Herpetofaunal Distribution at University of Notre Dame Environmental Resource Center

BIOS 569: Practicum in Field Biology

Keely Davidson

Advisor: Dr. Karen Francl

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Abstract

Amphibians are commonly viewed as indicators of regional environmental health because of their dual life cycle, sensitivity to environmental changes, and dependence on water. In order to clarify species ranges and identify of factors influencing distribution, I surveyed 25 sites on UNDERC property in Gogebic Co., Michigan for herpetofauna: 5 predominantly mixed forest stands, 5 predominately deciduous forest stands, 5 lakes, 5 vernal ponds, and 5 open water bogs using pitfall traps with drift fences, active visual surveys, and incidental captures. I expected to find positive correlations between number of downed logs and salamander numbers, number of snags and number of salamanders and painted and snapping turtles, and soil moisture and overall number of amphibians and a negative correlation between overall number of reptiles and soil moisture. I observed a positive correlation between overall number of reptiles and soil moisture (p=.031, f=5.226, df=1) and no relationships supporting the other hypotheses. Much of the disagreement with previously cited literature can likely be explained by a very small sample size of salamanders and turtles. Percentage of open water per habitat tract was positively correlated with number of individuals captured (p=0.051, f=4.268, df=1). A significant negative relationship depth of leaf litter with species richness was also found (p=0.0176, f=6.6365, df=1; p=0.0038, f=10.5911, df=1). Identification of depth of leaf litter and

percentage of open water per habitat tract could potentially be important in determining areas that should be preserved as herpetofaunal habitat.

Introduction

Amphibians are commonly viewed as indicators of regional environmental health because of their dual life cycle, sensitivity to environmental changes, and dependence on water. Human activities have negatively influenced the abundance and biodiversity of amphibian species. The presence of roads (Lehteinen et al., 1999; Marsh and Beckman, 2004; Gibbs, 1998), wetland isolation, and urban-land use (Lehteinen et al., 1999) have adversely affected species richness and relative abundance of amphibians. Further studies on other determinants of amphibian and reptile distribution will be useful in identifying strategies to minimize the negative impact on amphibian and reptile populations caused by humans.

This study will examine the relationships between species richness of herpetofauna and microhabitat metrics and habitat type. We will also conduct a species-specific habitat analysis using the same microhabitat characteristics and habitat types. Previous herpetofaunal surveys in other localities have provided a basis for the formation of hypotheses. Welsh and Lind (1991) found a positive correlation between number of downed logs and snags on the overall abundance of salamanders. In the same study, the authors also noted a positive correlation between overall number of amphibians found and soil moisture, and a negative correlation between overall number of reptiles and soil moisture. DonnerWright et al. (1999) observed a significant positive correlation between the number of snags and rocks along a river channel and the number of common snapping turtles (*Chelydra serpentina*) and painted turtles (*Chrysemys picta belli*). In accordance with the cited literature, we hypothesize that we will also find positive correlations between number of downed logs and salamander numbers, number of snags and number of salamanders and painted and snapping turtles, and soil moisture and overall number of amphibians. We also expect a negative correlation between overall number of reptiles and soil moisture.

According to Harding (1997), the 17 amphibian species and 9 reptilian species have ranges that may include the UNDERC property (Table 1). Of these, two species, the wood turtle (*Clemmys insculpta*) and the chorus frog (*Pseudacris triseriata*), are state species of concern in Michigan (Harding, 1997). This study will be useful in confirming previously documented ranges and learning more about habitat preferences of these animals, especially the species of concern.

Methods

I will study 25 sites on UNDERC property in Gogebic Co., Michigan: 5 predominantly mixed forest stands, 5 predominately deciduous forest stands, 5 lakes, 5 vernal ponds, and 5 open water bogs. Methods utilized will be pitfall traps with drift fences and active visual surveys. Dip netting will be used as a component of active visual surveys for aquatic sites according to the protocol established for the tadpole survey group project at UNDERC 2005 with 2 people surveying for 25 minutes (S. Boyd, personal communication). Pitfall trapping will be modeled after the descriptions in Heyer et al. (1994). Drift fences (2' x 100') will be arranged in an X shape in terrestrial habitats and linearly along the shoreline in aquatic habitats. Pitfalls (160-oz plastic containers placed flush to the soil surface) containing a 5 cm x 5 cm x 1 cm piece of sponge (in case of inundation) will be installed. Traps will be checked twice daily (within 4 hours after sunset and within 4 hours before sunrise) for five days. Captured animals will be measured (snout-vent length), sexed if possible, marked (by single-toe clipping in frogs and salamanders and non-toxic modeling paint for snakes, turtles, and other reptiles), and released.

We will also conduct active visual surveys in each of the tracts where the pitfall traps were placed. Two researchers will simultaneously survey two randomly placed 25 m x 25 m transects within each tract for 1 hour, overturning logs and digging through leaf litter. Researchers will walk a parallel path (Heyer et al., 1994) and will survey only during daylight hours. Habitat analysis will occur at the same time as active visual surveys. We will measure soil moisture number of standing dead trees (dbh >10 cm), number of downed logs (dbh >10 cm), maximum annual canopy cover, and percent of open water per tract at a maximum of 1 ha. For aquatic sites, pH will be measured with a pH meter and maximum water area will be measured using GIS and aerial photos or with a meter tape in the field. For both aquatic and terrestrial sites, we will dig holes within the tracts or surrounding the aquatic sites, and measure depth of living organic matter, leaf litter depth, and depth of dead organic matter at 5 points within the 1 ha sampled portion of the tract and take soil moisture samples at 20 points within the plot. We will also record weather data (high and low temperatures for that day and temperature at recording time) using a Kestrel 3000 meter, description of weather conditions during survey, and average temperature and rainfall for the week of the survey (available from on-property weather station) for each site.

Analysis

Regressions of soil moisture, snags, and downed logs will be conducted for salamanders, turtles, number of amphibians, and number of reptiles to test the hypotheses.

We will also look for overall trends in the herpetofaunal populations at UNDERC. To accomplish this, we will first calculate a Shannon-Weiner Index value for each site as a means of comparing biodiversity across sites. We will then use ANOVAs to examine the influence of habitat type on number of individuals, species richness, and Shannon-Weiner Index values. Additional 2-way ANOVAs will be run to determine the effects of trap technique and habitat on the number of individuals at each site. Finally, multiple regressions of habitat variables will be conducted for number of individuals and species richness.

We will enter and graph all data in Microsoft Excel and perform statistical analyses in Systat 11 and Systat 10.5. We will consider data values with $p \leq .10$ to be significant.

Results

I collected 535 amphibians and reptiles of 13 species from 25 sites across five habitats on UNDERC property (Table 1). Of these, 248 individuals were found in vernal ponds, 145 in lakes, 89 in bogs, 47 in deciduous forest stands and 25 in mixed forest stands (Figure 1).

Total number of amphibians, total number of herpetiles, and species richness were significantly related to habitat type. Shannon-Weiner Index and total number of reptiles were not significantly related to habitat (Table 2). In terms of total number of herpetiles, vernal ponds were significantly different from mixed forest stands (Tukey's, $p=0.084$) (Figure 1). For total number of amphibians, vernal ponds and mixed forest stands differed significantly (Bonferroni, $p=0.078$). Bogs had significantly higher species richness values when compared to both deciduous and mixed forests deciduous forests and bogs and mixed forests and bogs were significantly different (Bonferroni, p=.033, p=.085, respectively) (Figure 2).

High temperature on day of active survey and percentage of open water per habitat tract were positively correlated with number of individuals captured (Multiple regressions , Table 3). Significant negative relationships of temperature at time of active survey and depth of leaf litter with species richness were also found (Multiple regressions, Table 4).

There was also no clear relationship between soil moisture and the number of amphibians, but soil moisture was positively correlated to number of reptiles(Table 5).. Snags had no significant effect on salamander or painted turtle numbers. Logs had no significant effect on the number of salamanders found (Table 6).

Additional regressions were performed for aquatic habitats, but no significant relationships were found among total number of herpetiles and habitat data (Table 7).

Analyses of variance examining the effects of habitat and trap technique on the number of individuals of each species showed that *Hyla versicolor* and *Psuedacris crucifer* numbers were significantly affected by trap technique and an interactive effect between habitat and trap technique (Table 8). *Rana clamitans melanota* numbers were significantly affected by habitat, trap technique and an interactive effect between habitat and trap technique, indicating an additive effect.

Rana clamitans melanota were found much less often in pitfalls than incidental or active searches and found more often in terrestrial than aquatic sites (Figure 3). *Rana pipiens* numbers were significantly affected by habitat. *Rana pipiens* were only collected in aquatic habitats. No significant effects of habitat or trap technique on the numbers of the other species were observed. Overall, more individuals of each species were captured in aquatic than terrestrial habitats (paired t-test, p= 0.061, df=12, t=2.072, Table 9).

Discussion

Our data does not support our hypotheses or the results of previously published studies. This is likely due to the small sample size of reptiles we caught. Unlike Welsh and Lind (1991), we did not find a significant relationship between number of downed logs and snags on the overall abundance of salamanders. Similarly, although DonnerWright et al. (1999) noted a significant positive relationship between the number of snags and *Chrysemys picta bellii*, we did not. A factor that likely prevented the observation of significant relationships was our small sample size of salamanders and of turtles.

While Welsh and Lind (1991) found a positive correlation between overall number of amphibians and soil moisture and a negative correlation between overall number of reptiles and soil moisture, we found no relationship between overall number of amphibians and soil moisture and a positive relationship between overall number of reptiles and soil moisture. Of the two species of reptiles we captured during our study, *Chrysemys picta bellii* is a water turtle and *Thamnophis sirtalis* can live in wetland areas, unlike many other reptiles (Conant and Collins 1998). Because of the limited number of species captured in our study, and their relative affinity to water, it is logical that we should observe a positive rather than negative relationship.

The effects of temperature are evidenced in this study by the positive correlation between high temperature on day of active survey and total number of herpetiles and the negative relationship of temperature at time of active survey. Such weather related effects could potentially mask significant determinants of herpetofaunal distribution in studies that only survey each site for one week. In order to minimize this effect, future studies should attempt to survey all sites repeated times throughout the summer months and compare captures in a variety of conditions.

However, our data did show that species richness was greatest for bogs, that vernal ponds had the most individuals captured, and that aquatic sites had significantly more of individuals of each species in and terrestrial habitats. Factors potentially influencing the differences among habitats were also identified. For example, percent of open water per tract was significantly related with number of herpetiles found when maximum water area was not. This suggests that small bodies of water such as vernal ponds can be as valuable of herpetofaunal habitat as lakes or bogs. The negative relationship between depth of leaf litter and species richness is likely related to differences among habitat type given that many of the bogs and lakes in the area lack leaf litter. Future studies could consider whether the same relationship is true of leaf litter depth that only consider sites in which leaf litter is present.

The information gained through this research about herpetofaunal distribution may prove useful in determining what land in the area should be preserved for herpetofauna protection, what areas rare herpetofauna might inhabitat, and determining whether or not UNDERC should be considered part of the range maps for species whose range edges are close to property.

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Common Name	Scientific Name	Code	# Captured
Spotted Salamander	*Ambystoma maculatum*	AMMA	26
Blue-spotted Salamander	*Ambystoma laterale*	AMLA	7
Red-backed Salamander	*Plethodon cinereus*	PLCI	3
Eastern American Toad	*Bufo americanus americanus*	BUAM	67
Northern Spring Peeper	*Pseudacris crucifer crucifer*	PSCR	27
Eastern Gray Treefrog	*Hyla versicolor*	HYVE	25
Bullfrog	*Rana catesbeiana*	RACA	6
Green Frog	*Rana clamitans melanota*	RACL	170
Mink Frog	*Rana septentrionalis*	RASE	12
Wood Frog	*Rana sylvatica*	RASY	169
Northern Leopard Frog	*Rana pipiens*	RAPI	32
Common Garter Snake	*Thamnophis sirtalis sirtalis*	THSI	8
Western Painted Turtle	*Chrysemys picta bellii*	CHPI	3

Table 1: Herpetiles captured in study 2005 survey of 25 sites on UNDERC property

Table 2: Results of 1-way ANOVAs to determine effects of habitats on species composition

Source	df	F-ratio	p	r^2
Total number of herpetiles x habitat	**4**	**2.458**	**0.079**	**0.33**
Total number of amphibians x habitat	**4**	**2.462**	**0.078**	**0.33**
Total number of reptiles x habitat	4	1.516	0.235	0.233
SW x habitat	4	2.172	0.109	0.303
SR x habitat	**4**	**3.461**	**0.026**	**0.409**

Table 3: Multiple regressions results with total number of herpetiles as the dependent variable

In		Effect	Coefficient	Std Error	Std Coeff	Tol.	df	F	p
	1	Constant							
	2	OW	0.323	0.105	0.536	0.9842	1	9.411	0.006
	4	HITEMP	3.626	1.755	0.361	0.9842	1	4.268	0.051
Out		Part. Corr.							
	3	CURTEMP	-0.191	.	.	0.85353	1	0.759	0.394
	5	LOWTEMP	-0.166	.	.	0.30079	1	0.566	0.461
	6	SNAGS	0.031	.	.	0.96958	1	0.02	0.89
	7	LOGS	0.339	.	.	0.73629	1	2.601	0.122
	8	LIVEORGMAT	0.086	.	.	0.92155	1	0.149	0.704
	9	DEADORGMAT	-0.169	.	.	0.83224	1	0.585	0.453
	10	LEAFLIT	-0.001	.	.	0.62468	1	0	0.998
	11	SOILMOIST	-0.201	.	.	0.54876	1	0.842	0.37

Table 4: Multiple regressions results with species richness as the dependent variable

		Effect	Coefficient	Std Error	Std Coef	Tol	df	F	P
In									
	1	Constant							
	3	CURTEMP	-0.30958	0.120173	0.606476	0.56528	1	6.6365	0.0176
	10	LEAFLIT	-0.91929	0.282476	0.766153	0.56528	1	10.5911	0.0038
Out			Part. Corr.						
	2	OW	0.223306	.	.	0.8178	1	1.0497	0.3178
	4	HITEMP	-0.2431	.	.	0.84772	1	1.2562	0.2757
	5	LOWTEMP	-0.11847	.	.	0.76779	1	0.2847	0.5995
	6	SNAGS	-0.03006	.	.	0.799	1	0.0181	0.8944
	7	LOGS	-0.30511	.	.	0.9185	1	2.0529	0.1674
	8	LIVEORGMAT	0.241837	.	.	0.94729	1	1.2424	0.2782
	9	DEADORGMAT	0.114737	.	.	0.46688	1	0.2668	0.6111
	11	SOILMOIST	0.199369	.	.	0.67528	1	0.8279	0.3737

Table 5: Regression results for soil moisture

Source	df	F-ratio	p	r^2
Total number of amphibians xsoil moisture	1	1.23	0.279	0.051
Total number of reptiles xsoil moisture	1	**5.266**	**0.031**	**0.186**

Table 6: Regression results examining relationship between salamanders and turtles and snags and logs

Source	df	F-ratio	p	r^2
# of CHPI x snags		0.811	0.378	0.036
# of PLCI x snags	1	0.199	0.66	0.009
# of AMLA x snags	1	0.582	0.312	0.014
# of AMMA x snags	1	0.161	0.692	0.007
# of PLCI x logs	1	0.255	0.618	0.011
# of AMLA x logs	1	0.002	0.964	0
# of AMMA x logs	1	0.009	0.924	0

Table 7: Regression results for aquatic variables in sites with water

Total number of herps x pH	1	0.087	0.773	0.007
Total number of herps x max area	1	0.012	0.914	0
SR x pH	1	0.725	0.411	0.057
SR x max water area	1	0.326	0.578	0.024
SW x pH	1	0.2486	0.627	0.02
SW x max water area	1	2.093	0.172	0.139

Table 8: The effects of habitat and trap technique on numbers of each species caught

Dependent	**Independent**	**df**	**F-ratio**	**p**	**r^2**
TotHerps	Habitat	4	0.8	0.53	0.18
TotHerps	Trap	2	0.6	0.552	0.18
TotHerps	Habitat x Trap	8	1.1	0.376	0.18
BUAM	Habitat	4	1.673	0.168	0.237
BUAM	Trap	2	2.116	0.129	0.237
BUAM	Habitat x Trap	8	0.965	0.472	0.237
HYVE	Habitat	4	1.709	0.16	0.352
HYVE	**Trap**	**2**	**5.512**	**0.006**	**0.352**
HYVE	**Habitat x Trap**	**8**	**1.849**	**0.005**	**0.352**
PLCI	Habitat	4	1.25	0.3	0.28
PLCI	Trap	2	1.167	0.318	0.28
PLCI	Habitat x Trap	8	2	0.062	0.28
PSCR	Habitat	4	1.97	0.111	0.377
PSCR	**Trap**	**2**	**6.62**	**0.003**	**0.377**
PSCR	**Habitat x Trap**	**8**	**1.895**	**0.077**	**0.377**
RACA	Habitat	4	1.364	0.257	0.175
RACA	Trap	2	1.182	0.314	0.175
RACA	Habitat x Trap	8	0.614	0.763	0.175
RACL	**Habitat**	**4**	**7.4**	**0**	**0.543**
RACL	**Trap**	**2**	**7.124**	**0.002**	**0.543**
RACL	**Habitat x Trap**	**8**	**3.415**	**0.003**	**0.543**
RAPI	**Habitat**	4	**2.885**	**0.03**	**0.265**
RAPI	Trap	2	1.667	0.196	0.265
RAPI	Habitat x Trap	8	0.846	0.566	0.265
RASE	Habitat	4	1.333	2.128	0.088
RASE	Trap	2	0.973	1.553	0.22
RASE	Habitat x Trap	8	0.973	1.553	0.158
RASY	Habitat	4	2.429	0.057	0.331
RASY	Trap	2	2.429	0.093	0.331
RASY	Habitat x Trap	8	1.882	0.08	0.331
THSI	Habitat	4	2.15	0.086	0.227
THSI	Trap	2	1.3	0.28	0.227
THSI	Habitat x Trap	8	0.8	0.605	0.227

AMLA	Habitat	4	1.388	0.249	0.256
AMLA	Trap	2	1.265	0.29	0.256
AMLA	Habitat x Trap	8	1.571	0.153	0.256
AMMA	Habitat	4	2.565	0.047	0.374
AMMA	Trap	2	2.565	0.085	0.374
AMMA	Habitat x Trap	8	2.565	0.018	0.374

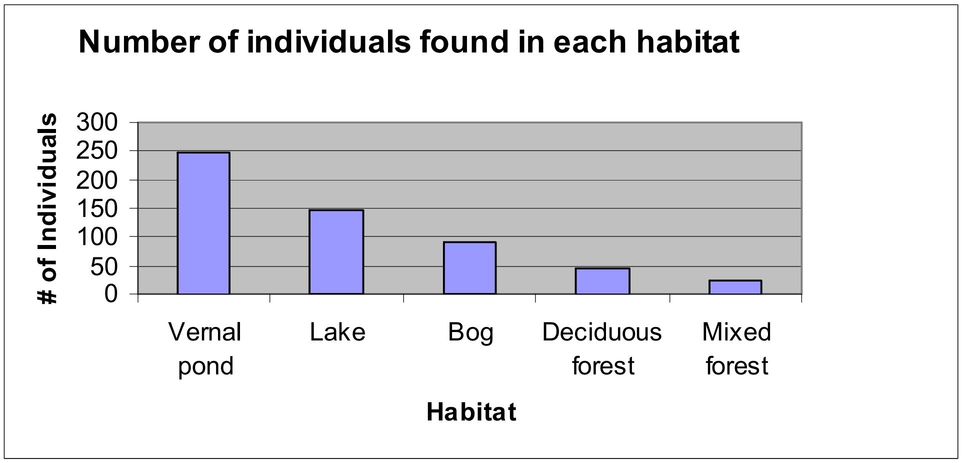

Figure 1: Vernal ponds contained the greatest number of individuals; mixed forest stands, the least.

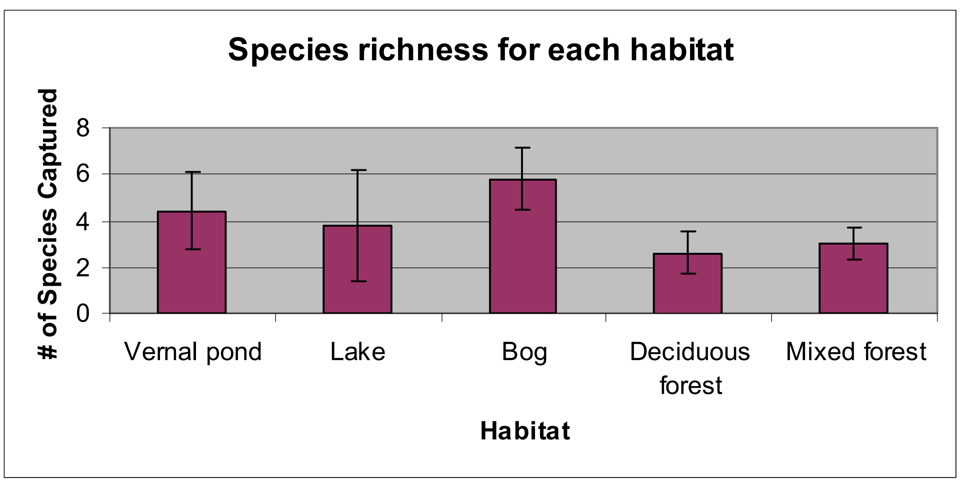

Figure 2: Of the habitats examined bogs had the greatest species richness and deciduous forest stands had the least. Error bars on the graph represent one standard deviation of the mean. Only mixed forests and vernal ponds are significantly different (Tukey's, p= 0.084).

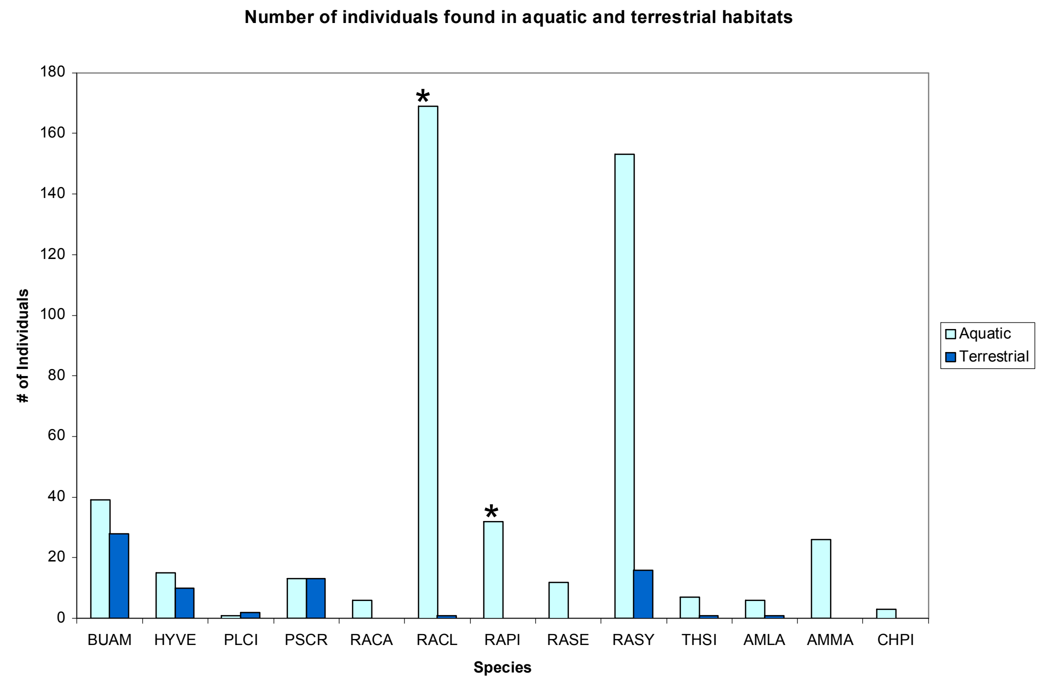

Figure 3: Number of individuals found in aquatic and terrestrial habitats. See Table 1 for codes.* = significant effect of habitat on number of individuals.

Appendix

Site	**UTM E**	**UTM N**
VP K	303867	5123730
VP 5	303867	5122324
VP 7	3070303998	5122395
Beaver Bog	3057888	5122349
Mixed Forest 1	306397	5123730
Mixed Forest 2	*	*
Mixed Forest 3	307407	5122349

Donut Bog	306885	5123284
Roach Deciduous	30455	5125735
Morris Lake	305601	5125416
Ward Lake	305894	5125200
VP V	305936	5124820
Ward Deciduous	305866	5125069
Cranberry Bog	301897	5122910
Mixed Forest 4	307217	5121616
VP N	306333	5122325
GP Aspen	304373	5125462
Mixed Forest 5	306245	5124699
Ziesnis Bog	305777	5122712
Inkpot Lake	306680	5122152
Inkpot Maple	306384	5122141
Hummingbird Lake	306762	5124017
Ed's Bog	307800	5122819
Raspberry Lake	306677	5124808

*Mixed Forest 2 = GPS File 060411A