MONITORING OF BREEDING COMMON LOONS: DOWNEAST LAKES LAND TRUST 2008

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Downeast Lakes Land Trust (DLLT) is a nonprofit organization located in Grand Lake Stream, Maine. Founded in 2001, DLLT's mission is to contribute to the long-term economic and environmental well-being of the Downeast Lakes region through the conservation and exemplary management of its forests and waters.

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Photo caption: *Newly-hatched common loon (Gavia immer) chick with adult. Photo courtesy of Ginger Gumm and Dan Poleschook*

Suggested citation: *Taylor, K., D. Yates, D., D.C. Evers, M. Berry, J. Tompkins, J. MacKenzie and W. Goodale. 2009. Monitoring of Breeding Common Loons: Downeast Lakes Land Trust 2008. Report BRI 2009-02. BioDiversity Research Institute, Gorham, ME.*

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(Report BRI 2009-02)

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April 2009

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1.0 Executive Summary

We report results from survey efforts on lakes with suitable loon breeding habitat in the Downeast Lakes Region of Maine. The purpose of this study was to acquire an 8th year of data on common loon (*Gavia immer*) populations and productivity in the Downeast Lakes Region in Maine. On May 25, 2005, Downeast Lakes Land Trust (DLLT) acquired the 27,000-acre Farm Cove Community Forest and New England Forestry Foundation (NEFF) acquired a conservation easement on 312,000 acres in the surrounding area. The purchased land and easement have ensured the protection of over 445 miles of lake shorelines. This monitoring effort is supported through a cooperative agreement between the U. S. Fish and Wildlife Service (USFWS), DLLT, and NEFF. The fee acquisitions and conservation easements of DLLT and NEFF were funded in part by USFWS, acting for and on behalf of the Trustees of the North Cape Oil Spill.

DLLT began loon monitoring in 2001. BioDiversity Research Institute (BRI) joined the project in 2005, applying standardized loon survey methodologies to determine the number of territorial pairs and breeding success of loons. BRI and DLLT worked collaboratively in 2005, 2006, 2007 and 2008. Field work completed in 2008 includes 12 weeks of ground and boat-based monitoring 5 nights of banding and one aerial survey in August.

Forty-two lakes were surveyed across the study area. Based on well-defined criteria for an established loon territory, a total of 76 territorial pairs were documented and of these, 33 pairs were observed to attempt nesting. From these nests, at least 23 chicks hatched and 13 survived to > 6 weeks of age – an age considered as fledging.

Preliminary results from 2005 through 2008 suggest an annual average of 80 territorial pairs, 14 and fledged young, and an average productivity in the study area of 0.17 fledged young per pair (though 2005 data may have underestimated productivity). Reproductive success in our study area is similar to those found for loon populations in the Allagash and Rangeley Lakes Region of Maine. Both these populations have reduced overall productivity due to hydrological impacts and elevated methylmercury (MeHg) availability, respectively.

Hydrological impacts have also been demonstrated to be a contributor to low reproductive success in portions of the Downeast Lakes study area, and this region has been identified as an area of concern for atmospheric Hg deposition. Half the adult loon blood samples from 2008 have Hg levels at risk for reproductive effects. In order to better assess potential impacts from MeHg, we need to monitor both spatial and temporal trends in loon blood Hg to better understand the risk to breeding common loons in the Downeast Region.

2.0 Introduction

On 19 January 1996, the tank barge North Cape struck ground and spilled an estimated 828,000 gallons of No. 2 fuel oil off the Rhode Island coast. As a result, over 400 loons were killed (NOAA et al. 1999). Models based on the population dynamics of color-marked individuals (Evers 2001a) indicated approximately 3,900 loon-years lost. The on-site replacement of this injury was deemed logistically impractical and the trustees focused on the protection of lake shoreline breeding habitat in New England to restore the injury. Monies paid by the responsible party for the loon-years lost were administered through the USFWS. In an effort to identify the highest quality breeding loon habitat, BRI conducted surveys in target areas to search, find, and evaluate loon territories.

Although Maine's breeding loon population is robust and estimated at 1,400 pairs (Evers 2007), major stressors to the state's population demand vigilance. Protection of loon breeding habitat at a landscape level is critical to maintaining the integrity of populations and avoiding increased patchiness of suitable habitat. Although the modeling of source-sink habitats is currently being investigated for the Northeast's loon meta population, we feel that there are multiple stressors at play that are causing local negative population growth rates. And, although Pulliam (1988) argued that species in spatially heterogeneous environments can maintain large sink populations in an evolutionary stable manner, we contend that the extremely restrictive dispersal abilities of breeding loons (i.e., an average of two km for adult males, Evers 2001a) combined with chronic breeding ground stressors (e.g., MeHg) and unpredictable but frequent wintering area stressors (e.g., marine oil spills) produces enough uncertainty that the chances for creating sink populations need to be aggressively minimized to maintain a minimum viable population.

Mercury (Hg) has become an issue of significant ecological health concern and can lead to adverse effects in fish and wildlife (Driscoll et al. 2007; Evers et al. 2008a). Accumulation of the organic form of Hg, MeHg has been demonstrated to affect reproduction, behavior, and survival in fish and wildlife (Evers et al. 2008a; Wiener et al. 2003; Scheuhammer et al. 2007). Specifically, adverse effects from environmental Hg loads have been documented in breeding common loons on lakes and reservoirs throughout the northeastern United States and Canada (Evers et al. 2008a). Methylmercury accumulation can be especially elevated in reservoirs created for the production of hydroelectricity, as increased water level fluctuations enhance the landscapes sensitivity to MeHg accumulation (Evers et al. 2007; Gerrard and Louis 2001).

On May 25, 2005 DLLT acquired the 27,000-acre Farm Cove Community Forest and NEFF acquired a conservation easement on 312,000 acres in the surrounding area. This project, including the purchased land and easement, has ensured the protection of over 445 miles of lake shorelines. The goal of this year's study was to acquire standardized data on loon populations and productivity in the project area, including (1) documentation of the number of territorial and nesting loon pairs, (2) capture and banding of individuals to assess mercury exposure in the study area, and (2) confirmation of juvenile survivorship. The overall purpose of the study is to establish a baseline set of data, including number of territorial pairs and number of chicks fledged, that can be used in the future to evaluate potential changes in loon populations in the Downeast Lakes region.

3.0 Loon Breeding Habitat Requirements:

Loons prefer lakes >60 acres (>24 ha) with clear water, an abundance of small fish, numerous small islands, and an irregular shoreline that creates coves; however, they are found in a wide variety of freshwater aquatic habitats. Lake size and configuration are important determinants for loon density. Habitat heterogeneity is particularly difficult to quantify and typically requires an evaluation for what constitutes high and low quality. Loons likely have an overall habitat use pattern that follows Pulliam and Danielson's (1991) "ideal pre-emptive distribution" model where an individual selects the best available site and prevents other individuals from occupying that site.

Water quality is an important habitat feature for breeding loon success. Loons are visual predators; therefore clear water is crucial for foraging efficiency. The benefits of foraging in clear water are apparent through a Michigan study that documented adults' time spent foraging in turbid water was significantly greater than in clear water (Gostomski and Evers 2001). Water clarity can be measured with a Secchi Disk or with specially designed probes and instruments. Secchi Disk readings of 5 feet or less (1.5m) alter loon foraging behavior (Barr 1986). Total suspended solid measurements at Seney National Wildlife Refuge, Michigan, indicated that breeding pairs preferred lakes with <28 Nephelometric Turbidity Units (NTU). Lakes over 28 NTU were not used for nesting purposes (BRI, unpubl. data).

Loons nest in close proximity to the water's edge and tend to select small islands, floating bog mats, and marshy hummocks. Loons prefer to nest on small islands, primarily the lee side (Olson and Marshall 1952, Sutcliffe 1980, Titus and VanDruff 1981, Yonge 1981, Dahmer 1986, Jung 1987). Islands provide the widest range of visibility on the territory and afford better protection from mammalian predators. Floating sphagnum bog mats afford particularly high nesting success (Reiser 1988) because they can move with water level fluctuations related to natural and anthropogenic forces. Marsh and mainland sites are of lower preference and most likely occur in response to lack of islands, shoreline development (Alvo 1981, Christenson 1981, McIntyre 1988) and high conspecific densities. In cattail (*Typha* spp.) marshes and other emergent wetlands with tall vegetation, muskrat (*Ondatra zibethicus*) houses provide suitable nesting platforms (Munro 1945). Beaver (*Castor canadensis*) houses may also be used (K. Taylor, pers. com.).

Loons prefer foraging in clear waters of littoral zones; they tend to avoid deeper parts of lakes. Breeding adults and their young generally forage in relatively shallow areas < 16.5 feet (<5 m) and within 165 to 500 feet (50 to 150 m) from the shoreline (Strong and Bissonette 1989; Ruggles 1994; McIntyre and Barr 1997). Preferred prey species, such as yellow perch (*Perca flavescens*) and size classes, such as 4 to 6 inches (10 to 15 cm) are found in this zone (Barr 1996).

Nest sites are generally located within 4 feet of the water's edge (although water level draw-downs can extend their limits and >50 foot (>15 m) pathways have been documented (J. Fair, pers. com.). Available submergent and emergent materials are used for nest structures. Common

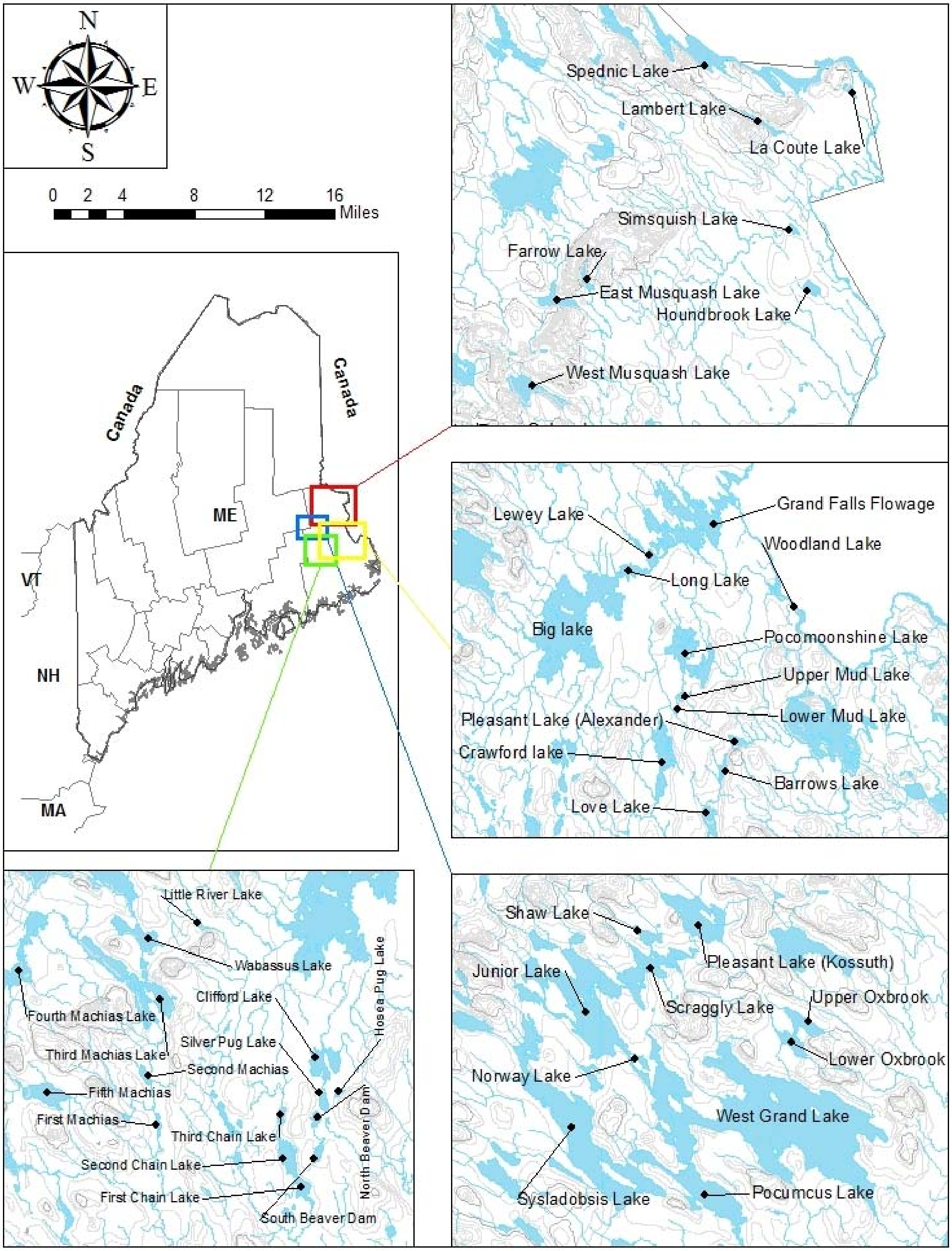
Loons select nest sites with steep drop-offs that allow for underwater approaches and exits (Olson and Marshall 1952, Christenson 1981, McIntyre 1988, Ruggles 1994), however Sutcliffe (1980) and Valley (1987) did not find this to be a predictor of site location. Strong et al. (1987) found between-year reuse of nest sites by loons to be 78-88%. Changes in nest locations were more frequent after nest failures and reuse occurred more often after successful nesting.

Chick rearing areas or nurseries share much of the same attributes as foraging areas. They are typically in shallow water close to shore, with prey size classes suitable for feeding young. These areas experience less prevailing wind and waves that can separate chicks from adults. Chicks hide among shoreline vegetation in response to threats or when left unattended (Yonge 1981, Strong and Bissonette 1989, Ruggles 1994).

4.0 Study Area

The study area for this project is the Downeast Lakes region of interior Washington County, Maine, and is generally focused on the lakes adjacent to the fee acquisitions and conservation easements of DLLT and NEFF. The area is contiguous to other conservation lands, including the Machias River lands, the Duck Lake Unit (Maine Department of Conservation), and Crown Lands in New Brunswick. The Downeast Lakes region was named a Globally Important Bird Area by the American Bird Conservancy in 2006.

Figure 1. Downeast Lakes Project Area and Associated Loon Productivity, 2008.



Loon surveys were conducted on a total of 46 lakes in the St. Croix River, Machias River, East Machias River, and Dennys River watersheds, a region comprising the study area (Figure 1).

Lake size, depth, and perimeter measurements are listed by watershed in Appendix 1. Data is from PEARL, an online data source maintained by the University of Maine. A brief description of the lakes that were surveyed follows.

St. Croix River watershed:

West Grand Lake is one of the clearest and deepest lakes in the study area. The southeast end is the most developed part of the lake, near to the village of Grand Lake Stream. The body of West Grand has many rocky shores; however there are enough coves and islands to provide habitat for multiple pairs. **Junior Bay** and **Pug Lake** are considered part of West Grand Lake, and are among the less developed portions of West Grand providing suitable nesting habitat. A total of 15 loon territories are surveyed on West Grand Lake, including Junior Bay and Pug Lake.

The West Grand Lake watershed includes **Pocumcus, Sysladobsis, Wabassus, Norway, Scraggly, Shaw, Junior, and Pleasant Lakes. Pocumcus** is less developed than West Grand with a few camps and a campground at Elsemore Landing. It also has more suitable habitat for loon nesting, and as such, supports three established territorial loon pairs. **Sysladobsis**, where eight loon territories are surveyed, is largely open with rocky shorelines, has an ample amount of small islands and protected marshy coves that provide good nesting areas. **Wabassus Lake** is a medium-sized lake with only a few camps and some marshy areas on the shoreline. Five loon territories are found on Wabassus Lake. While **Norway Lake** has a few marshy, sheltered spots suitable for nesting, and human activity is low on the lake, only one loon pair occupies this lake. **Scraggly**, with eight loon territories and **Shaw** with one loon pair are remote lakes accessible by logging roads north of West Grand Lake, with many coves and marshy spots providing nesting habitat. Parts of **Junior Lake** are remote, but there are many camps on its shoreline and considerable human activity in certain areas of the lake. Although some shores are rocky, there are multiple islands to provide suitable nesting spots for seven potential loon territories. **Pleasant Lake** is accessible from Route 6 on a well-traveled dirt road, however there are only a few camps and a campground on the lake. There are no islands and few coves and nesting locations are sparse. Three loon territories are surveyed on this lake.

The watershed of Big Musquash stream, which drains into **Big Lake** from the north, includes **Upper and Lower Oxbrook, East and West Musquash, and Farrow Lakes.** The **Oxbrook**

Lakes are minimally developed with only a few camps and include a total of two loon territories. **West Musquash Lake** is accessible by dirt road and has a few camps. West Musquash Lake has nesting potential in the southern end of the lake where there are islands and protection from the wind. Four loon territories are surveyed on this lake. **East Musquash** is located along Route 6, with one shore populated with camps, and the rest rocky and exposed. There are nesting spots where Waldon Brook flows into the lake. Two loon territories are surveyed on East Musquash. The entirety of **Farrow Lake** is visible from the shoreline and encompasses a single loon territory.

Clifford Lake with three loon territories and several smaller lakes **(Little River Lake, Silver Pug,** and **Hosea Pug)** are in the Big Lake watershed. These are all relatively remote lakes with limited development. Clifford is divided into three branches, all with islands and marshy shorelines suitable for nesting. Little River Lake, Silver Pug, and Hosea Pug have single loon territories.

Big Lake is a developed lake, with much boat traffic and human activity, but also includes many protected coves and islands. A total of 20 potential loon territories are surveyed on this lake. **Lewey Lake** and **Long Lake,** both supporting a single loon pair, connect Big Lake and Grand Falls Flowage. **Grand Falls Flowage** runs into the St. Croix River from Lewey Lake. It has many coves and islands and lots of submerged logs. There are many suitable wind-sheltered nesting areas. A total of seven loon territories are surveyed on Grand Falls Flowage. A single loon territory exists on **Woodland Lake**, which is part of the flowage, contains several marshy spots suitable for nesting.

Spednic Lake, with seven loon territories, on the U.S.-Canada border, is one of Maine's largest lakes. This watershed also includes the much smaller **Lambert, La Coute, Hound Brook** and **Simsquish Lakes.** Each of these lakes houses a single loon pair.

<u>Machias River watershed:</u>

Fifth, Fourth, Third, Second, and **First Machias Lakes,** with 18 loon territories surveyed in total, are along the main stem of the Machias River. Each includes a few camps, but there is relatively little shoreline development on any of these lakes. **First Chain**, **Second Chain** and

Third Chain Lakes are quiet lakes with a single loon territory each. All have both rocky and sandy shorelines with marshy areas that are suitable nesting areas for loons. Each lake has a few camps.

East Machias River watershed:

Pocomoonshine Lake with five loon territories has many islands and marshy areas that appear to be perfect nesting sites for loons. **Upper and Lower Mud Lakes** are small lakes along the Maine River between Pocomoonshine and Crawford Lakes and encompass two loon territories in total. **Crawford Lake** has many islands, yet much of the shoreline is rocky and less suitable for nesting. Three loon territories are surveyed on this lake. **Love Lake** is accessible by paved roads off of Route 9. **Possum Lake**, **North Beaverdam** and **South Beaverdam** are very small lakes. **Barrows Lake** is south of Route 9 and is relatively undeveloped. Single loon territories are surveyed on all of these lakes.

Dennys River watershed:

Pleasant Lake, is very close to Barrows Lake but is in the Dennys river watershed, and is much more developed with camps and houses surrounding the lake. One loon territory is surveyed on this lake.

5.0 Methods

In 2008, BRI accompanied DLLT field staff for their 8th year of loon surveys in order to standardize survey methodologies with other loon monitoring being conducted in New England. From mid-May to mid-August, BRI and DLLT seasonal biologists conducted ground surveys for territorial pairs inhabiting lakes bordered by protected lands. Surveys focused on 46 lakes within the project area. The presence of territorial pairs was documented including chick hatches, habitat conditions and pressures for each area using similar standardized methodologies. Territories with hatched young were targeted for banding and sampling. Aerial surveys conducted in August confirmed chick survivorship.

5.1 Ground Survey Field Methods

Survey methods were consistent with those reported in Evers et al. (2001a). All known or potential loon territories and surrounding areas were surveyed using 10X binoculars with occasional use of a 15-45X spotting scope. A canoe or kayak was used on moderate- and large-sized lakes with poor road access or launching facilities. Lakes with difficult access were reached on foot guided by a Garmin® GPS and orienteering. The seasonal staff surveyed each day with registered Maine guides from the Grand Lake Stream Guide Association. Every effort was made to gather information from the greatest distance possible from the loons to minimize impacts on nesting and brooding activities. Since nesting evidence may be obscured by vegetation, it was often necessary to search for presence/absence of nest evidence by foot. On these occasions, searches were conducted for evidence of natural nesting attempts by walking the perimeter of the available nesting habitat in loon territories. All known historical nesting sites were checked regularly for nesting evidence.

Loon territories were delineated according to observed territorial behavior by a loon pair such as close physical association, defensive posturing and calling along borders. Territories are used by pairs for feeding, resting, breeding, nesting, chick rearing and are protected against incursion by other loons (and sometimes waterfowl) for a minimum of four weeks. Territories are used as a unit of reference in describing loon breeding activity and are recognized as being either "*established*" or "*transitional*." Established territories have consistent occupancy for at least three seasons; transitional territories exhibit inconsistent occupation and likely represent less quality habitat.

Nesting pairs (NP) were defined as those laying at least one egg while a **successful pairs** (SP) hatched at least one chick. A nest categorized as a "fail" included evidence as to the cause of the failure if it could be reported with confidence.

Chicks hatched (CH) were recorded as those that hatched completely out of their eggs, not necessarily departing from the nest. For this report, we define the terms "chick" and "fledgling" as follows: "chicks" refer to loon young ≤6 weeks post-hatching and "fledglings" or "fledged young" refer to loon young >6 weeks of age. The number of loon chicks to survive past six weeks of age was assumed to have survived or fledged (CS). All other terms not noted in the methods are defined in Appendix 2.

5.2 Aerial Survey Field Methods

In order to efficiently cover the entire study area, aerial surveys were utilized by BRI on 18 August to confirm chick survivorship through the summer. Aerial surveys were conducted by experienced observers in small fixed-wing aircraft that could decrease speed to approximately 70 m/hr (116 km/hr) and maintain an altitude to 500 ft (60 m) or less, if necessary.

Each territory was circled at low altitude for a minimum of two minutes, or until information was gathered. Territories with known chicks were searched with multiple passes. Surveys were conducted on days with light wind to improve visibility of loons on the water. Although diving birds can be easily missed, in calm conditions loons are readily observed.

While ground surveys provide the best insight on nesting attempts and reasons for nest failure, aerial surveys provide an efficient and confident technique for confirming territorial pair occupancy, chicks, and non-breeding adults.

5.3 Loon Capture and Sample Collection

Loons were captured using well-established nightlighting and playback techniques to collect blood and feather samples for MeHg analysis (Evers 2001). Adult and juvenile birds were banded with USFWS aluminum bands and a unique combination of plastic colored bands, enabling identification of individual birds to be made from a distance in future observations. Chicks were not banded if their legs are too small to hold adult-size bands. All sampling was accomplished using non-lethal methods.

Loon blood was collected to evaluate short-term MeHg accumulation from the tibiotarsal vein through a multiple leur adapter system and deposited directly into a green top vacutainer, or, in the case of small chicks, into a microtainer or capillary tube. Blood samples were double labeled and refrigerated.

Feather samples were collected from adult birds and older chicks to provide an indication of long-term MeHg accumulation. Feather samples from adult loons include the second secondary feather from each wing and two central tail feathers. If present, two central tail feathers were collected from young chicks (feathers may not be grown out in younger chicks). Feathers were placed in zip-lock® bags and double-labeled. Bill and leg measurements and weight were recorded

5.4 Laboratory Analysis

Loon tissues were analyzed to determine total Hg content (which reflects >95% MeHg) at Center for Environmental Sciences and Engineering, University of Connecticut, Storrs, CT. (based on methods by Evers et al. (1998, 2003, 2005). Homogenization of blood, feathers, and eggs followed established standard laboratory USFWS protocols (Evers et al., 1998, 2003). Loon blood, feather, and egg samples were analyzed using Cold Vapor Atomic Adsorption and Fluorescence techniques. Blood and feather Hg levels are expressed in wet weight (ww), while egg Hg levels are provided on a wet and dry weight (dw) basis. The lab used USEPA/USFWS approved QA/QC protocols for all assays.

5.5 Defining Reproductive Success

Reproductive success was evaluated according to four parameters: nesting frequency, hatching success, chick survivorship and overall productivity. *Nesting frequency* was defined as the number of nesting pairs per total territorial pairs. This measure indicates the percent of the total potential breeding population that attempts to reproduce each season. The rate of success by these pairs, or *hatching success*, was measured through the number of chicks hatched by these pairs. *Chick survivorship* was defined as the number of chicks surviving in September divided by the number of chicks hatched. *Overall productivity* is a combination of the prior three parameters and measured through fledged young per territorial pair.

6.0 Results

6.1 Results of the 2008 Breeding Season

In the 2008 field season, field staff spent 12 weeks surveying 42 of 46 lakes in the survey across the Downeast Lake study area (Table 1, Appendix 3 and 4). Seventy-six territorial loon pairs were recorded in 2008; comparable to the 72 pairs in 2007 yet still below the high of 95 pairs reported in 2005 (see discussion).

Table 1: Common Loon Population and Productivity Summary, 2005-2008

Year	2005	2006	2007	2008	Average/sd
Population					
Territorial Pairs	95	75	72	76	80+/-11
Nesting Pairs	36	33	34	33	35+/-1
Chicks Hatched	32	21	29	23	26+/-5
Chicks Surviving	20	10	11	13	14+/-5
Reproductive Success					
Nesting Frequency	38%	44%	47%	43%	43+/-4%
Hatching Success	89%	64%	85%	70%	77+/-12%
Chick Survivorship	63%	48%	38%	57%	51+/11%
Overall Productivity	21%	13%	15%	17%	17+/-3%

During the 2005-2008 monitoring period, an average of 80 +/-11 pairs has been recorded. Of the 76 pairs in 2008, 33 were confirmed as nesting yielding a nesting frequency of 43% nests per territorial pairs. Twenty-three chicks hatched with 13 surviving to fledge. The number of chicks hatched decreased 21% from the previous year (n=29) with an average of 26+/- 5 chicks hatching in the study area since 2005. While hatching success (70%) decreased from the previous year (85%), chick survivorship was the second highest recorded over the monitoring period.

6.2 Capture and Banding of Loons

In 2008, 10 loons were captured over five nights, including eight adults (5 males, 3 females) and two chicks (Table 2).

Table 2: Summary of Common Loons Banded, 2008

Date	Lake	Territory	Age	Sex	Left Leg	Right Leg	USFWS#
7/10	Pocomoonshine Lake	West Black Cove	Adult	Male	Blue/Yellow	Silver/Red Stripe	938-447-38
7/10	Upper Mud Pond	Upper Mud	Adult	Female	Red/Blue	Blue Stripe/Silver	938-447-12
7/10	Upper Mud Pond	Upper Mud	Chick	Unknown	Blue Stripe/Silver	Yellow/Green	938-447-45
7/10	Upper Mud Pond	Upper Mud	Chick	Unknown	Blue Stripe/Silver	While/Yellow	938-447-13
8/7	Junior Lake	McKinney Point	Adult	Male	Yellow/Blue	Blue Dot/Silver	938-617-81
8/7	West Grand Lake	Blood Brook	Adult	Female	Red/White	Blue Dot/Silver	938-617-82
8/8	West Grand Lake	Farm Cove	Adult	Female	Yellow Dot/Green	White Stripe/Silver	938-617-95
8/11	Big Lake	Clark Cove	Adult	Male	Red Stripe/Red	White Stripe/Silver	669-205-56
8/11	Big Lake	Gould Meadow Brook	Adult	Male	Blue Stripe/Yellow	Blue Dot/Silver	938-617-99
8/12	Big Lake	Musquash Cove	Adult	Male	Orange/Orange	Blue Dot/Silver	669-205-61

6.3 Mercury Exposure in Common Loons

Eggs: Egg Hg levels in the egg collected on East Musquash Lake was 1.13 ug/g (ww), representing moderate Hg risk (Table 3 and 4) in the sample from East Musquash Lake.

Table 3. Mercury Risk Categories in Common Loons.

Tissue Type	Low Risk Levels	Moderate Risk	High Risk Levels	X-High Risk Levels
Adult Blood	0.0-0.99	1.00-2.99	3.00-3.99	>4.00
Juvenile Blood	0.0-0.09	0.10-0.65	0.66-0.99	>1.00
Egg	0.0-0.49	0.50-1.29	1.30-1.99	>2.00
Adult Feather	0.0-8.99	9.00-39.90	40.00-79.99	>80.00

Blood: Adult blood Hg levels ranged from 1.73 to 4.22 ug/g (ww) with a mean of 3.06 +/- 0.91 ug/g (n = 8). Adverse effect thresholds of 3.0 ug/g (ww) were exceeded in 50% of adult blood.

Feather: Feather Hg levels ranged from 10.02 to 16.02 ug/g (fw) with a mean of 13.12 +/- 2.16 ug/g (n = 6) representing moderate Hg risk.

Table 4. Mercury Levels in Common Loon Tissues Collected in the Downeast Region, 2008.

Tissue	Lake	Territory	Hg ug/g (ww)	Risk Level
Egg	East Musquash Lake	East Musquash	1.13	M
Adult Blood	West Grand Lake	Blood Brook	1.73	M
	Pocomoonshine Lake	West Black Cove	2.06	M
	West Grand Lake	Farm Cove	2.65	M
	Big Lake	Clark Cove	2.78	M
	Upper Mud Pond	Upper Mud	3.20	H
	Big Lake	Musquash Cove	3.89	H
	Big Lake	Musquash Island	3.94	H
	Junior Lake	McKinney Point	4.22	XH
		Average	***3.06***	
		SD	***0.91***	
Juvenile Blood	Upper Mud Pond	Upper Mud	0.19	M
	Upper Mud Pond	Upper Mud	0.26	M
		Average	***2.49***	
		SD	***1.61***	
Feather	Junior Lake	McKinney Point	10.02	M
	Big Lake	Clark Cove	11.34	M
	West Grand Lake	Farm Cove	13.02	M
	Big Lake	Musquash Cove	13.90	M
	West Grand Lake	Blood Brook	14.39	M
	Big Lake	Musquash Island	16.02	M
		Average	***13.12***	
		SD	***2.16***	

6.4 Relationship between Loon Productivity and Lake Size

In analyzing 2005-2007 data, we found a significant relationship between hatching success and lake size (r^2=0.63, p=0.03). Hatching success was considerably lower on whole-lake territories (or those lakes occupied by only one territorial pair) when compared to that found on partial lake territories (or those lakes occupied by >1 territorial pairs). We found no relationship between chick survival (CS/CH) and overall productivity (CS/TP) with lake size and large impoundments. See Taylor et al. 2007 for more information. In the final report from the 2009 field season, we can use a standardized 5-year dataset (2005-09) to retest these patterns for significance.

6.5 Downeast Region in Comparison with other Loon Populations

Overall, the reproductive success of loons in the Downeast Lakes study (2005-2008) is lower than averages for New Hampshire and other areas of Maine (Table 5). Of the other Maine populations studied, the limiting factor in reproductive success for loons in the Allagash Region appears to be hydrological in nature (Yates et al 2005) while elevated MeHg availability has been a driving factor in reducing overall productivity in the Rangeley Lakes area (Evers 2008a). Evers et al 2008b demonstrated hydrological impacts as a contributor to low reproductive success in portions of the Downeast Lakes study area. While other secondary factors could be attributed to lowered reproductive success in northern and eastern Maine, anthropogenic factors (e.g., methylmercury availability and hydrological impacts) resulting in lower habitat quality are more likely.

Table 5. Summary of Overall Reproductive Success for Downeast Lakes (2005-2008) in Comparison to other Maine Regions and New Hampshire.

Region	#Lakes Surveyed	#Lakes with TPs	TP	NP	CH	CS	Nesting Frequency	Hatching Success	Chick Survivorship	Overall Producitivity
Downeast Lakes 2008	42	30	76	33	23	13	0.43	0.70	0.57	0.17
2007	46	33	72	33	29	11	0.46	0.88	0.38	0.15
2006	46	34	75	33	21	10	0.44	0.64	0.48	0.13
2005*	46	38	95	36	32	20	0.38	0.89	0.63	0.21
Average	***45***	***34***	***80***	***34***	***26***	***14***	***0.43***	***0.78***	***0.51***	***0.17***
Rangeley Lakes 2008	37	30	101	64	45	19	0.63	0.70	0.42	0.19
2007	38	35	123	77	53	41	0.63	0.69	0.77	0.33
2006	38	6	84	61	44	25	0.73	0.72	0.57	0.30
2005	40	30	116	73	59	40	0.63	0.81	0.68	0.34
Average	***38***	***25***	***106***	***69***	***50***	***31***	***0.65***	***0.73***	***0.61***	***0.29***
New Hampshire 2008	263	164	247	160	128	97	0.65	0.80	0.76	0.39
2007	272	151	223	141	131	103	0.63	0.93	0.79	0.46
2006	252	151	218	140	130	104	0.64	0.93	0.80	0.48
2005	215	135	204	152	142	112	0.75	0.93	0.79	0.55
Average	***251***	***150***	***223***	***148***	***133***	***104***	***0.67***	***0.90***	***0.78***	***0.47***
Allagash Region 2000-2004										
Average	***24-36***	***14-25***	***107***	***48***	***29***	***15***	***0.45***	***0.60***	***0.52***	***0.31***

*The number of territorial pairs in 2005 is considered higher than the actual population of pairs in the Downeast Lakes Region. Counts based on the 2006-2008 surveys are more reflective of the status of pairs in the study area.

6.6 Summary of Survey Results, 2001-2008

Table 6 summarizes data compiled from the 2001 – 2008 loon surveys. For each lake, the annual number of territorial pairs observed, nesting pairs, chicks hatched and surviving is presented, along with averages across years. Although loon monitoring from 2001-2004 was done on a subset of the currently surveyed lakes, data represented for these years provides a foundation for the current standardized effort.

Table 6. Summary of Loon Survey Results, 2001-2008

[redacted]

*Represent years of standardized survey methodology

7.0 Discussion

Average territorial pair counts of 74+/-2 pairs (2006-2008) are lower than the high of 95 pairs recorded in 2005. It is possible the high number of pairs recorded in 2005 was not a true reflection of the population in the study area, but instead the result of the first year of application of standardized survey methods, an effort that inherently takes several field seasons to establish. Furthermore, data collected previous to 2005 were done on a subset of the currently monitored lakes using different protocols and therefore caution must be used when comparing with 2005-2008 survey results (Table 1). Ground-truthing the 2005 lake and territory delineations in the following years has further refined the standardized survey. We therefore feel that the 2006-2008 field data most completely and accurately represent the population and productivity status of common loons in the study area.

However, the 20 chicks surviving in 2005 should be as accurate as the chick survival numbers for 2006-2008 – possibly having been produced by fewer than 95 territorial pairs. While this would suggest the overall productivity in 2005 was higher than 0.21 chicks surviving per territorial pair, reproductive success for loons in this region remains low, even when compared to other regional populations.

Loons are long-lived birds that on average produce 4.4 fledged young and up to 13 (modeled by using fecundity of 0.26 fledged young per female, 1-3 year annual survivorship of 55%, 3-20 year annual survivorship of 95%, and 20-30 year annual survivorship of 85%). Based on these population growth models that were generated through Ramas software (Akcakaya 1998), output indicates at least an average of 0.48 fledged young per territorial pair (or 0.24 females assuming a 1:1 sex ratio) needs to be produced to maintain a lamda greater than one (Evers 2007).

While this study did not quantify factors that may affect reproductive success in the Downeast Lakes study area, based on a separate study focused on a portion of our study area, water levels held high in the spring caused delays in nest initiation (Evers 2008b). Water levels that peak during the critical nesting period physically flood suitable nesting habitat. Potential nesting pairs delay initiation of a nest while waiting for suitable habitat to be exposed when lake levels decrease. The delay in nest initiation likely influences overall productivity because it disrupts pair bonds, which also reduces contributions from loons with high fitness.

Another factor known to reduce reproductive success is MeHg availability. Evers et al. (2008a) determined that loons with blood Hg levels over 3.0 ug/g (ww) produced 40% fewer fledged young than territories where adult blood Hg was less than 1.0 ug/g (ww). Samples taken from loons on Big Lake, Junior Lake and Upper Mud Pond were over the effects threshold of 3.0 ug/g (ww) in blood, and therefore are considered at high risk for reproductive effects. Further, Evers (2007) identified the Downeast Region as an area of concern for atmospheric Hg deposition. Loon tissue samples from 2008 are further evidence this area might be a biological Hg hotspot. Other studies have shown that MeHg accumulation in wildlife can be elevated in reservoirs created for the production of hydroelectricity, as increased water level fluctuations enhance the landscapes sensitivity to MeHg accumulation (Evers et al. 2008; Gerrard and Louis 2001).

In order to better assess potential impacts from MeHg, we need to monitor both spatial and temporal trends in loon blood Hg to better understand the risk to breeding common loons in the Downeast Region. Emphasis should be placed on increasing our banding and sampling efforts, including the tracking and recapture of known individuals. Color-marking loons also provides further information on inter-seasonal movements, between-year territory fidelity, mate switching, estimated minimum survival, individual behavior, loon social dynamics (Evers 2001), and links local breeding populations to key winter habitat. Many of these findings can then be related to productivity.

8.0 Recommendations

1. Continue to develop a standardized dataset by lake and loon territory by querying the database for established territories (those with occupancy by territorial pairs for > three years;
2. Continue to georeference all known nest sites;
3. Continue to georeference all occupied loon territories using best-estimate territory center in lieu of nest sites;
4. Continue capture, color-marking and sampling loons to determine Hg exposure in the study areas, including the recapture of known individuals;
5. Use two, well-trained BRI biologists to determine the location and size of loon territories on a subset of lakes monitored from 2006-2008 to better refine the relationship between fledging and shoreline in the study area.

9.0 Acknowledgements

DLLT and BRI would like to acknowledge the following: U.S. Fish and Wildlife Service for providing funding for the survey effort; the Registered Maine Guides from the Grand Lake Stream Guides Association for assisting with surveys, orientation and providing information. We would also like to thank Sue Hurd, Kim Vose, Damon Curtis, Steve Norris, Lance Wheaton, Jim Kesel, John Arcaro, Billy Gillespie, Jeff McEvoy, Laura Hunt and the Downeast Lakes community for providing invaluable information on loon sightings. Much of the information in this report was derived from the initial loon surveys by Ben Calvi (2001-2004), Kimmy Battista (2004-2005) and Marshall Crowe (2005); Jake Trask conducted the 2006 surveys.

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Appendix 1. Sizes, Perimeters, and Depths of Lakes in the Study Area.

St. Croix River Watershed:

Lake	Area (ac)	Perimeter (ft)	Mean Depth (ft)	Max Depth (ft)
West Grand Lake	14467	258866	37	128
Sysladobsis Lake	5430	6842	25	66
Pocumcus Lake	2211	116413	25	44
Wabassus Lake	989	52258	12	24
Norway Lake	130	18141	na	na
Scraggly Lake	1640	117774	22	42
Shaw Lake	251	24391	12	30
Junior Lake	4000	152,076	21	70
Pleasant Lake	1550	63195	34	92
Lower Oxbrook Lake	341	23719	16	30
Upper Oxbrook Lake	434	24966	9	18
West Musquash Lake	1606	62789	na	108
East Musquash Lake	818	48947	24	62
Farrow Lake	286	19484	34	76
Little River Lake	74	9425	na	na
Clifford	1247	117701	20	50
Hosea Pug	58*	na	na	35*
Silver Pug Lake	212	17741	21	38
Big Lake	10444	370530	12	70
Lewey Lake	469	44966	na	na
Long Lake	608	43741	12	25
Grand Falls Flowage	6099	34932	na	44
Woodland Flowage	2	2196	na	32
Spednic Lake	17219	559136	20	54
Lambert Lake	521	35170	20	60
Hound Brook Lake	310	17825	na	na
LaCoute Lake	138	12390	8	11
Simsquish Lake	141	13489	na	na

Machias River Watershed:

Lake	Area (ac)	Perimeter (ft)	Mean Depth (ft)	Max Depth (ft)
Fifth Machias Lake	1058	43429	11	27
Fourth Machias Lake	1913	147739	13	26
Third Machias Lake	2558	190391	14	28
Second Machias Lake	182	14683	7	12
First Machias Lake	122	17526	10	30
Third Chain Lake	233	46238	15	33
Second Chain Lake	799	66506	15	30
First Chain Lake	464	48247	16	31

East Machias River Watershed:

Lake	Area (ac)	Perimeter (ft)	Mean Depth (ft)	Max Depth (ft)
Pocomoonshine Lake	2538	171077	14	40
Upper Mud Lake	91	9871	na	na
Lower Mud Lake	74	7985	na	na
Crawford Lake	1879	145266	na	na 27
Love Lake	651	33898	17	45
Barrows Lake	253	28477	14	40
Possum Lake	25	5518	11	18
North Beaverdam Lake	148	13259	13	21
South Beaverdam Lake	181	21210	18	39

Dennys River Watershed:

Lake	Area (ac)	Perimeter (ft)	Mean Depth (ft)	Max Depth (ft)
Pleasant Lake	337	18532	17	36
Total Acreage & Perimeter	85,143	3,298,955		

Appendix 2. Definition of Terms

Artificial nesting island or "rafts" – Artificial floating platforms for use as an alternate nesting site for Common Loons as described by the New Hampshire Loon Preservation Committee (LPC) raft protocol and Fair (1989). Artificial nesting islands were first developed and employed as a loon research tool by McIntyre (1977), later improved for management use by LPC.

Avian guard – A camouflage mesh cover that is attached to artificial nesting islands with the intent of minimizing the visibility of the nest and eggs from avian predators and boat traffic.

Between-year territory fidelity – The return of an established territory holder to its previously occupied territory.

Breeding adults – Established and transitional territory holders that attempt to breed.

Buffer population – That portion of the loon population that includes non-breeders.

Chick survival – Number of loon chicks fledged divided by the number of loon chicks hatched; often expressed as a percentage.

Established Territory – Paired adults found on territory for at least three consecutive weeks for three consecutive years

Estimated minimum survivorship – The known return rate for adult loons during the breeding season.

Fledge rate – Number of chicks fledged divided by either the number of nesting pairs (F/NP) or territorial pairs (F/TP). Also referred to in this report as "fledging success." F/NP is a representation of the total number of chicks fledged relative to pairs that attempted to nest, F/TP is a representation of the number of chicks fledged relative to all of the territorial pairs within a given subpopulation – including those territorial pairs that did not nest.

Hatch rate – Number of chicks hatched divided by the number of nesting pairs (H/NP) or territorial pairs (H/TP) of a given or study-area population. H/NP is a representation of the total number of chicks hatched relative to pairs that attempted to nest (also referred to as "hatching success"). H/TP is a representation of the number of chicks fledged relative to all of the territorial pairs within a given population – including those territorial pairs that did not nest.

Hatch window – The estimated time frame in which hatching is expected to occur.

Individual performance – Tracking the reproductive success of color marked individuals over time.

Long-term productivity – a measure of productivity taking into consideration the number of years the territory has existed or has been monitored. This value is calculated by dividing the number of chicks hatched by the number of years during which the parameter was measured.

Loon – Common Loon (*Gavia immer*); no other loon species was observed in the study area during the report period.

Loon return-year – A measure of loon site fidelity that represents the number of years an individual loon returned to the territory from which it was originally banded.

Mate fidelity – The known pairing of an adult with the previous years' mate

Mate switching – The known change of mates within or between years.

Multiple lake territory – Paired adults using two or more lakes during a breeding cycle to provide the required resources. Multiple-lake territories are only those that require flight to access another lake.

Natal site fidelity – The known return of an individual originally banded as a juvenile

Nest attempt – Presence or evidence of any loon nest constructed or scraped that contained eggs or had evidence of eggs; this excludes copulatory platforms and nests of uncertain origin.

Nest failure – Any nest attempt that fails to completely hatch or at least one egg.

Nest onset – The time, often expressed as a "window" of dates, during which a nesting pair initiates incubation.

Nest success – Any nest attempt in which at least one chick hatches.

Nesting frequency – Number of nesting pairs divided by the number of territorial pairs in a given population or study area; often expressed as a percentage. Nesting frequency is an index of the portion of a population attempting reproduction on a given year or time period.

Nesting season – That part of the year encompassing early reproductive behavior on the breeding grounds through late hatching of chicks. Nest building may begin prior to complete ice-out in Maine and New Hampshire and hatches may occur as late as mid August in western Maine (Fair unpubl. Data). The nesting season varies from year, across latitudes and sometimes between lakes. On Aziscohos Lake during this study period, nesting season is generally defined as May 15 – August 5.

Nesting success – The number of loon pairs hatching at least one chick divided by total number of pairs exhibiting at least one nesting attempt; usually expressed as a percentage.

Non-breeding adults – Territorial and non-territory holders that do not breed in a given year.

Partial lake territory –Paired adults sharing a lake with other established territory holders.

Production – The number of chicks fledged within a given time period by a loon population.

Productivity – The number of fledged chicks divided by the number of territorial pairs in a given population.

Raft – Artificial nesting island for loons.

Raft use by loons – a raft is considered used when one or more nest attempts occur on that raft; may be expressed as the number of raft nest attempts divided by number of rafts deployed that year.

Renest – A second nest attempt in a given year.

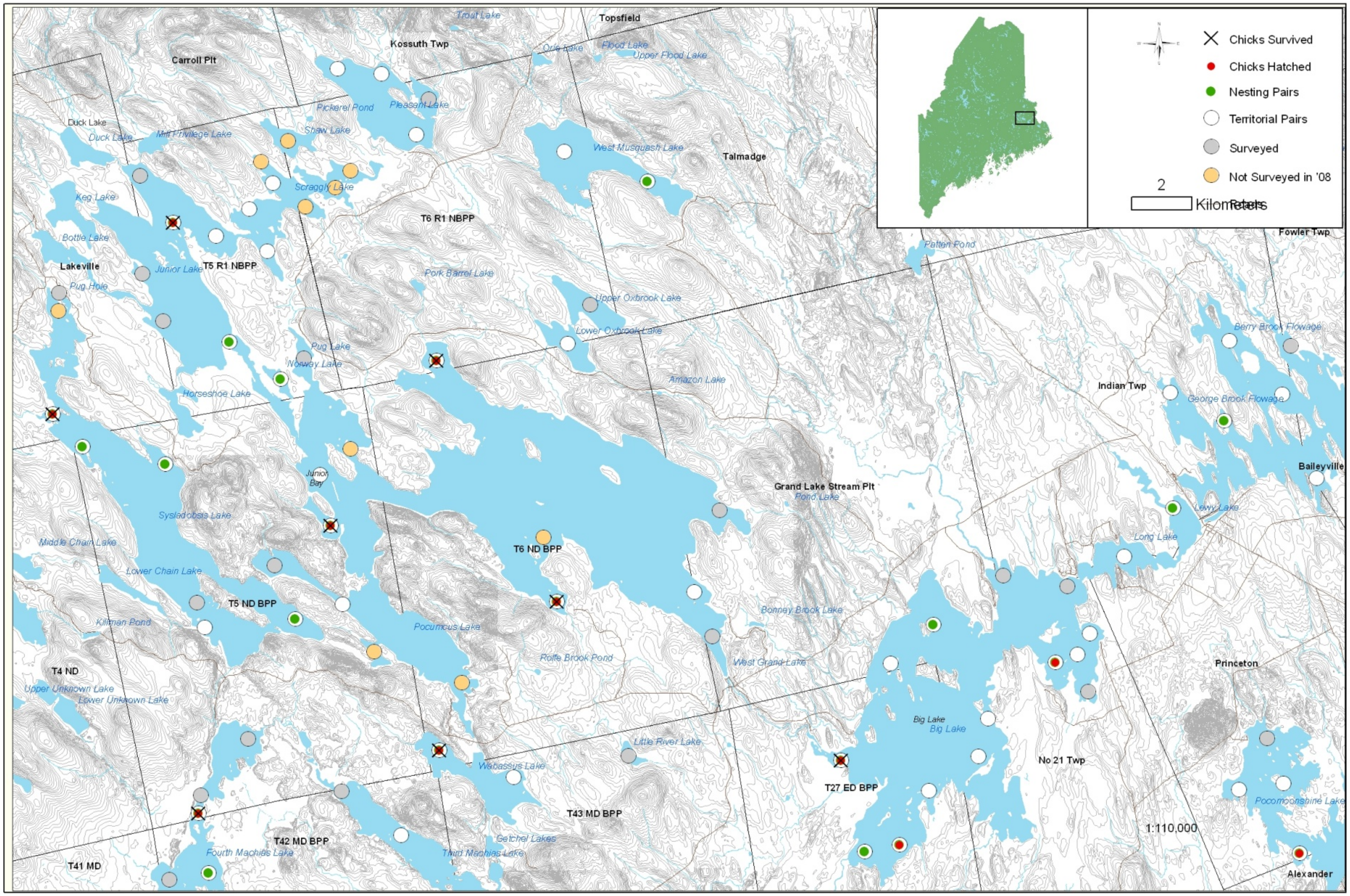
Territorial persistence – The tendency for territorial pair to remain present within their territory throughout the season. Measured by the length of time a pair remains on territory throughout the year.

Territory years - The number of years a territory has been surveyed. Used as the denominator of the long-term hatch rate productivity measure.

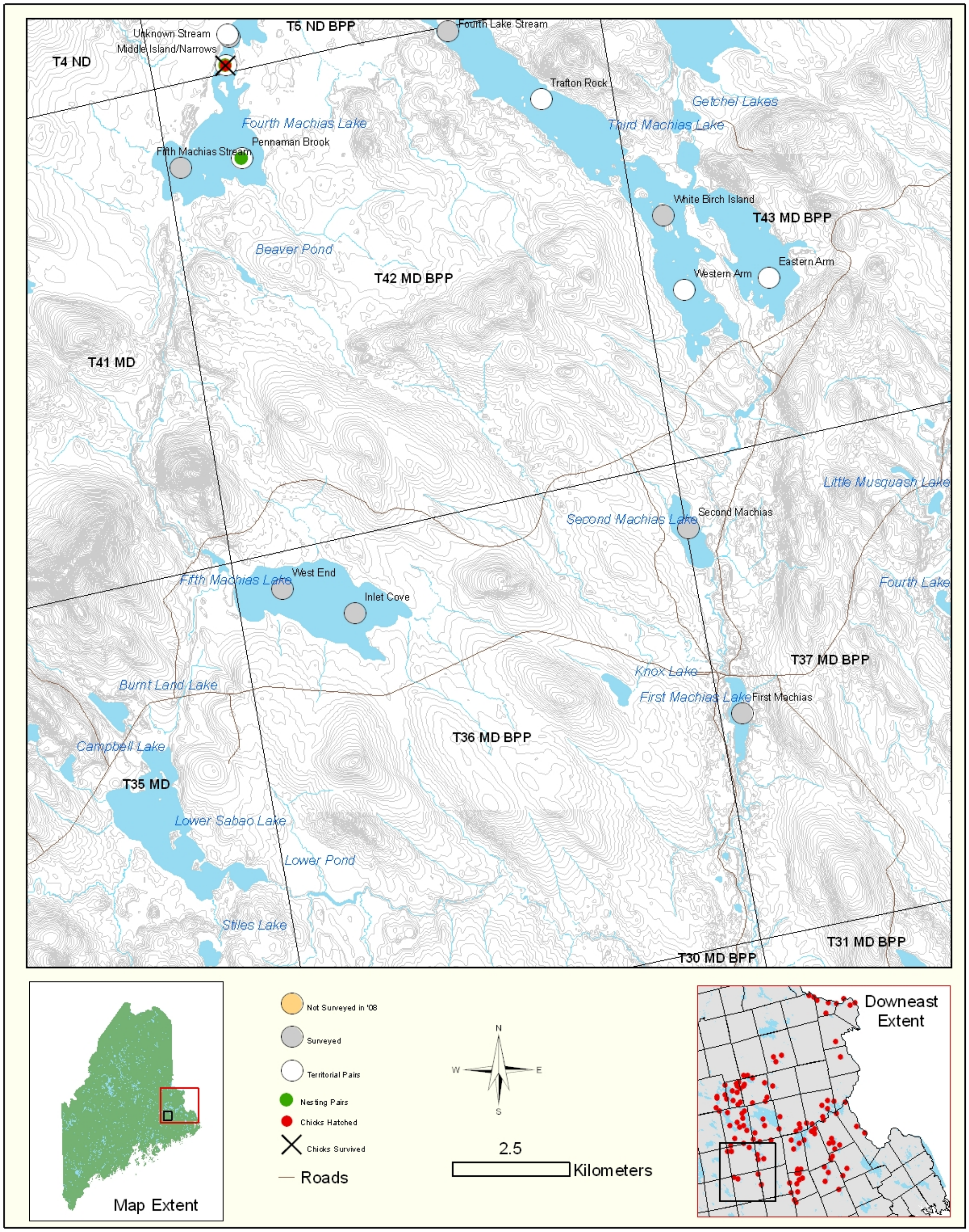
Total production – The total number of loon chicks fledged lakewide during the breeding season.

Whole lake territory – One established territory on a waterbody. This territory may or may not encompass the entire lake, however, a second pair is not established.

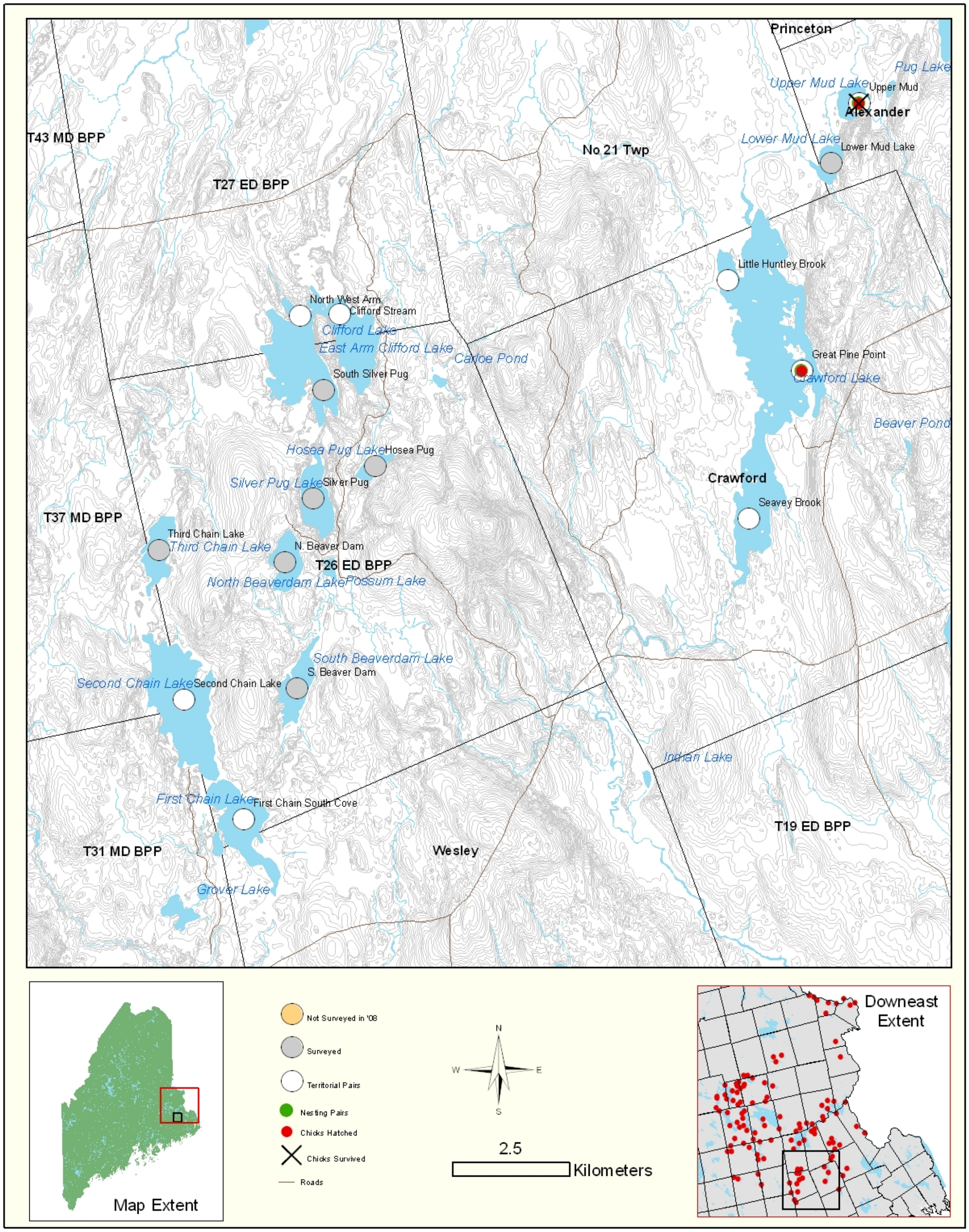
Appendix 3. Downeast Lakes Land Trust Study Area; 2008 Overall Loon Productivity Maps.



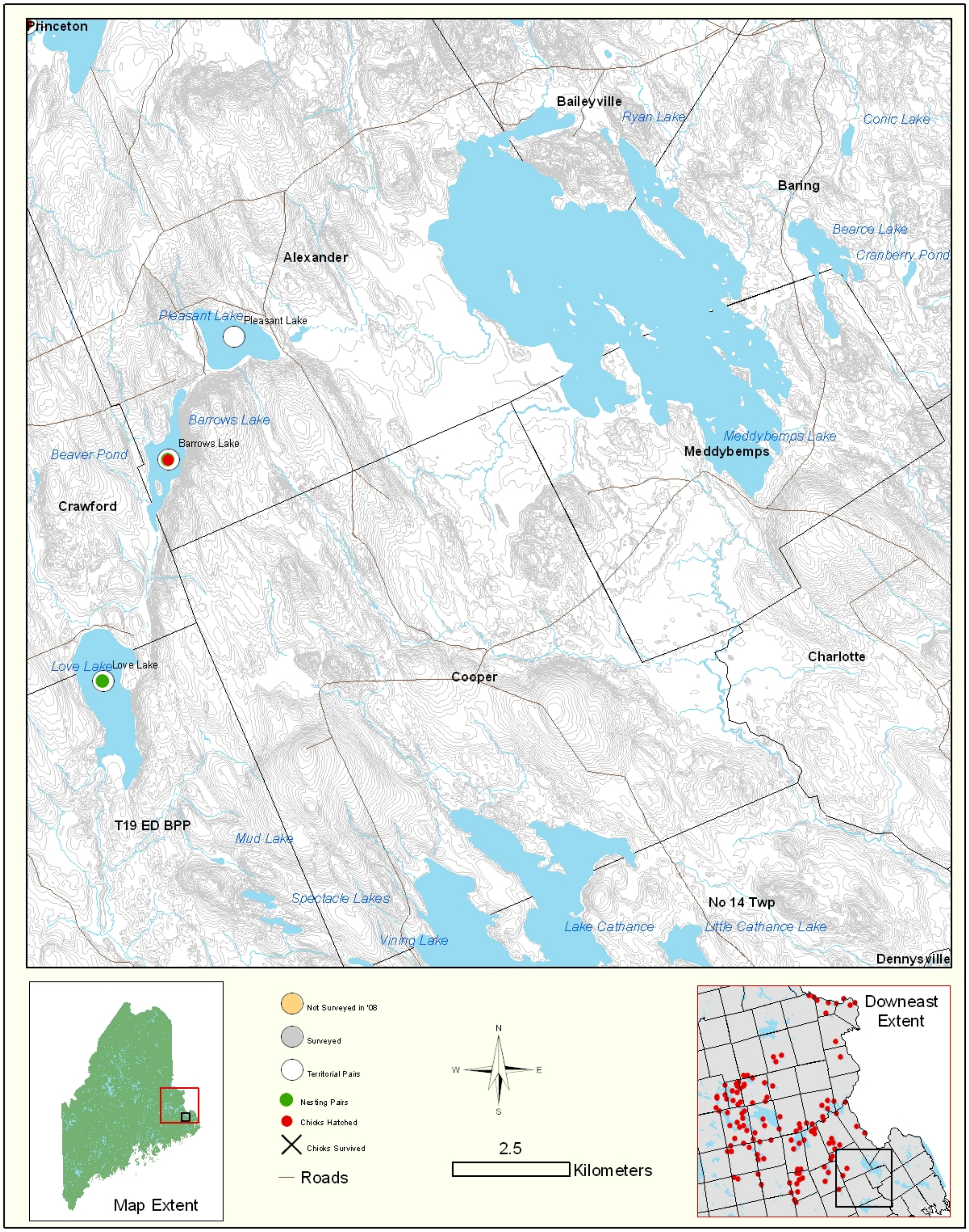
Appendix 3.1. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



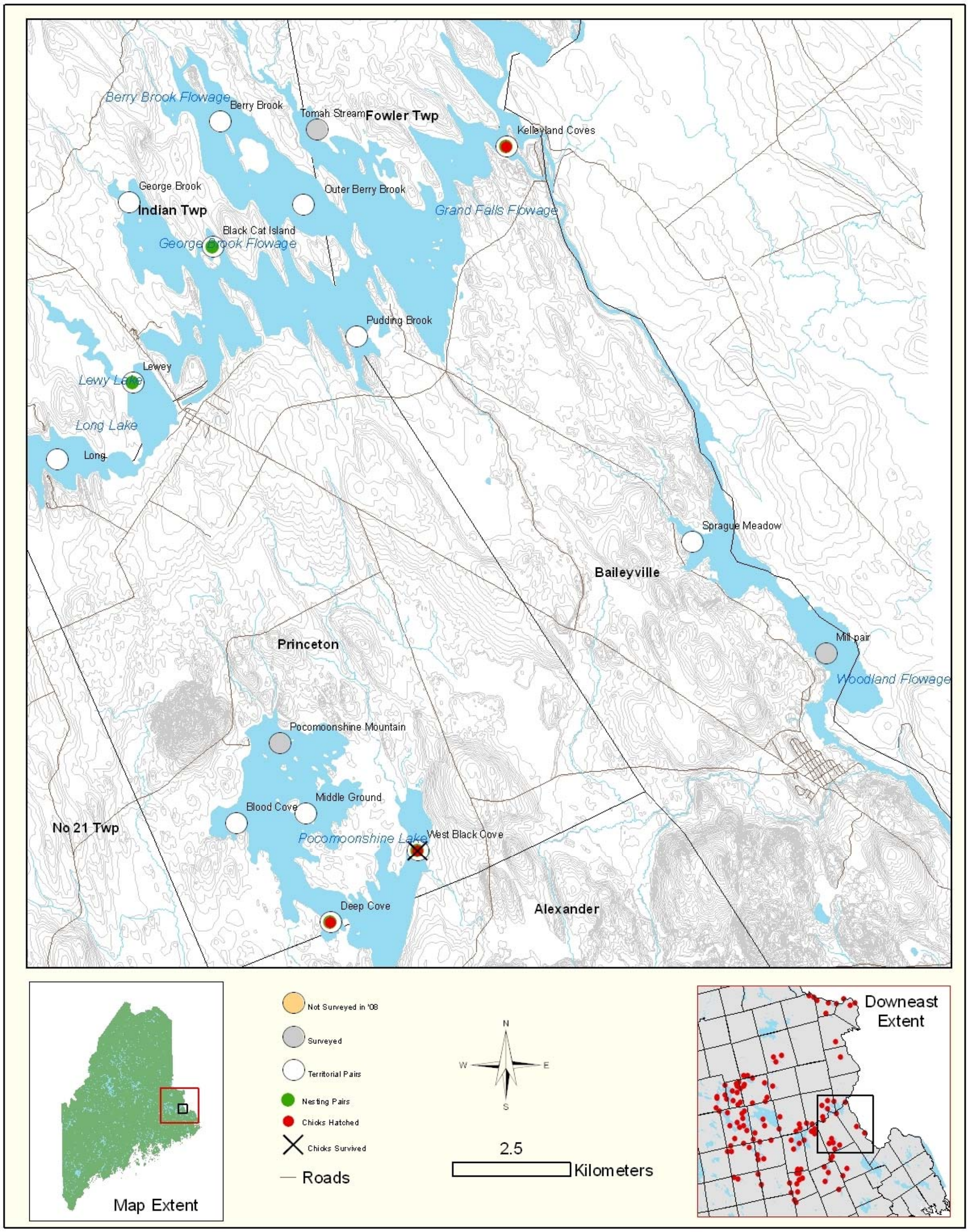
Appendix 3.2. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



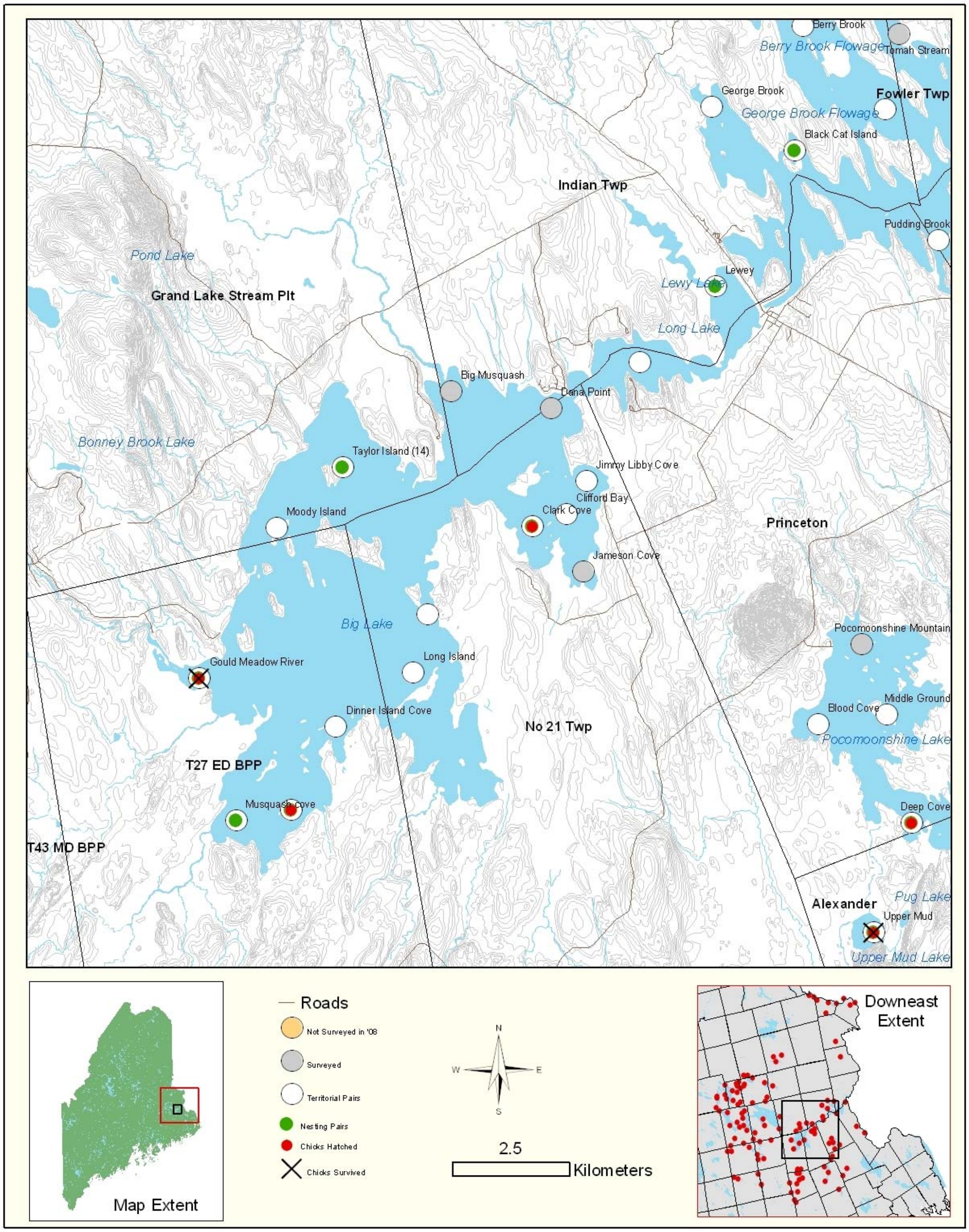
Appendix 3.3. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



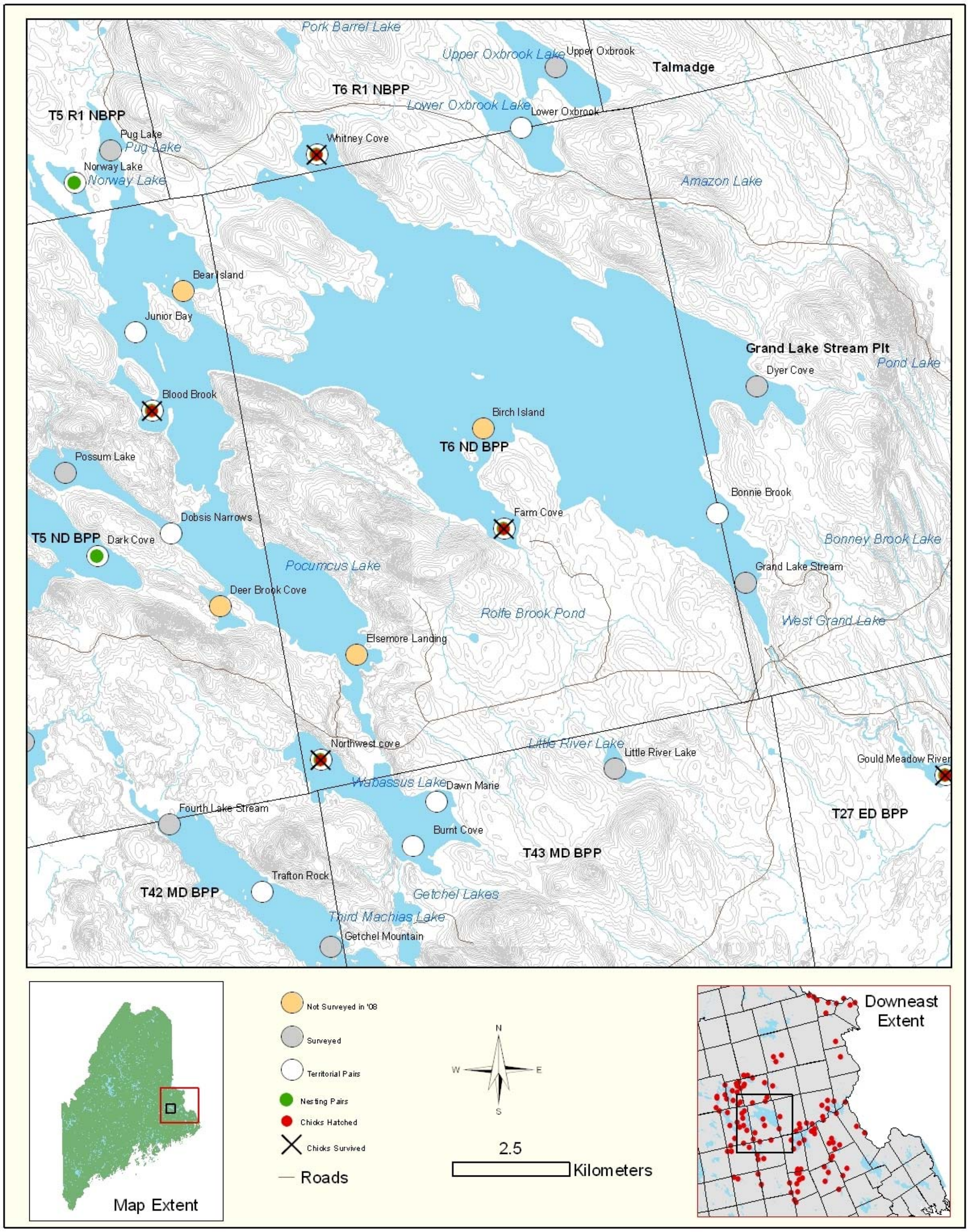
Appendix 3.4. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



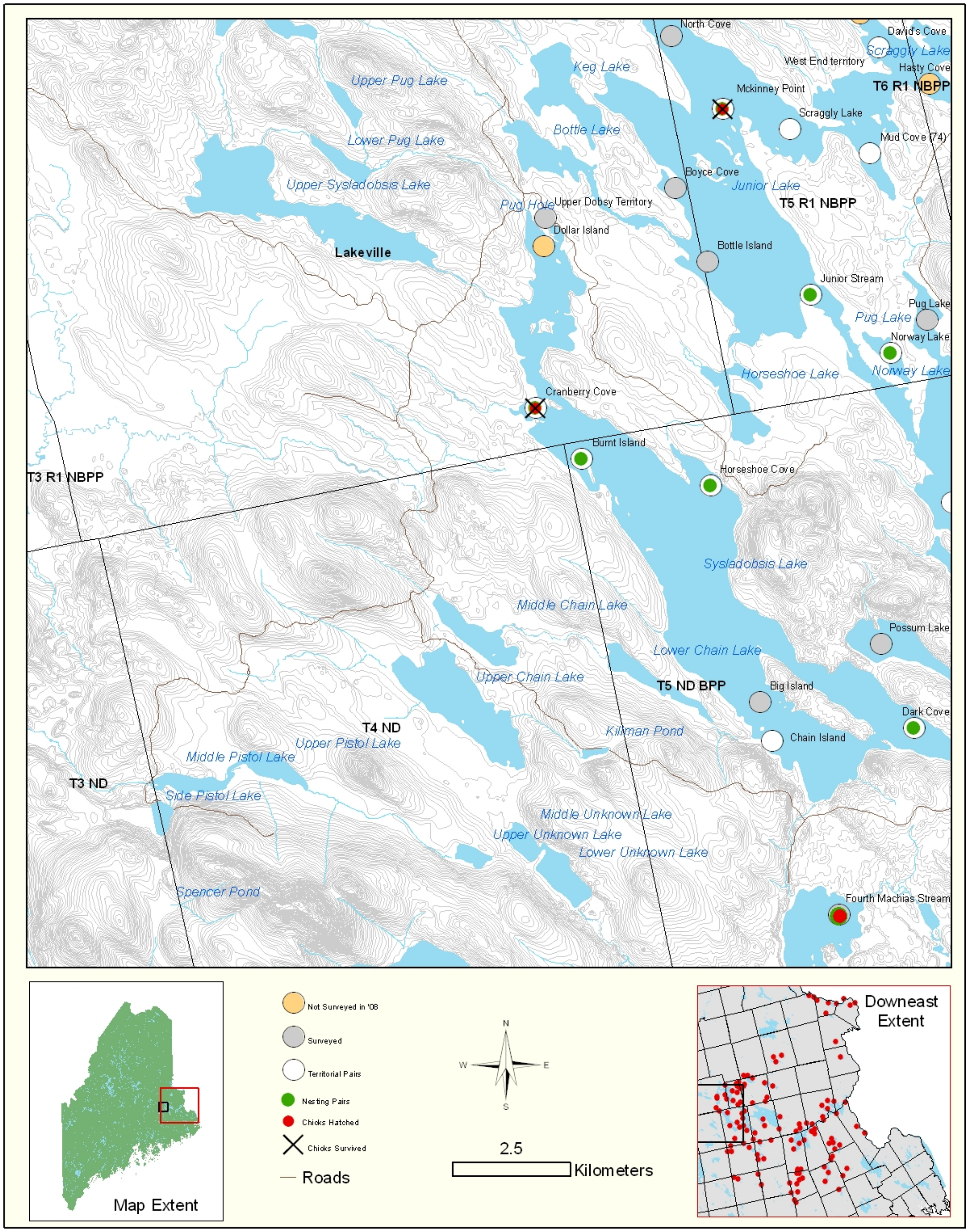
Appendix 3.5. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



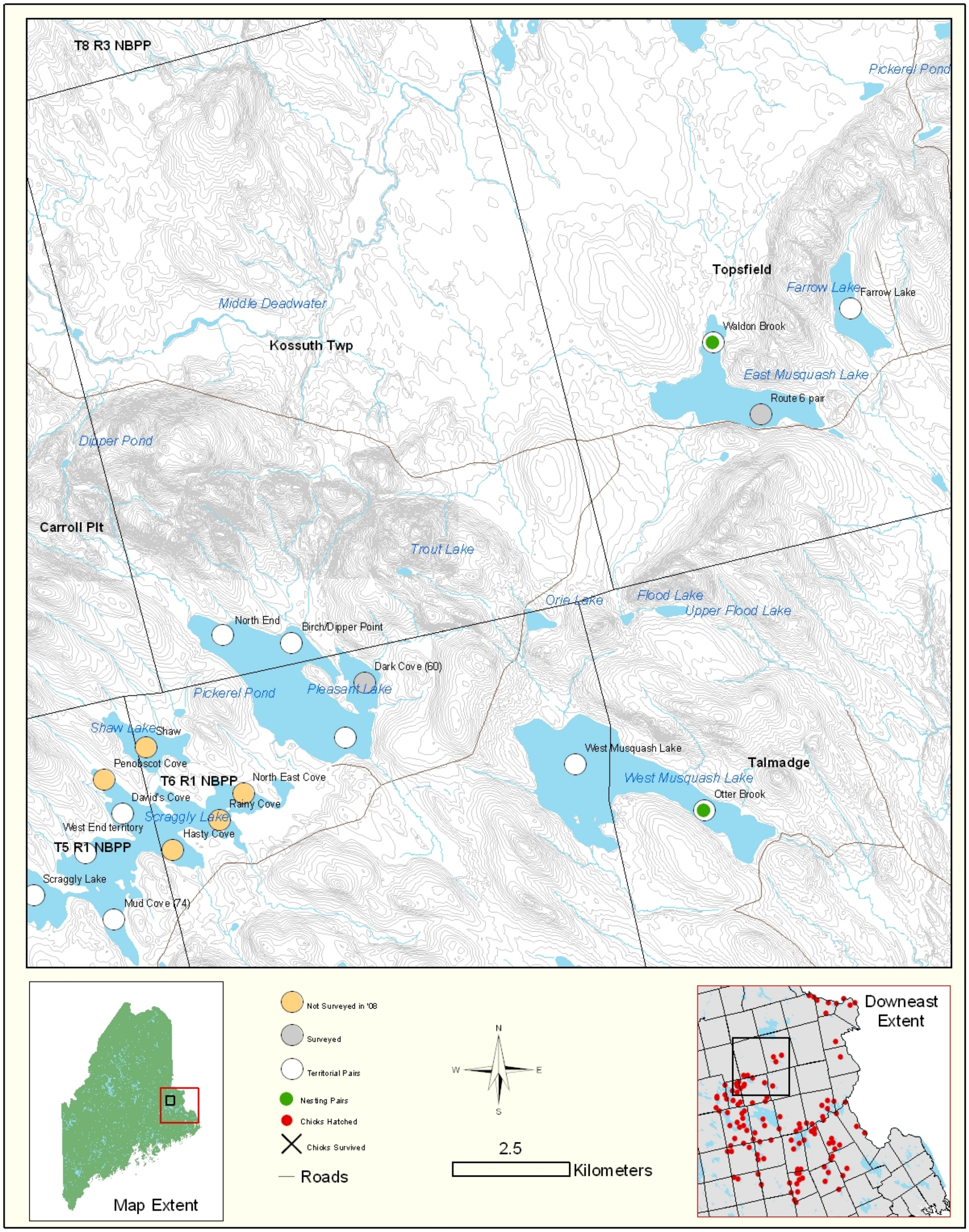
Appendix 3.6. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



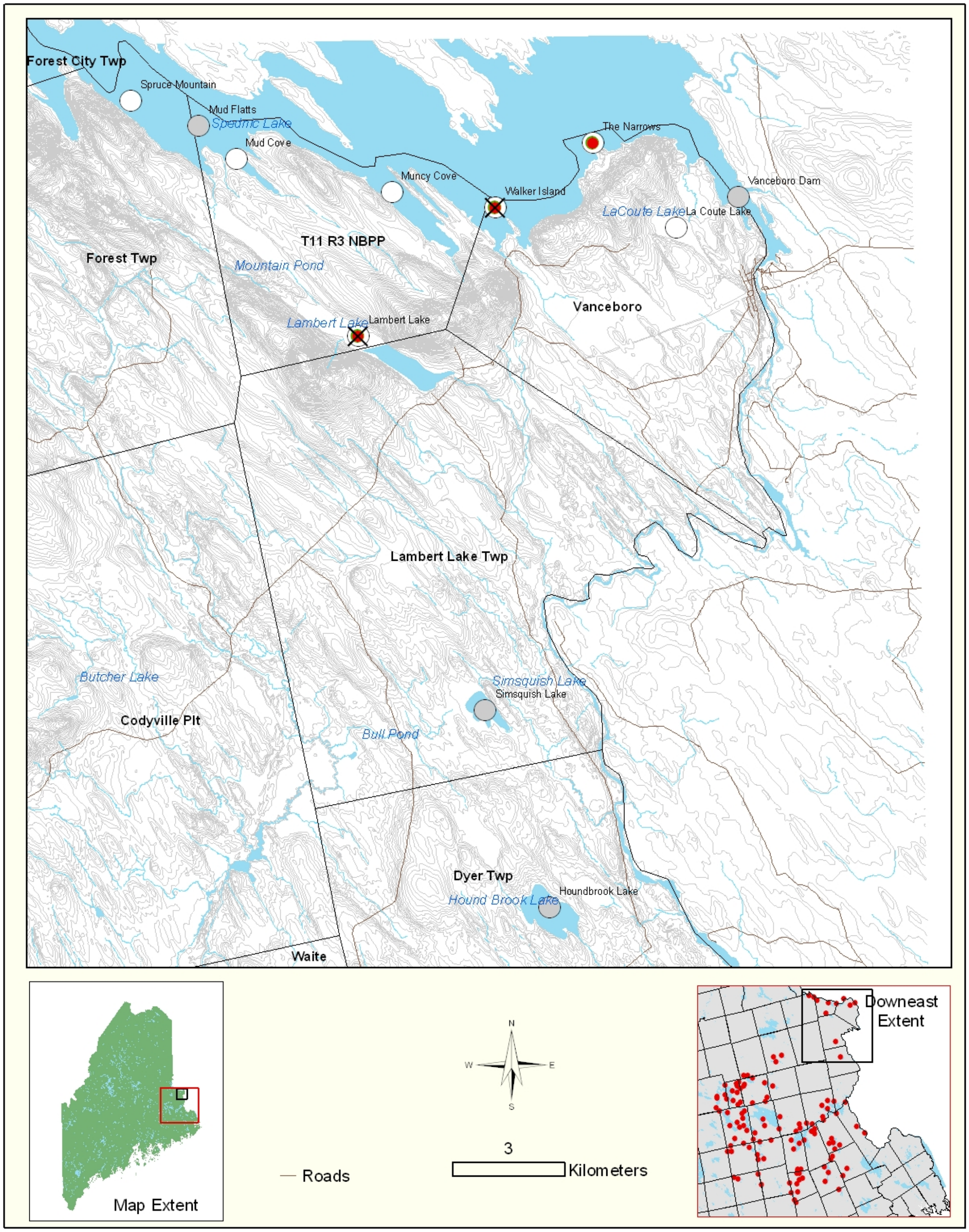
Appendix 3.7. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



Appendix 3.8. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



Appendix 3.9. Downeast Lakes Land Trust Area with Associated Loon Productivity, 2008.



Appendix 4. Territory-specific Productivity Summary for the Downeast Lakes Region, 2008*

SiteName	Territory_Name	TP	NP	CH	CS	SNP
Barrows Lake	Barrows	1	1	1	0	1
Big Lake	Big Musquash	0	0	0	0	0
Big Lake	Clark Cove	1	1	1	0	1
Big Lake	Clifford Bay	1	0	0	0	0
Big Lake	Dinner Island	1	0	0	0	0
Big Lake	Gordan Island	1	0	0	0	0
Big Lake	Jameson Cove	0	0	0	0	0
Big Lake	Jimmy Libby Cove	1	0	0	0	0
Big Lake	Gould Meadow Brook	1	1	1	1	1
Big Lake	Long Island	1	0	0	0	0
Big Lake	Moody Island	1	0	0	0	0
Big Lake	Musquash Cove	1	1	0	0	0
Big Lake	Musquash Island	1	1	0	0	0
Big Lake	Dana Point	0	0	0	0	0
Big Lake	Red Beach	1	1	2	0	1
Big Lake	Taylor Island	1	1	0	0	0
Clifford Lake	Clifford Stream	1	0	0	0	0
Clifford Lake	North West Arm	1	0	0	0	0
Clifford Lake	South Silver Pug	0	0	0	0	0
Crawford Lake	Great Pine Point	1	1	1	0	1
Crawford Lake	Little Huntley	1	0	0	0	0
Crawford Lake	Seavey Brook	1	0	0	0	0
East Musquash Lake	Route 6 Pair	0	0	0	0	0
East Musquash Lake	Walden Brook	1	1	0	0	0
Farrow Lake	Farrow	1	0	0	0	0
Fifth Machias Lake	Inlet Cove	0	0	0	0	0
Fifth Machias	West End	0	0	0	0	0
First Chain Lake	First Chain South	1	0	0	0	0
First Machias Lake	First Machias	0	0	0	0	0
Fourth Machias	Fifth Machias Stream	0	0	0	0	0
Fourth Machias	Fourth Machias Stream	0	0	0	0	0
Fourth Machias	Middle Island/Narrows	1	1	1	1	1
Fourth Machias	Pennaman Brook	1	1	0	0	0
Fourth Machias	Unknown Stream	0	0	0	0	0
Grand Falls Flowage	Berry Brook	1	0	0	0	0
Grand Falls Flowage	Black Cat Island	1	1	0	0	0

SiteName	Territory_Name	TP	NP	CH	CS	SNP
Pocomoonshine Lake	Blood Cove	1	0	0	0	0
Pocomoonshine Lake	Deep Cove	1	1	1	0	1
Pocomoonshine Lake	Middle Ground	1	0	0	0	0
Pocomoonshine Lake	Pocomoonshine	0	0	0	0	0
Pocomoonshine Lake	West Black Cove	1	1	1	1	1
Pocumcus Lake	Dobsis Narrows	1	0	0	0	0
Possum Lake	Possum	0	0	0	0	0
Scraggly Lake	David's Cove	1	0	0	0	0
Scraggly Lake	Mud Cove	1	0	0	0	0
Scraggly Lake	West End	0	0	0	0	0
Second Chain Lake	Second Chain	1	0	0	0	0
Second Machias	Second Machias	0	0	0	0	0
Silver Pug Lake	Silver Pug	0	0	0	0	0
Simsquish Lake	Simsquish	0	0	0	0	0
South Beaver Dam	South Beaver	0	0	0	0	0
Spednic Lake	Mud Cove	1	0	0	0	0
Spednic Lake	Mud Flatts	0	0	0	0	0
Spednic Lake	Muncy Cove	1	0	0	0	0
Spednic Lake	Spruce Mountain	1	0	0	0	0
Spednic Lake	The Narrows	1	1	1	0	0
Spednic Lake	Vanceboro Dam	0	0	0	0	0
Spednic Lake	Walker Island	1	1	1	1	1
Sysladobsis Lake	Upper Dobsy Territory	0	0	0	0	0
Sysladobsis Lake	Big Island	0	0	0	0	0
Sysladobsis Lake	Burnt Island	1	1	0	0	0
Sysladobsis Lake	Chain Island	1	0	0	0	0
Sysladobsis Lake	Cranberry Cove	1	1	1	1	1
Sysladobsis Lake	Dark Cove	0	0	0	0	0
Sysladobsis Lake	Horseshoe Cove	1	1	0	0	0
Third Chain Lake	Third Chain	0	0	0	0	0

SiteName	Territory_Name	TP	NP	CH	CS	SNP
Third Machias Lake	Eastern Arm	1	0	0	0	0
Third Machias Lake	Fourth Lake Stream	0	0	0	0	0
Third Machias Lake	Getchel Mountain	0	0	0	0	0
Third Machias Lake	Trafton Rock	1	0	0	0	0
Third Machias Lake	Western Arm	1	0	0	0	0
Third Machias Lake	White Birch Island	0	0	0	0	0
Upper Mud Lake	Upper Mud	1	1	2	1	1
Upper Oxbrook	Upper Oxbrook	0	0	0	0	0
Wabassus Lake	Burnt Point	1	0	0	0	0
Wabassus Lake	Dawn Marie	1	0	0	0	0
Wabassus Lake	Northwest Cove	1	1	2	1	1
West Grand Lake	Blood Brook	1	1	2	2	1
West Grand Lake	Bonnie Brook	1	0	0	0	0
West Grand Lake	Dyer Cove	0	0	0	0	0
West Grand Lake	Farm Cove	1	1	1	1	1
West Grand Lake	Grand Lake Stream	0	0	0	0	0
West Grand Lake	Junior Bay	1	0	0	0	0
West Grand Lake	Pug Lake	0	0	0	0	0
West Grand Lake	Whitney Cove	1	1	1	1	1
West Musquash Lake	Otter Brook	1	1	0	0	0
West Musquash Lake	West Musquash Lake	1	0	0	0	0
Woodland Lake	Mill Pair	0	0	0	0	0
Woodland Lake	Sprague Meadow	1	0	0	0	0

*TP=territorial pair, NP=nesting pair, CH=chicks hatched, CS=chicks surviving, SP=successful pairs.