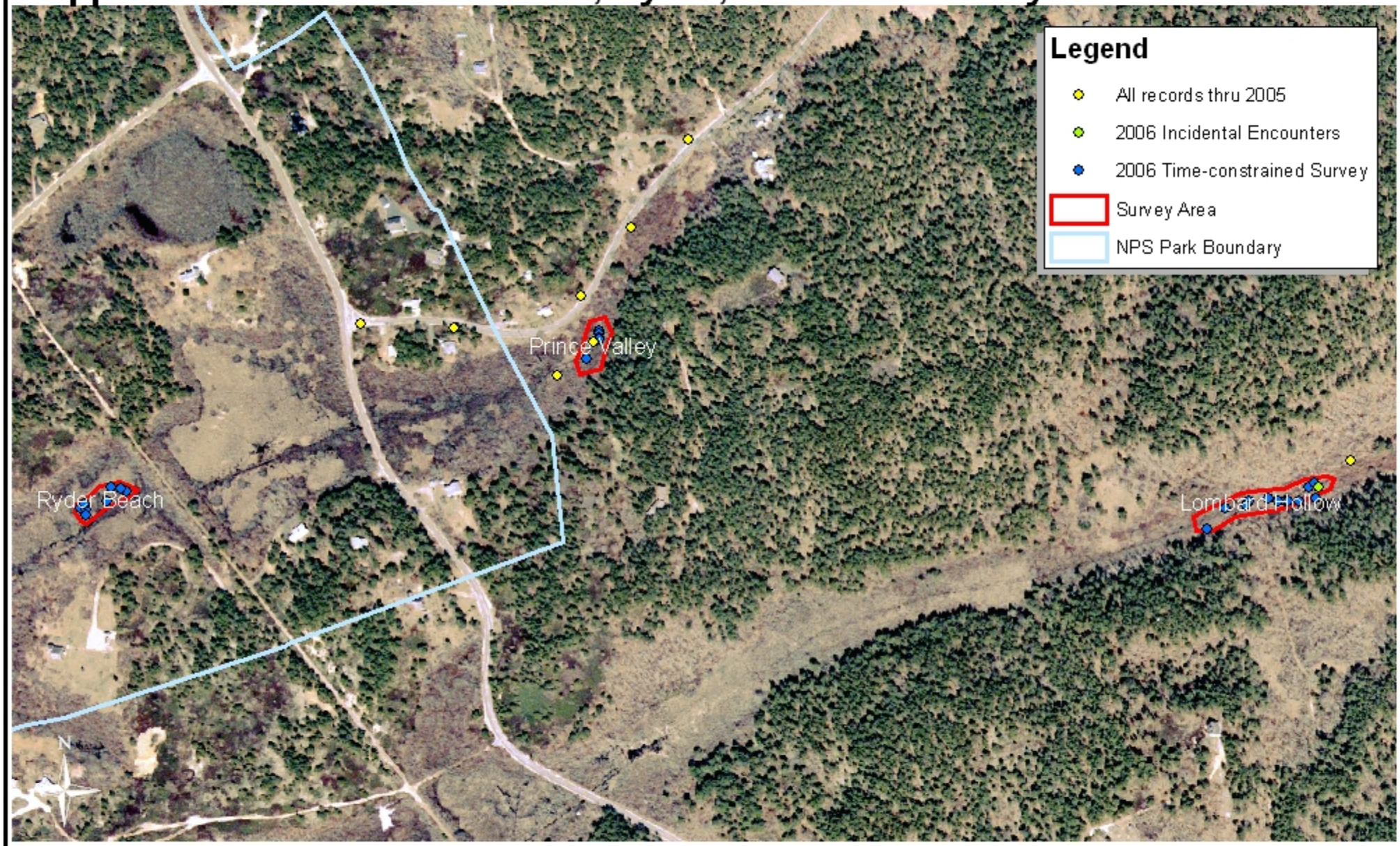
Appendix 2-K. Lombard Hollow, Ryder, and Prince Valley search areas



0 45 90 180 270 360 Meters

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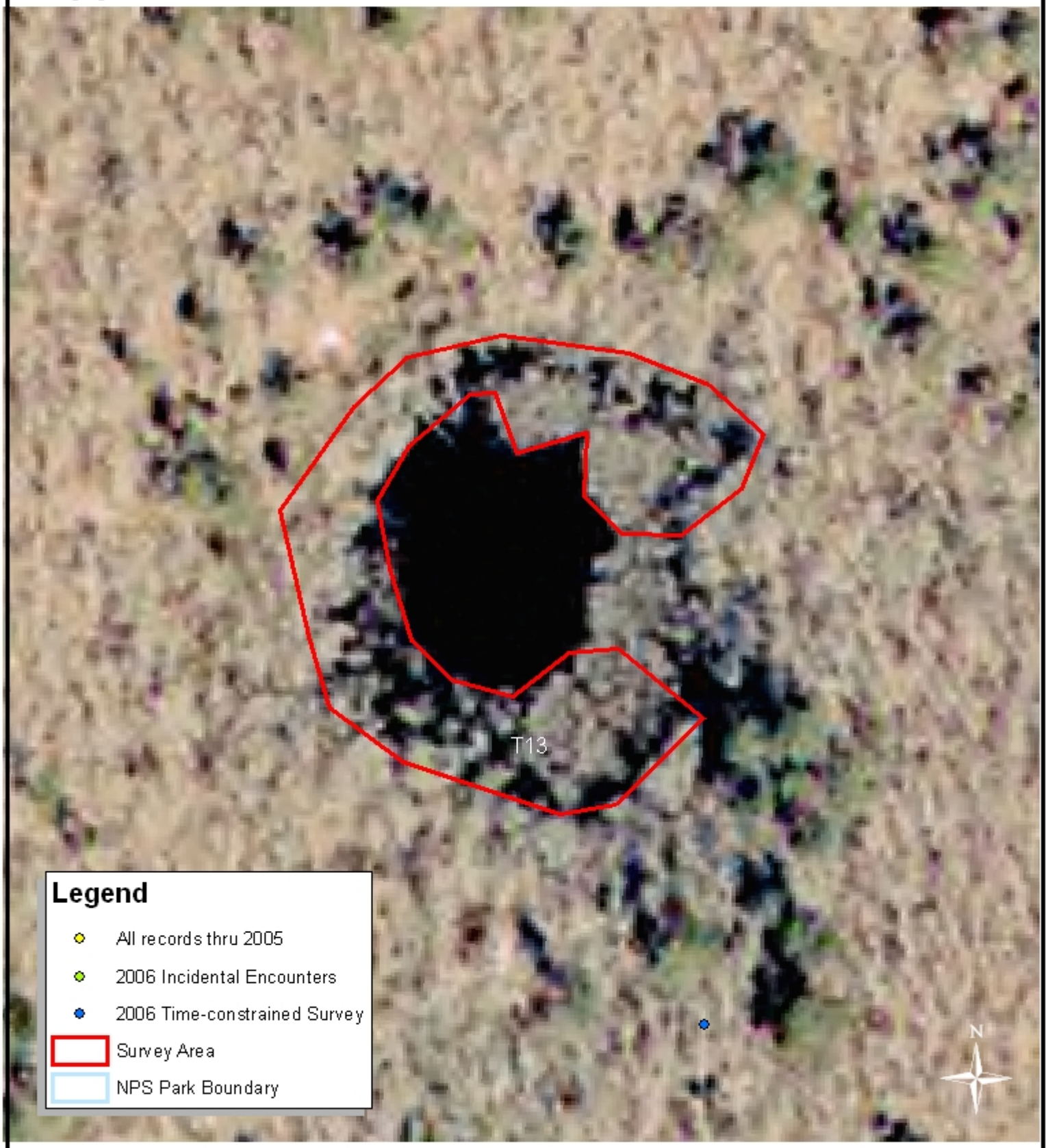
Appendix 2-L. T13 search area



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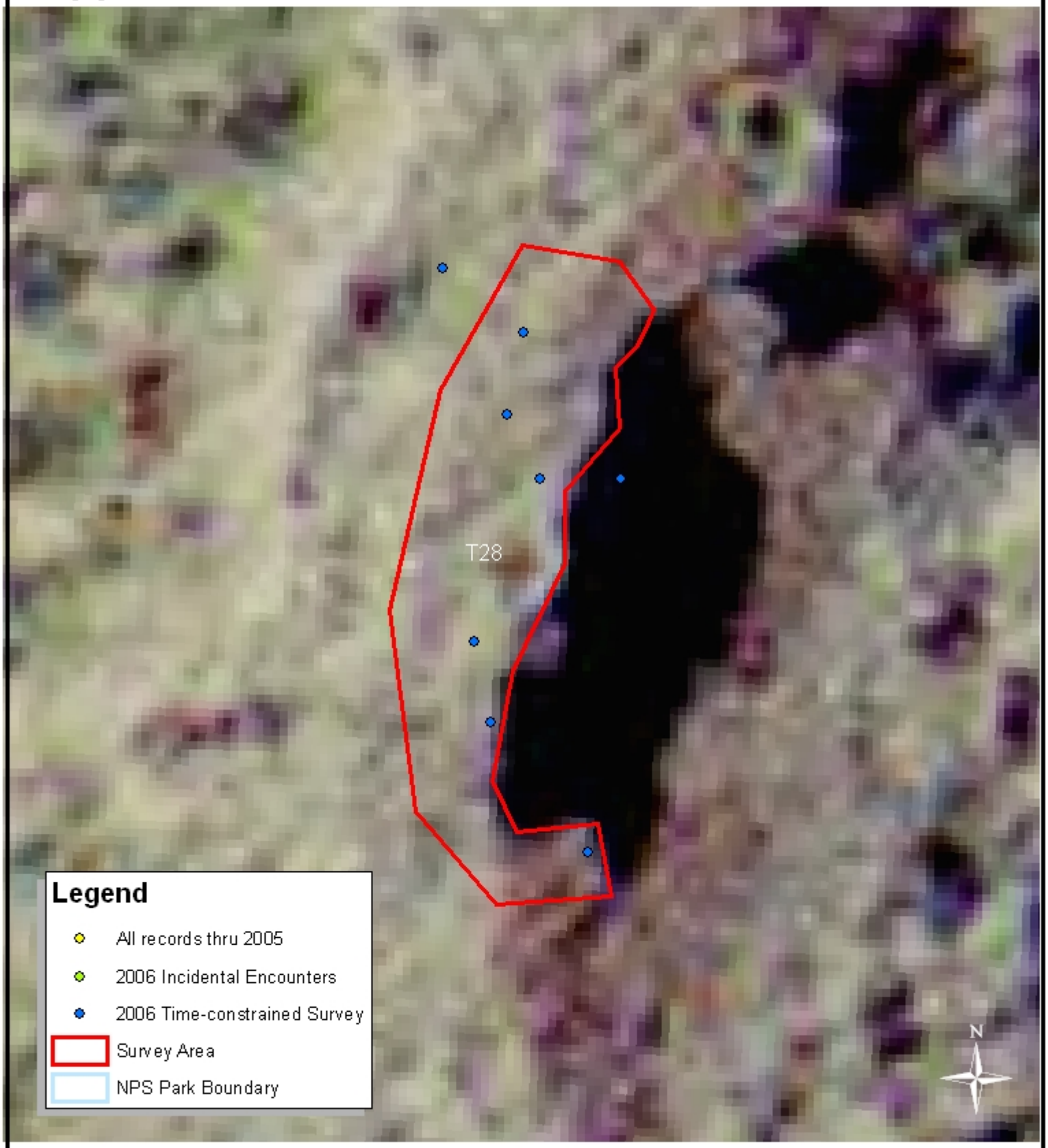
Appendix 2-M. T28 search area



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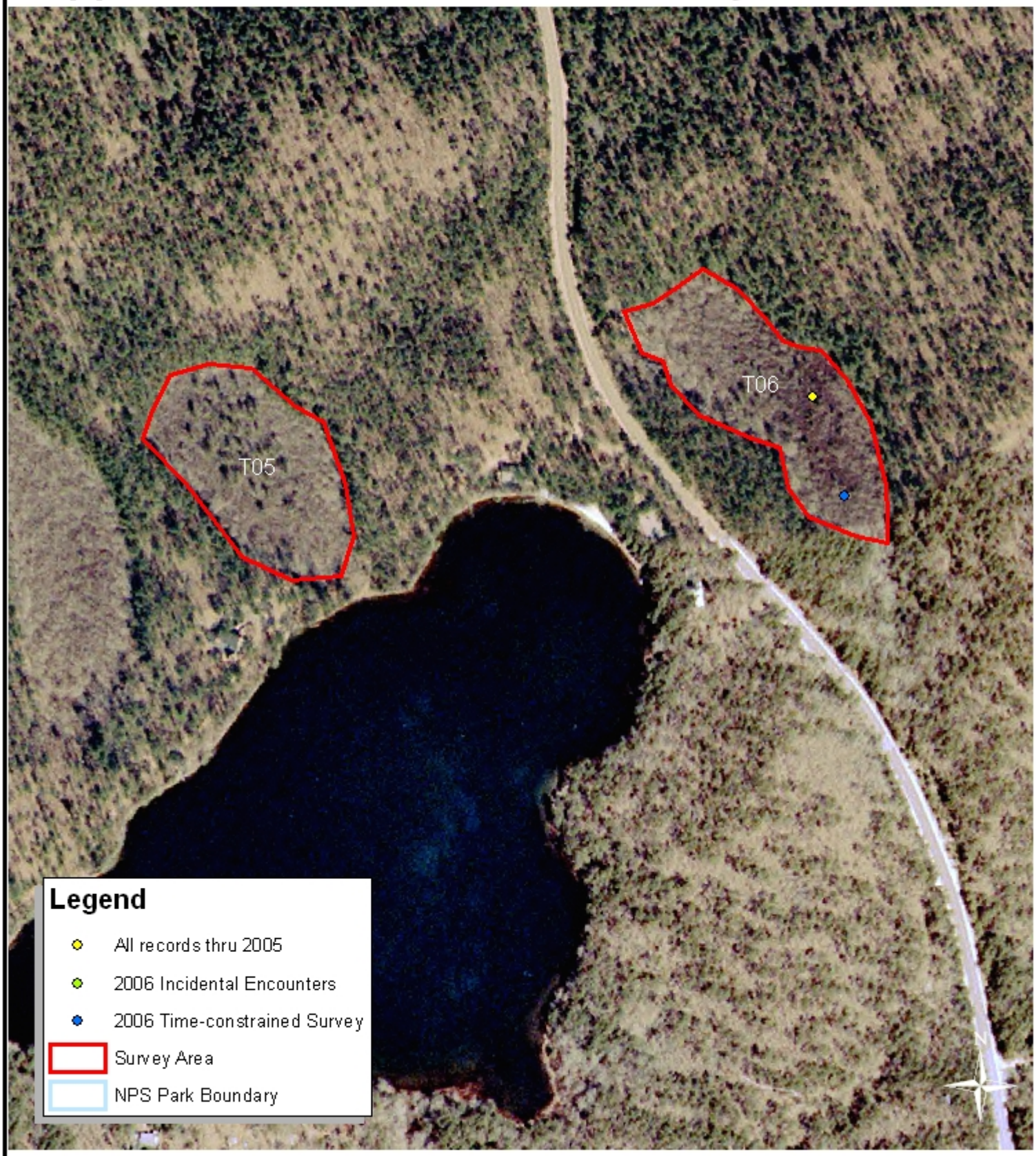
Appendix 2-N. T05 and T06 survey areas



0510203040
Meters

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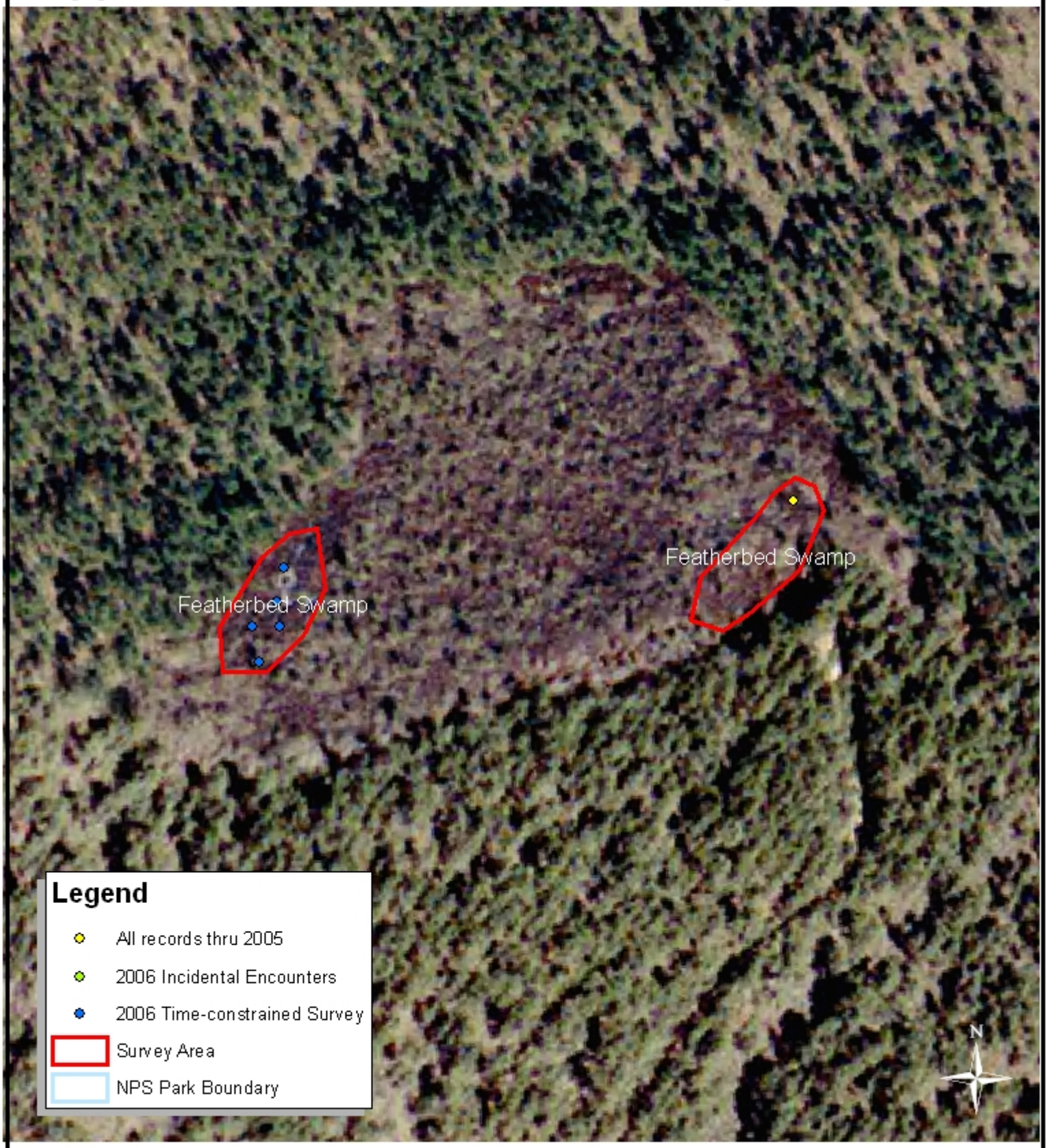
Appendix 2-O. Featherbed Swamp search area



0 5 10 20 30 40
Meters

Appendix 2-P. T47 search area

01.53 6 9 12
Meters

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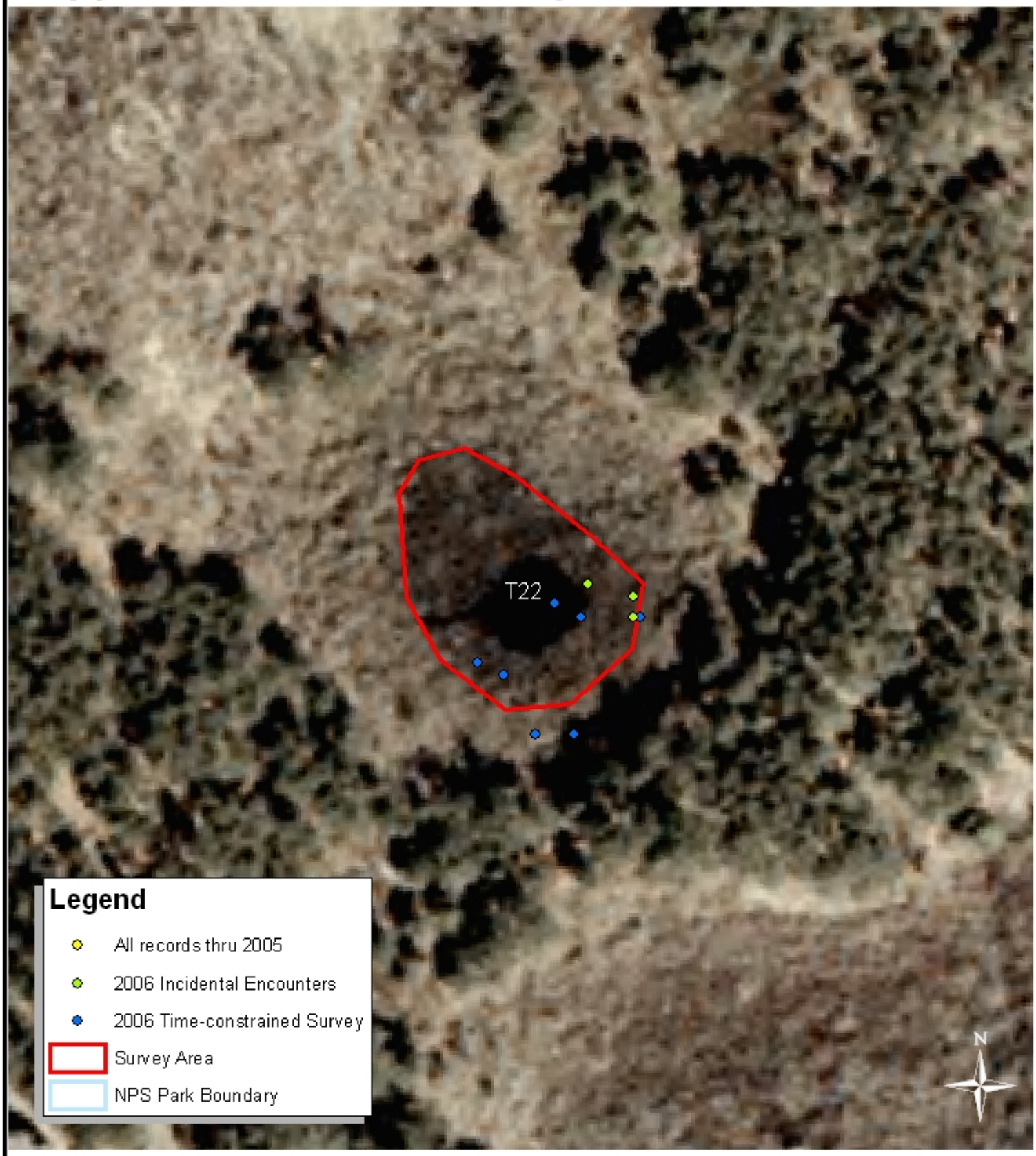
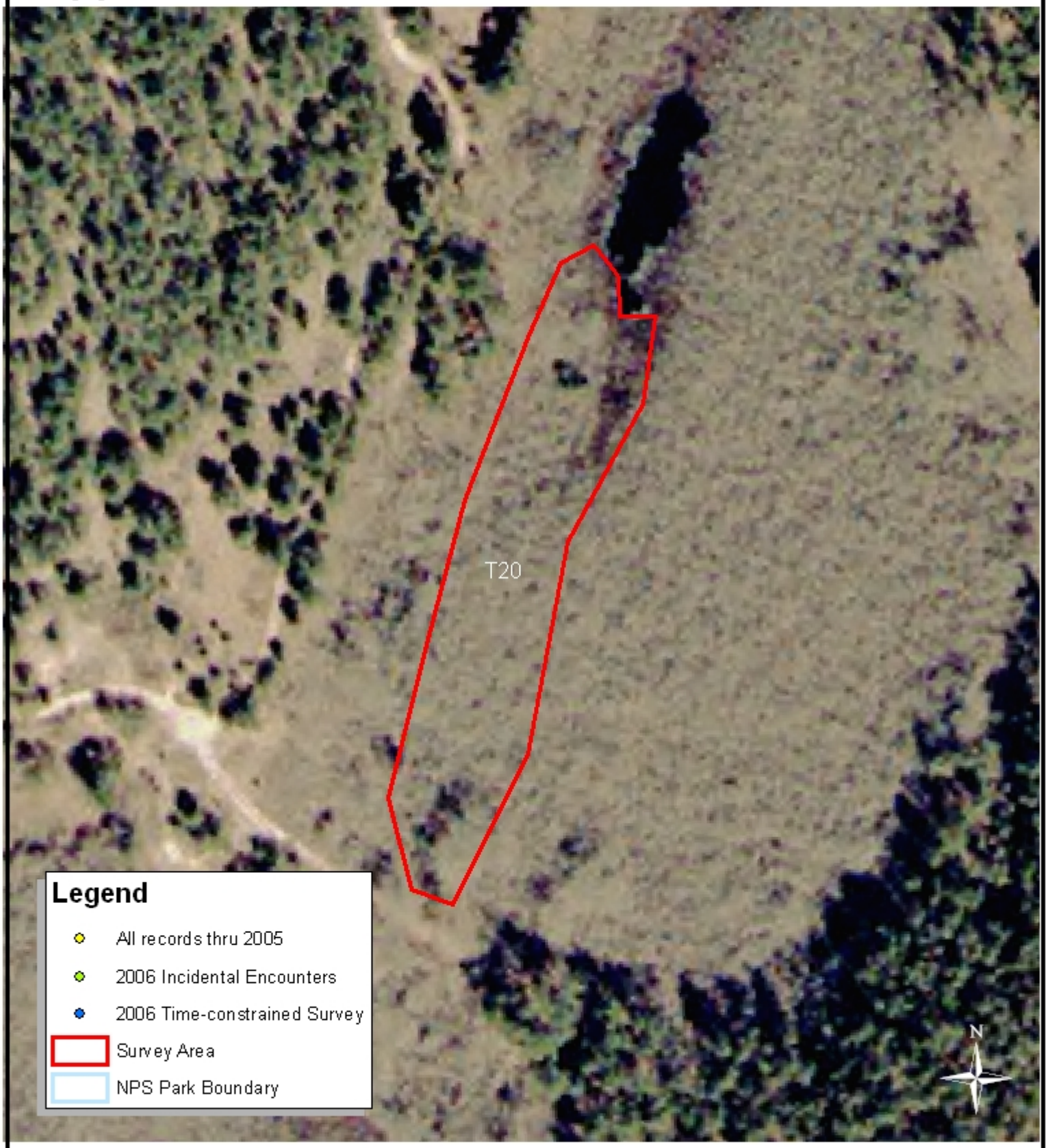
Appendix 2-Q. T22 survey area



0 4.5 9 18 27 36 Meters

Appendix 2-R. T20 search area



0 5 10 20 30 40
Meters

Produced by CACO

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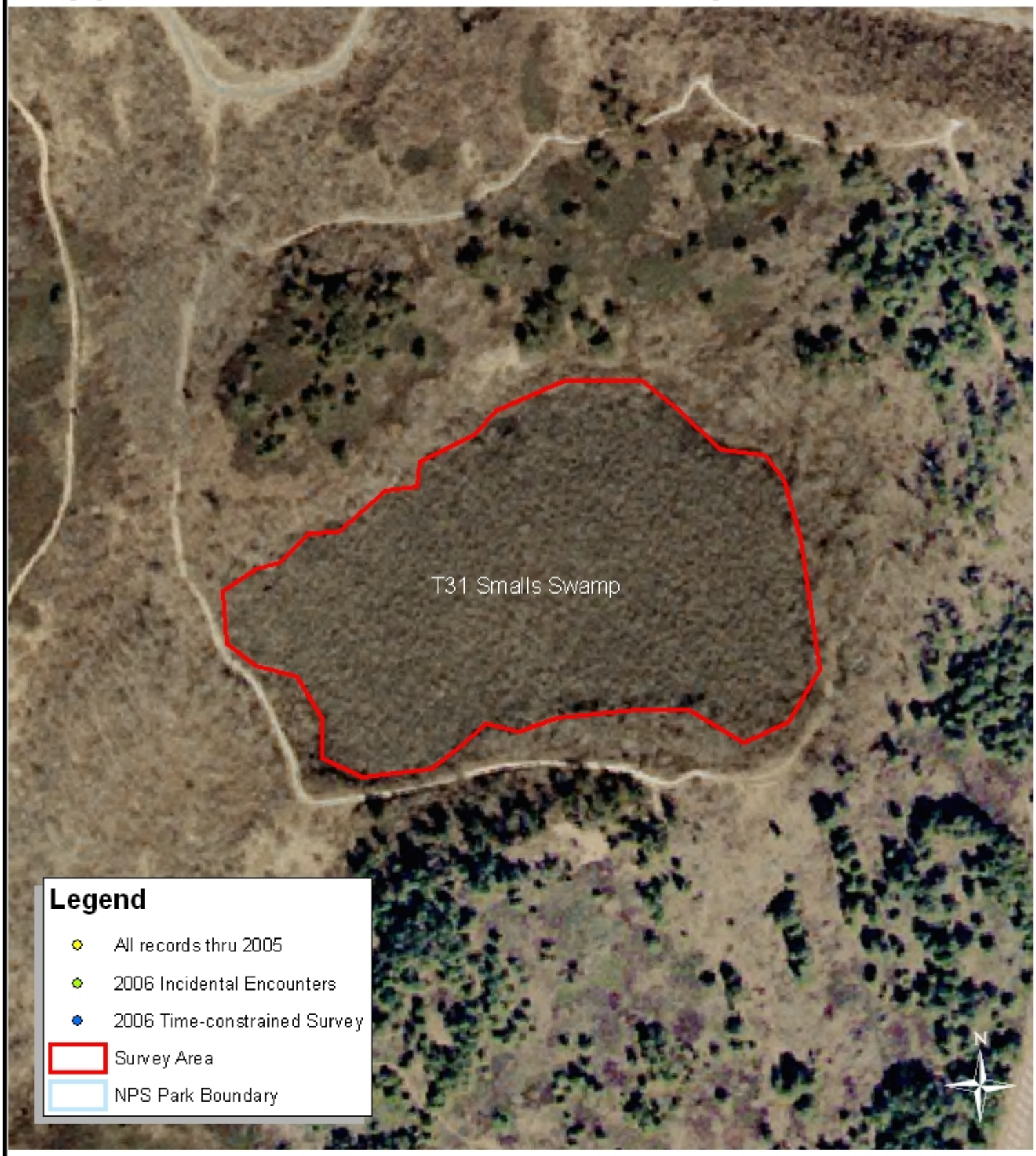
Appendix 2-S. Salt Meadow search area

0 4 8 16 24 32
Meters

Appendix 2-T. T31 Smalls Swamp search area



0 5 10 20 30 40
Meters

Appendix 2-U. Grassy 3 search area

0 5 10 20 30 40 Meters

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Appendix 2-V. P14 search area

0 3 6 12 18 24 Meters

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Appendix 3. Records of HESC encountered outside of time constrained surveys at Cape Cod National Seashore in 2006.

Site Name	Date	Time	Easting	Northing	Notes	Nesting Females
E03	5/23/2006	18:00	420374	4633964	1 nest with 25 eggs	1
FreshBrook	5/17/2006	11:45	419104	4638101	1 nest with 31 eggs	1
Upper Pole Dike Marsh	5/18/2006	10:45	414147	4643907	1 nest with 40 eggs	1
Lower Pole Dike Marsh	4/19/2006	14:15	413092	4643983	1 adult female with 1 nest	1
Bound Brook East	4/19/2006	15:10	412535	4645313	1 adult female	1
Old County Road	4/7/2006	21:20	412696	4645419	1 adult, sex unknown	
Old County Road	4/7/2006	21:55	412737	4645526	1 adult, sex unknown	
Old County Road	4/7/2006	23:02	412719	4645566	1 adult, sex unknown	
Old County Road	4/7/2006	22:05	412704	4645637	1 adult, sex unknown	
Old County Road	4/7/2006	23:01	412688	4645658	1 adult, sex unknown	
Old County Road	4/7/2006	22:17	412688	4645749	1 adult, sex unknown	
Old County Road	4/7/2006	22:25	412711	4645776	1 adult, sex unknown	
Bound Brook East	5/5/2006	10:10	412421	4645819	1 adult female with 1 nest of 20 eggs	1
Old County Road	4/7/2006	22:37	412582	4645887	1 adult, sex unknown	
Upper Herring River	4/19/2006	15:30	415219	4645891	1 adult female with 2 nests	2
Bound Brook North	4/20/2006	15:00	411173	4646041	1 adult female	1
Upper Herring River	4/17/2006	14:19	414922	4646053	1 adult female with 1 nest of 100 eggs	2
Upper Herring River	4/17/2006	14:20	414919	4646053	1 nest with 140 eggs	3
Upper Herring River	4/17/2006	14:17	414919	4646054	1 adult female with 2 nests: 40 eggs and 26 eggs	2
Upper Herring River	4/17/2006	14:21	414916	4646056	1 adult female with 2 nests: 27 eggs and 14 eggs	2
Upper Herring River	4/17/2006	14:18	414908	4646057	1 adult female	1
Upper Herring River	4/17/2006	14:16	414922	4646084	2 adult females with 1 nest of 29 eggs	2
Upper Herring River	4/17/2006	14:15	414930	4646095	1 nest with 50 eggs	1
Ryder Beach	4/20/2006	15:00	411288	4646368	1 adult female with 1 nest	1
Lombard Hollow	4/20/2006	16:20	412465	4646566	2 nests each with 30 eggs	2
T47	5/3/2006	11:30	413968	4649512	1 adult female with 1 nest of 26 eggs	1
T22	4/18/2006	15:45	414557	4650714	1 adult female with 1 nest of 30 eggs	1
T22	4/18/2006	15:47	414557	4650717	1 nest with 80 eggs	2
T22	4/18/2006	15:50	414550	4650719	1 nest with 50 eggs	1