ILLINOIS NATURAL HISTORY SURVEY

TECHNICAL REPORT

Identifying the Distribution and Habitat of Jefferson's Salamander, *Ambystoma jeffersonianum*, in Illinois

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Within Illinois, there is concern for apparent local amphibian extinctions and widespread decreases in amphibian abundance. Habitat disturbance, structure and composition of habitat, and habitat fragmentation are the primary threats to amphibian species in greatest need of conservation. For these reasons, current data are largely inadequate to quantify changes in abundance and distribution of salamander species in greatest need of conservation. Currently, most amphibian sampling in Illinois is opportunistic, resulting in a poorly known distribution of many species. Surveys for pond-breeding salamanders are particularly difficult because they are primarily subterranean and therefore are only available for sampling during their breeding season. Further, the essential breeding habitats for pond-breeding salamanders, ephemeral and semi-permanent wetlands, are difficult to identify because they may be dry for a large part of the year and are easily converted or drained.

Jefferson Salamander, *Ambystoma jeffersonianum*, was first documented in Illinois in 1990, and subsequently listed as a state threatened species because of its restricted range and dependence on rare or vulnerable habitat (Illinois—DNR 2006). From their discovery in 1990 through 2007, Jefferson Salamanders were documented from fewer than ten locations along the Illinois-Indiana border in Clark and Edgar Counties, and one disjunct population in Lincoln Trail State Recreation Area (INHS amphibian and reptile collection; UIMNH amphibians and reptiles collection; unvouchered Illinois amphibians and reptiles database; Non-INHS amphibians and reptiles database). Jefferson Salamanders require undisturbed well-drained upland forests that are within 200-250 m of seasonal, semi-permanent, non-acidic wetlands (Petranka 1998). Because *A. jeffersonianum* is listed as state threatened and therefore a species in greatest need of conservation, it is important to determine its distribution, abundance, and habitat use (Illinois—DNR 2006).

Objectives:

1. Model the potential range of *A. jeffersonianum* in Illinois using Maxent (Maximum Enropy).
2. Create a predictive distribution map for *A. jeffersonianum* within Illinois
3. Conduct field surveys of areas the model predicts as having high likelihoods of *A. jeffersonianum* presence.
4. Identify breeding ponds used by *A. jeffersonianum.*
5. Quantify habitat characteristics of sampled ponds used and not used by *A. jeffersonianum.*
6. Create shape files of known breeding ponds of *A. jeffersonianum* using Arc-GIS.
7. Determine the applicability of using niche modeling as a conservation tool for endangered and threatened species in Illinois.

Materials and Methods:

Niche Modeling— We used Geographical Information Systems (GIS) niche-based models to predict the distribution of *Ambystoma jeffersonianum*, focusing in Illinois. We procured locality data for specimens of *A. jeffersonianum* using HerpNET (www.herpnet.org). Specimens that lacked coordinates were geo-referenced by ARK if the locality information was specific enough to infer that coordinates would be within 1 km of the actual site locality. Additional unpublished locality data for Indiana was provided by Zack Walker (State Herpetologist – Indiana Department of Natural Resources). We then used Maxent® to generate a predicted distribution based on characteristics of environmental–climatic variables for 145 known localities throughout the range of *A. jeffersonianum*. Locality information was overlaid onto database consisting of 20 environmental variables available from the Worldclim project (Hijmans *et al.*, 2005). Details, descriptions, and files for download are available free on-line at:

<http://www.worldclim.org>. We mapped the output to give us isopleths of suitability starting at >85%, and dropping 5% for each subsequent isopleth. We then used the resulting maps to determine suitable sampling locations focusing on sampling in the upper three predicted isopleths (ie. <85%, 80% to 84.99%, and 75% to 79.99%.

Field Surveys — Using the predictive map generated by Maxent as a guide (Figures 1 & 2), we selected 31 ponds in the highest predicted isopleths to sample for Jefferson Salamanders. We tried to select smaller ponds with wooded habitat surrounding or adjacent to the pond periphery (ie. that appeared qualitatively suitable for Ambystomatid salamanders). We recorded pond dimensions (Length and Width), Canopy Cover (spherical concave densitometer) and average Leaf Litter Depth (straight ruler +/- 1mm). Both canopy cover and leaf litter measurements were taken at the North, South, East, and West shores of ponds. In each pond, we placed from four to eight double-throated un-baited minnow traps (Plate 1). An effort was made to leave a portion of the trap above the waterline so that captured individuals would have access to atmospheric oxygen. Ponds were sampled for two consecutive nights for two separate sampling sessions for a total of 4 nights per pond, and four trap checks per pond.

At each trap check we recorded the total numbers of each amphibian species captured and we recorded the sex of each Jefferson Salamander using the secondary sexual characteristic of males having a swollen cloaca during the breeding season (Petranka 1998). We also recorded if females contained eggs. We clipped the tip of the fourth toe of the rear right foot of all Jefferson Salamanders to allow us to determine if individuals had been previously captured. For each pond we preserved up to 5 toe-clips in 100% ethyl alcohol and accessioned them into the Illinois Natural History Survey Unvouchered tissue collection for future genetic analysis. For up to 10 Jefferson Salamanders per pond, we recorded three measurements of size, snout to cloaca length

(±1mm), tail length (±1mm), and weight (±0.5g). Salamanders were immediately released back into the pond. We collected one voucher specimen of each species from each pond, with the following exceptions: the landowner stipulated that all individuals must be released; the only specimen found was a gravid female or; in the case of Jefferson Salamanders, a recent specimen from the location already existed.

We used the marked-recapture models, modified by MacKenzie et al. (2002) for use with presence-absence data in Program PRESENCE 2.0 (United States Geological Survey, Patuxent, Maryland), to analyze the fit of several models to the data set. We used this program to estimate the probability of detecting Jefferson Salamanders (*Ambystoma jeffersonianum*). According to the simulation performed by MacKenzie et al. (2002), it is likely that our survey effort was sufficient to estimate reliable site-occupation probabilities using PRESENCE 2.0; hence, detection probabilities used to calculate occupancy must be accurate. We considered 5 models to estimate detection probabilities and site occupancy (another parameter estimated by PRESENCE 2.0). The first model estimated a constant probability of detection across all surveys during the season (Table 1). The second model considered detection probability as specific to each individual survey (survey-specific). The third model examined the influence of daily average temperature at 15:00 CST during each sampling period on detection probability. The fourth model examined the influence of nightly average temperature at 22:00 CST during each sampling period on detection probability. The last model examined the influence of total rainfall during each sampling period. Every model considered occupancy of sampling sites as constant. We selected models based on Akaike's Information Criterion (AIC) and AIC weights (Burnham and Anderson 2002).

Results:

Niche Modeling —The ecological niche model generated by Maxent resulted in good fit to the data (Training AUC = 0.984; Testing AUC = 0.954). The three climatic variables that had the highest percent contribution to determining environmental suitability were BIO6: minimum temperature of the coldest month, Tmin2: minimum temperature in February; and Bio8: Mean temperature of the wettest quarter of the year.

Field Surveys— We conducted focal surveys of areas with the highest probability of occurrence as determined by the ecological niche model (Figure 1). Our surveys identified Jefferson Salamander from 12 new wetlands in Illinois (Tables 1, 2, 3; Figure 3). We were also able to confirm the continued presence of Jefferson Salamander at four historical locations (Tables 1, 2), but documented that four other historical breeding ponds are not holding enough water for successful recruitment (Plates 2, 3). Ponds where Jefferson Salamanders were documented were no different in size than ponds where Jefferson salamanders were not documented ($T=1.35$, $p=0.406$), but did have significantly denser canopy cover ($T = 24.00$, $p = 0.027$) and deeper leaf litter ($T = 47.40$, $p = 0.013$).

To estimate our likelihood of detecting the species and the percent of sites occupied, we selected the rainfall model based on the highest AIC weight of the models tested (Table 4). All other models tested had only minimal support (Table 4). The overall estimate of proportion of sites occupied was 0.65 and the probability of detection was 0.69.

Parasites—During our surveys we noticed cysts on salamanders from several sites. We collected an *Ambystoma texanum* and sent it off to parasitologist Chris McAllister for identification. It was identified as a *Clinostomum* trematode. We subsequently collected one *A. jeffersonianum* that appeared infected to be certain that it was the same parasite. Of the 23 sites

with Ambystomatid salamanders present, we documented parasites at eight. At Site 19 we made a conscious effort to document the occurrence of the parasite on all animals. At this site we captured 51 novel *A. jeffersonianum* and 59 novel *A. texanum*. For *A. jeffersonianum*, we captured 5 novel females, one of which had the parasite. We captured 46 *A. jeffersonianum* males, 12 of which had the parasite. For *A. texanum*, we captured 24 novel females, one of which had the parasite. We captured 35 *A. texanum* males, 3 of which had the parasite. Upon workup, Dr. McAllister also documented a *Myxidium serotinum* parasite in *A. jeffersonianum* we sent him. This is of interest because *A. jeffersonianum* is a new host species for the parasite and the occurrence appears to be the first documentation of the parasite in Illinois.

Discussion:

Niche Modeling — Maxent appears to be a useful tool for quickly and efficiently identifying areas in which to survey for rare species. The odds of Jefferson salamanders being detected at a site increased with each successive predicted isopleths (Table 5). While we were only able to sample 3 ponds in the highest predicted isopleth area, we were able to document Jefferson Salamanders from all three. Similarly, we sampled only three sites in the 75% to 80% isopleth but only one site had Jefferson Salamanders. Our results lead us to believe that modeling a species niche is a useful tool for being able to quickly focus in on the areas that give you the best chance for documenting the species. This is especially important for species that are only available for effective sampling for short periods of time, such as subterranean salamanders.

Field Surveys — We documented 12 new breeding ponds for Jefferson Salamanders within Illinois, more than doubling the previously known localities. The results of our surveys fill in gaps for the species between the previously known locations along the Illinois—Indiana state

line and Lincoln Trail State Recreation Area, and extend the species known range 5 km west. However, four ponds we classified as present were based on a lone Jefferson Salamander capture, and four of the previously known ponds no longer appear capable of supporting breeding populations of Jefferson Salamanders. Of the original five ponds documented by Lau, we were able to verify the continued presence of Jefferson salamanders at only one . The dams of two of the ponds have washed out and are now capable of holding only a few inches of water (Plate 2). One pond has been filled in, presumably by the proprietor of a new house going in beside it, and we were unable to secure permission from the property owner to find or trap the fifth pond. The hydrologic regime of the known Jefferson Salamander breeding pond in Lincoln Trail State Recreation Area prevents recruitment into the population (Plate 3). This pond was completely dry, despite a wet late winter, on 08 March. By 10 March the pond had filled to a depth of ~1.2m but was completely dry again within 7 days. We did catch Jefferson Salamanders in the pond when it was filled, but within 2 days most egg packets were suspended on twigs above the rapidly falling water surface. As this is the only known breeding location not on private property, this is a concern.

Parasites —The implications of trematode infection on *A. jeffersonianum* populations are unknown to the authors. A literature search revealed that for *Clinostomum marginatum,* snails are a first intermediate host, fish are a second intermediate host, and wading birds (such as herons) are the definitive host (Klaas 1963). Apparently, salamanders may take the place of fish as second intermediate hosts. We would assume that once the salamanders leave the water and return to subterranean refuges, the cycle would be broken as they would not have contact with aquatic snails to become re-infected until they again returned to the ponds to breed. The observations of the Clinostomum trematode parasites on both *A. jeffersonianum* and *A. texanum*

will be combined with information Chris McAllister and Stan Trouth have on infection in *Ambystoma maculatum* for a paper to be submitted to a paper in Comparative Parasitology or a regional journal. Once we are sure that *Ambystoma jeffersonianium* is indeed a novel host and distribution for *Myxidium serotinum*, a small note will be published to document the occurrence.

Summary:

The paucity of known locations for Jefferson Salamanders in Illinois appears, in part, due to inadequate sampling. This study documented Jefferson Salamanders from 12 new locations in Illinois. However, this study also documents that at least four of the previously known localities are not suitable for salamander recruitment at this time. Management efforts should focus on restoring these habitats while there is the possibility that adults are still present and capable of naturally recovering.

The new locations we documented in this study did little to expand the known range of the species but did fill in gaps in the known distribution. Because we focused sampling in a small area in an effort to sample as many sites as possible within the limits of one breeding season, we are able to provide little information on whether their distribution extends beyond what was previously known. Hopefully future surveys will be able to tackle this issue.

Acknowledgements:

We thank Roger Janzen, Illinois Department of Natural Resources, Heritage Biologist District 14 for all his work in compiling contacts and suggesting potential sampling sites, Dave Hiatt from the Martinsville NRCS office for providing landowner contact information, Zach Walker of Indiana Department of Natural Resources, for providing locality information on *A. jeffersonianum* in Indiana for the construction of the Maxent models, and the numerous

landowners who graciously granted us access to their ponds. We thank Dale Sparks and Bill Peterman of Indiana State University for assisting with finding suitable sites to trap. We thank Chris Phillips of the Illinois Natural History Survey for mentioning the need for additional surveys of Jefferson Salamanders. Partial funding for this project came from a grant from the Illinois Wildlife Preservation Fund administered by the Illinois Department of Natural Resources.

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Table 1. Localities, coordinates, sampling dates, and presence results of Ambystomatid salamanders and predatory fish of sites sampled for *Ambystoma jeffersonianum* in Clark and Edgar Counties, Illinois from 2008. AJEFF = *Ambystoma jeffersonianum* and ATEX = *Ambystoma texanum*.

Site number	Site Name	Lat.	Lon.	Present	Isopleth	Fish ?	Session 1	Session 2
1	Schotts' Pond	39.3441	-87.7883	AJEFF & ATEX	85th	No	2/25-2/27	3/11-3/13
2	Auburn Branch	39.3413	-87.7704	ATEX	80th	Yes	3/3-3/5	3/11-3/13
3	Auburn Corner	39.3404	-87.7694	ATEX	80th	No	2/25-2/27	3/11-3/13
6	Schotts' Lake	39.3408	-87.7858	AJEFF & ATEX	85th	Yes	2/18-2/20	2/25-2/27
7	Wallace	39.3244	-87.7642	None	75th	Yes	3/11-3/13	n/a
8	Anderson/Fox	39.3039	-87.7384	None	5th	No	2/18-2/20	2/25-2/27
13	Petzing Pond	39.4479	-87.7163	None	80th	Yes	2/18-2/20	2/25-2/27
18	IN - State Line	39.4444	-87.5312	AJEFF & ATEX	75th	Yes	3/12-3/14	3/17-3/19
19	State Line Rd -S	39.4519	-87.5317	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
24	Lawson	39.4337	-87.5655	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
32	Darwin Rd Ditch	39.3536	-87.6060	None	80th	No	2/18-2/20	n/a
50	Auburn Ridge	39.3451	-87.7696	AJEFF & ATEX	85th	No	2/25-2/27	3/11-3/13
51	Church @ 13550	39.3467	-87.6281	None	80th	No	2/26-2/28	3/11-3/13
52	Darwin Ag Pond	39.3531	-87.6056	ATEX	80th	No	2/26-2/28	3/11-3/13
54	Davis 1	39.3372	-87.7116	AJEFF & ATEX	80th	No	2/26-2/28	3/11-3/13
55	I-70 West	39.3956	-87.7874	ATEX	80th	No	3/3-3/5	3/17-3/19
56	I-70 East	39.3899	-87.8007	ATEX	80th	No	3/3-3/5	3/17-3/19
57	Davis 2	39.3364	-87.7094	None	80th	Yes	3/3-3/5	3/11-3/13
58	Pickering West	39.3801	-87.5877	AJEFF & ATEX	80th	No	3/3-3/5	3/17-3/19
59	Pickering Mid	39.3799	-87.5885	AJEFF & ATEX	80th	No	3/3-3/5	3/17-3/19
60	Pickering East	39.3795	-87.8559	AJEFF & ATEX	80th	No	3/3-3/5	3/17-3/19
62	Forsythe	39.3347	-87.7279	None	80th	Yes	3/11-3/13	3/17-3/19
63	LTSP new	39.3507	-87.6636	AJEFF & ATEX	80th	Yes	3/11-3/13	3/17-3/19
65	Lau site	39.5140	-87.5559	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
66	Lau site 2	39.51103	-87.5559	None	80th	No	————	————
67	Indiana RR	39.4696	-87.5309	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
68	County Line	39.4770	-87.5319	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
69	Turtle Pond	39.4337	-87.7704	AJEFF & ATEX	80th	No	3/12-3/14	3/17-3/19
70	Perrill	39.2831	-87.7129	None	75th	No	3/19-3/21	3/24-3/26
71	Lau Site 3	39.5092	-87.55987	ATEX	80th	No	————	————
53a	Pennzoil South	39.3572	-87.5636	AJEFF & ATEX	80th	No	2/26-2/28	3/17-3/19
53b	Pennzoil North	39.3591	-87.5632	AJEFF & ATEX	80th	No	2/26-2/28	3/17-3/19
n/a	LTSP known	39.3371	-87.7319	AJEFF & ATEX	80th	No	3/19-3/21	3/24-3/26

Table 2. Results of surveys for Jefferson Salamander in Clark and Edgar Counties, Illinois, Year 2008.

Total sites sampled	35
Novel sites sampled	27
Historical sites sampled	8*
Total sites with *A. jeffersonianum* present	16
Novel sites with *A. jeffersonianum* present	12
Historical sites with *A. jeffersonianum* present	4*

*Four of the historical sites no longer hold water long enough for successful recruitment.

Table 3. Results for sites where Jefferson Salamanders were captured.

Site		Female		Male		Total	
Number	Name	Individuals	Recaps	Individuals	Recaps	Individuals	Captures
50	Auburn Ridge	2	1	12	5	14	20
68	County line	1	0	0	0	1	1
54	Davis 1	5	2	13	8	18	28
65	LAU	11	1	17	6	28	35
24	Lawson Pond	2	0	14	1	16	17
n/a	LTSRA-Known	3	0	0	0	3	3
63	LTSRA- New	0	0	1	0	1	1
53b	Penzoil North	5	1	9	2	14	17
53a	Penzoil South	4	1	15	2	19	22
60	Pickering East	1	0	6	0	7	7
59	Pickering Middle	0	0	1	0	1	1
58	Pickering West	0	0	8	0	8	8
6	Shott's Lake	0	0	1	0	1	1
1	Shotts Pond	1	0	13	1	14	15
19	State Line Rd-South	5	0	14	7	19	26
69	Turtle Pond	0	0	1	0	1	1
	Totals	40	6	125	32	165	203

Table 4. Akaike's Information Criterion (AIC) for models estimating detection of Jefferson Salamanders* in East-Central Illinois.

Model	*AIC*	*ΔAIC*	*AIC weight*
p(rainfall)	71.54	0.00	0.54
p(.)	74.37	2.83	0.24
p(survey)	74.44	2.90	0.23
p(night temp)	74.67	3.13	0.21
p(day temp)	75.16	3.62	0.16

*We modeled detection probabilities (p) as constant among surveys (.), specific to surveys (survey), and influenced by daytime temperature (day temp), nighttime temperature (night temp), and total rainfall (rainfall). Occupancy was constant in all models.

Table 5. **Results of sampling for *Ambstoma jeffersonianum* by predictive maxent isopleths.**

Isopleth	# sites	Present	% Occupied
5th	1	0	0.00%
75th	3	1	33.33%
80th	24	14	58.33%
85th	3	3	100.00%
Overall	31	18	58.06%
75% and Up	30	18	60.00%

Figure 1. Areas of suitable environmental characteristics for *Ambystoma jeffersonianum* as predicted by Maximum Entropy Modeling. Hotter colors indicate locations with a higher probability of having suitable environmental conditions for *Ambystoma jeffersonianum*.

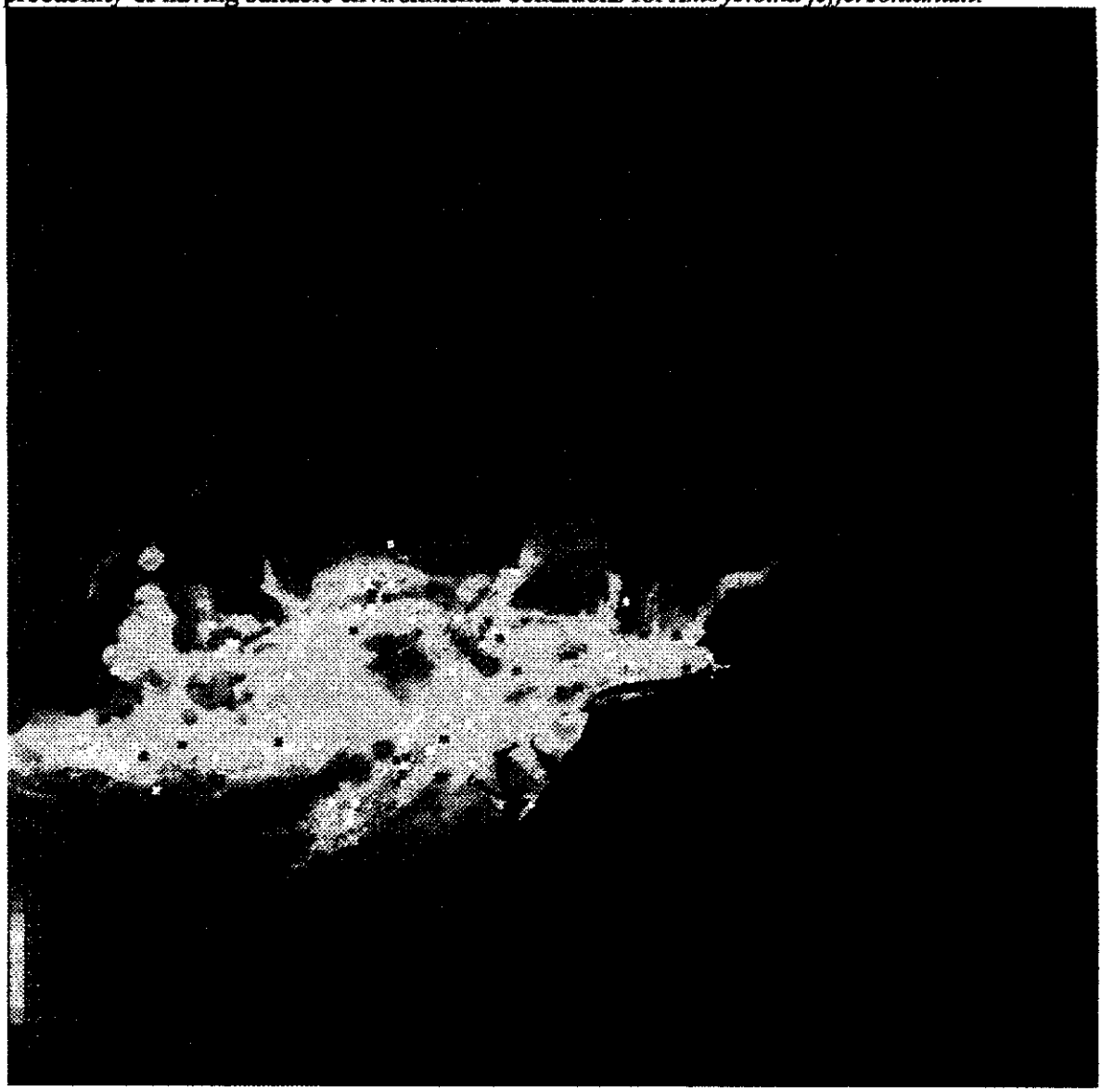

Figure 2. Areas of suitable environmental characteristics for *Ambystoma jeffersonianum* within Illinois as predicted by Maximum Entropy Modeling.

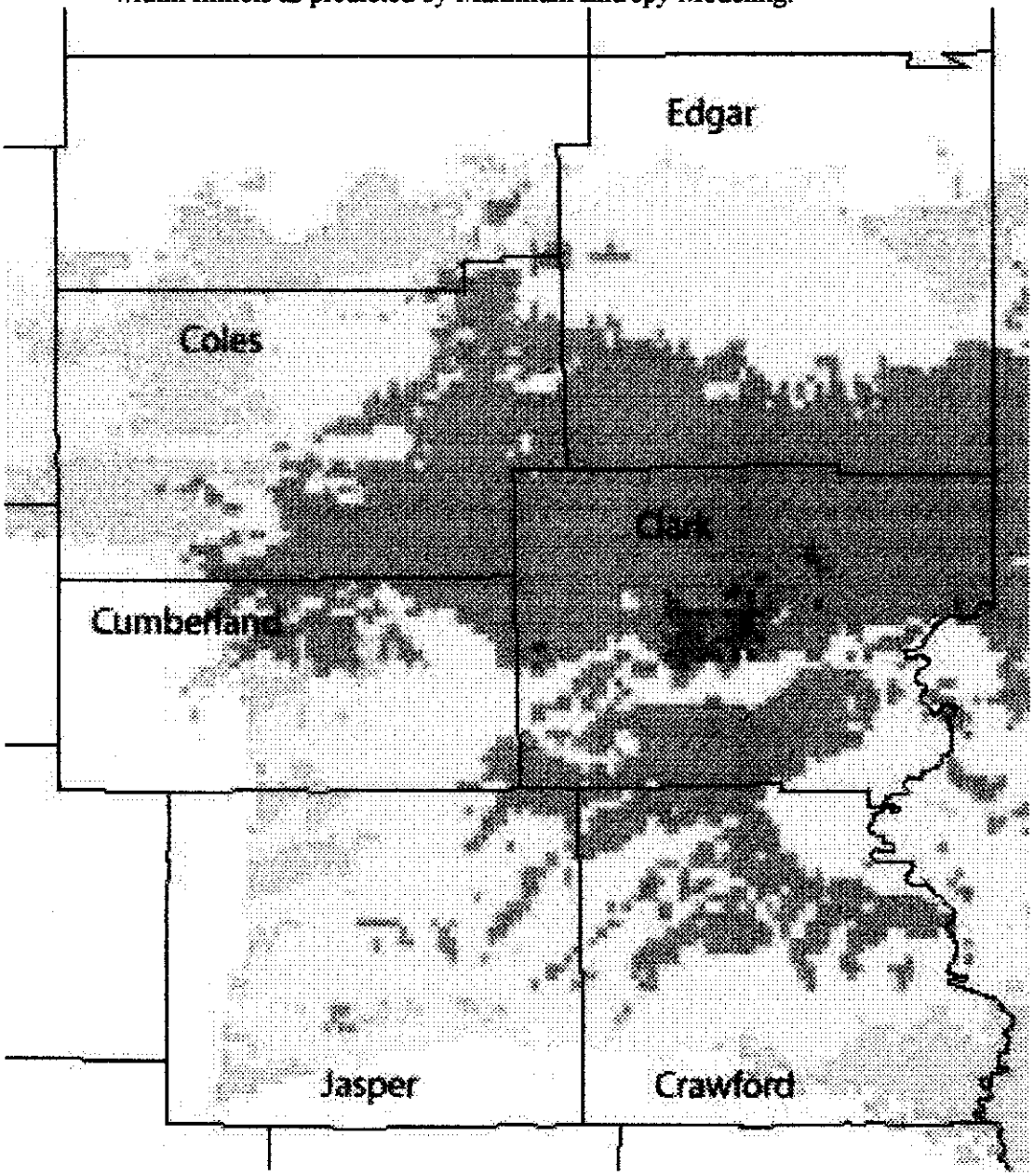

Figure 3. GIS map of sampled localities by salamander species captured.

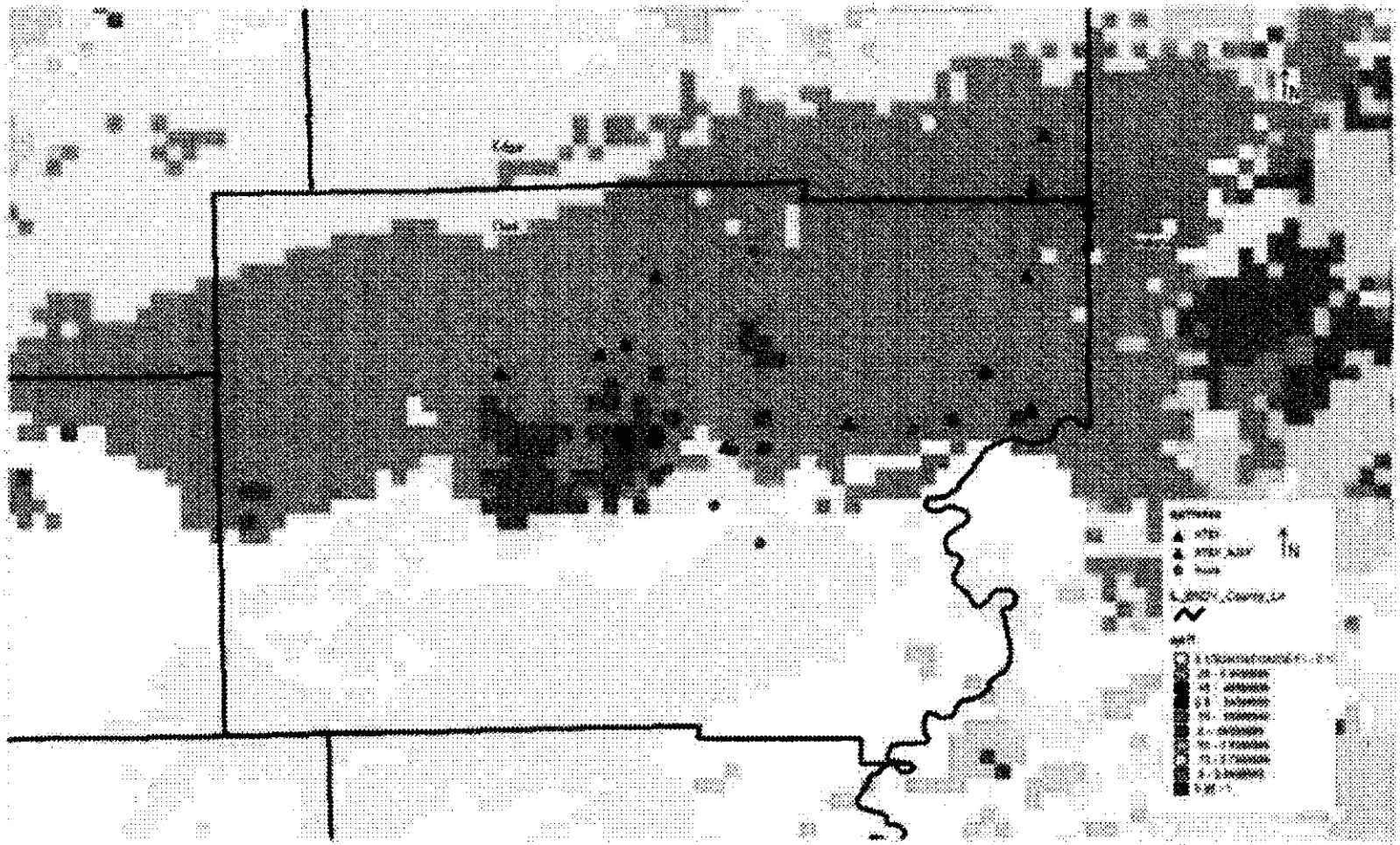

Plate 1. Representative photographs of ephemeral ponds with breeding populations of Jefferson Salamanders. The top picture is site 001 Shott's Pond. The bottom photograph is of Site 65 Lau's Pond, which is the original site location of Jefferson Salamanders in Illinois. Minnow traps are visible in both ponds.

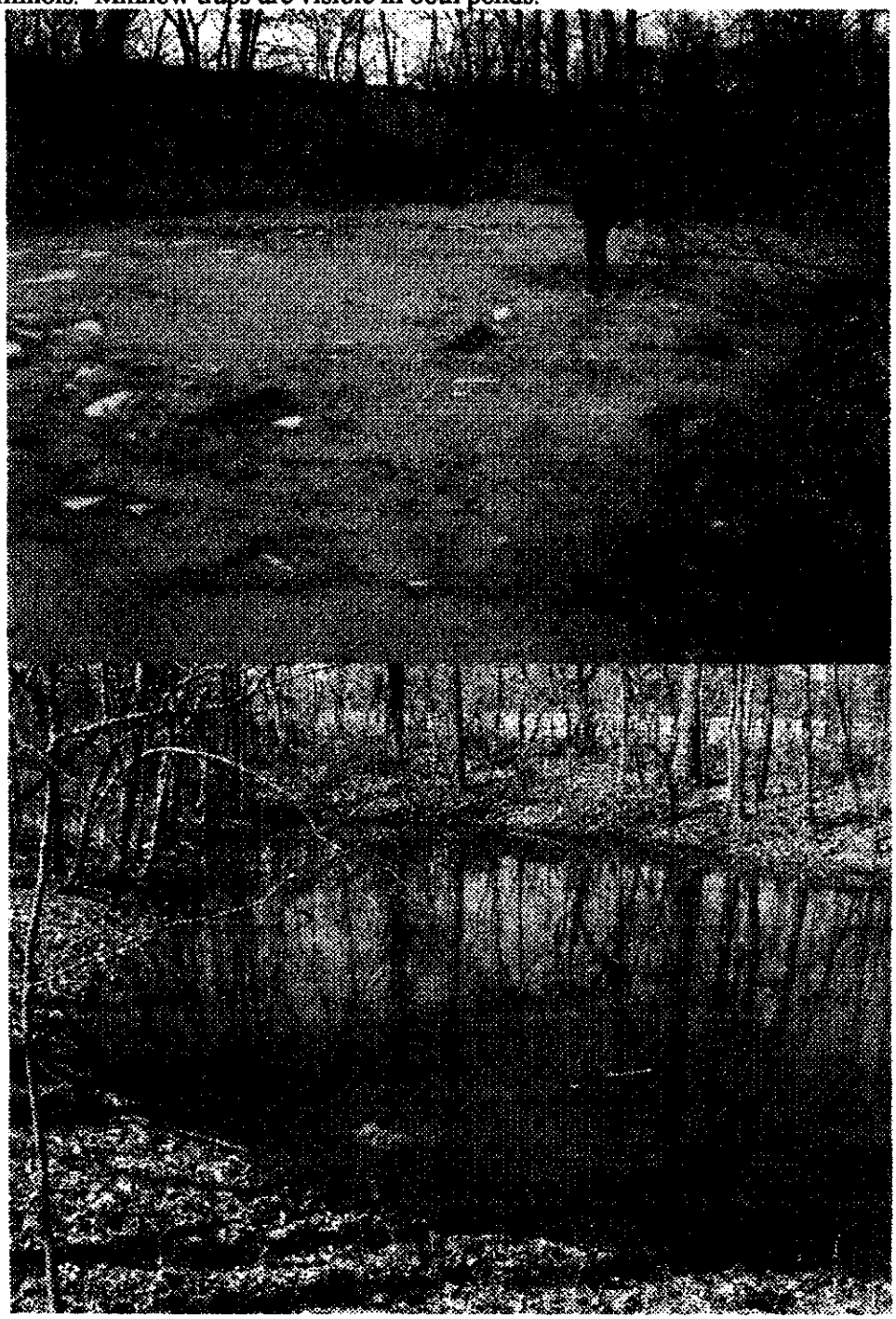

Plate 2. The top photograph shows one of the original localities for Jefferson Salamanders in Illinois. The dam has eroded (upper right) so that the pond is capable of holding no more than a couple of inches of water. The bottom photograph is of a Jefferson Salamander captured during this study.

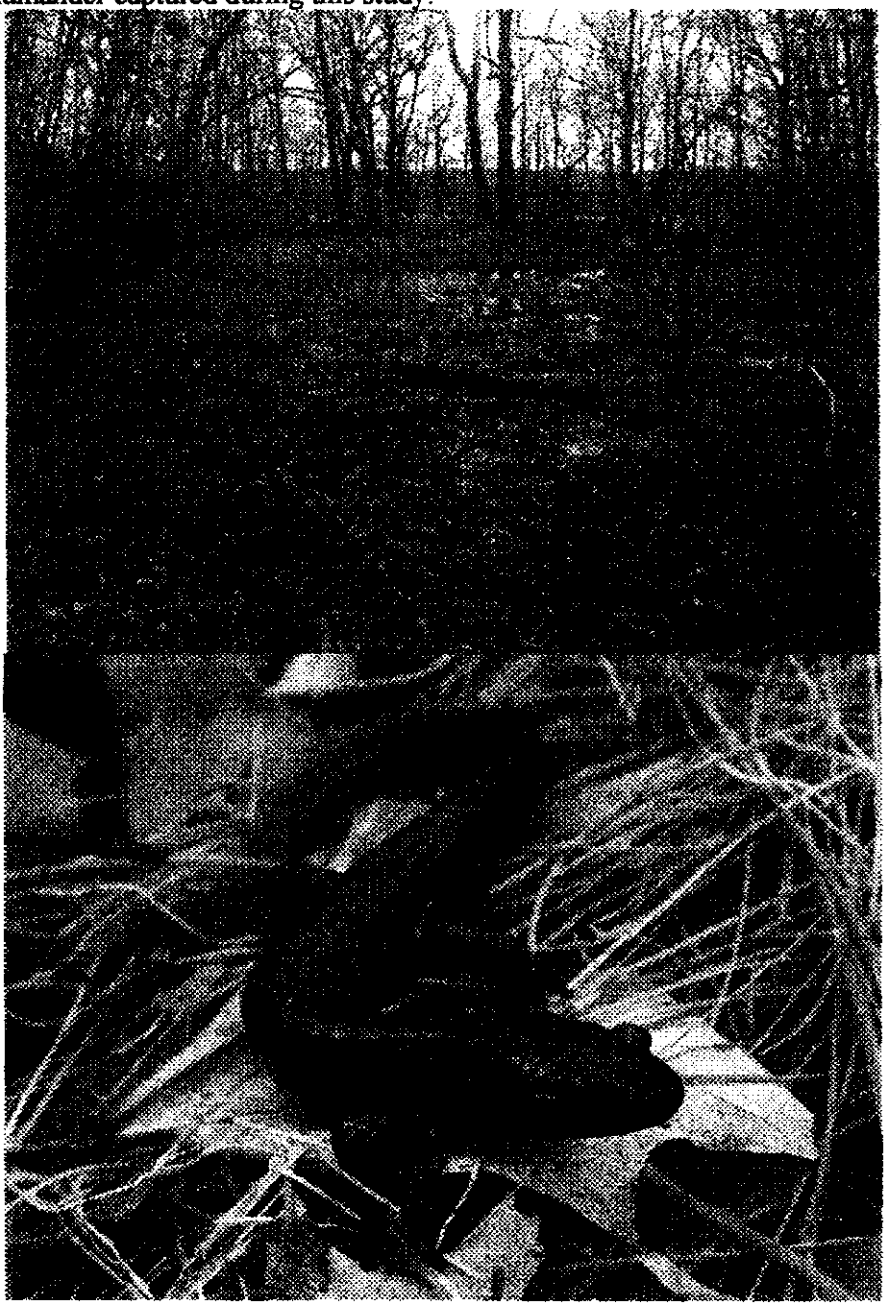

Plate 3. Ephemeral pond on the west edge of Lincoln Trail State Recreation Area for two dates in March showing the extreme fluctuations in water level. This pond went from completely dry on 08 March to full on 10 March (max. depth ~ 1.2 m), to almost completely dry again by 15 March 2008.

08 March 2008

10 March 2008