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Revitalization of Ephemeral Pools as Frog Breeding Habitat in an Illinois Forest Preserve

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Almost all land in the eastern United States that has been acquired to preserve nature was once in agricultural usage, and because of this, alterations of ephemeral pool hydrology are common in forest preserves and parks. These ephemeral pools are an important breeding resource for many amphibian species. We hypothesized that filling drainage ditches and recreating a more natural topography at eroded berms would enhance amphibian populations in the forest preserve. Restoration of the hydrology was begun by volunteers in 1993 and was associated with management to reduce non-native woody vegetation. Three ephemeral pools have had maximum water levels raised by as much as 10 cm. Assays of advertisement call activity suggest that raising the water level has increased the abundance of frogs at the revitalized pools.

INDEX DESCRIPTORS: ephemeral pools, habitat restoration, chorus frog, spring peeper, eroded berms, de-ditching, volunteer stewardship network.

The causes of the decline of amphibian populations throughout the world are undoubtedly diverse (Blaustein and Wake 1995, Laurance et al. 1997). Toxins and atmospheric changes seem to have caused declines in pristine areas (Stebbins and Cohen 1995, Lips 1998). Such declines are frightening as portents of dangers to ecosystems and to ourselves. Nevertheless, the more visible habitat alteration/destruction is still regarded as the biggest cause of decline (Blaustein and Wake 1995). Transportation and agriculture (Findlay and Houlahan 1997) are major culprits as they alter topology and hydrology, but vegetation changes are at least locally important (Denton et al. 1997, Skelly et al. 1998).

The preservation of flora and fauna are among the goals of forest preserve districts, county, state and national parks. In Illinois these agencies mostly own land acquired from private individuals, almost always with a history of agricultural usage. Classically, preservation has been considered sufficient for protection, but all preserved areas are affected by events outside the preserve boundaries as well as alterations within the area prior to and after preservation. For preserved areas to function efficiently in maintaining native populations the impacts of past and future, local and global human-induced environmental alterations need to be understood.

In the eastern USA it is not difficult to find evidence of alterations in the topography and hydrology in parks and preserves. During agricultural usage many wetlands were drained by ditches and/or tiling, while others were "improved" to ponds that would hold adequate water for farm animals by excavation and/or constructing berms. During ownership by public agencies, additional ditches have been dug during trail and road construction and ephemeral pools have been "improved" to provide fishing opportunities for the public. We hypothesized that making the land wetter by reversing alterations of the hydrology would increase the abundance of the small frogs that utilize ephemeral pools. We measured abundance by advertisement call surveys.

Even if the major causes of decline of amphibians involve lower survivorship or more deformities caused by global changes, it still may be practical to increase abundance in local populations by removing non-native species and reversing hydrological alterations. We filled in drainage ditches and restored natural contours to eroded berms. Increased calling activity suggests that these actions have enhanced frog populations on forest preserve land.

METHODS

The Study Area and Its Fauna

Country Lane Natural Area is a 229-ha area within the Cook County, Ilinois, Forest Preserve District (FPDCC), including the east half of section 9 (T37NR12E 3rd PM) plus parts of sections 10 and 16. CLNA is surrounded by forest preserve land beyond the bordering roads. Only about 2 ha of CLNA are impacted by a picnic area with a parking lot. About 149 ha of CLNA are a dedicated Illinois Nature Preserve, Cranberry Slough. The glacial till soils are poorly drained. The natural communities include oak woodlands, oak savanna, sedge meadow, a bog and other wetland communities. While parts of the 229 ha have almost intact plant communities, about half the area has been heavily impacted by prior agricultural use and sometimes by "reforestation" projects which included non-native trees.

Within CLNA there are 14 wetlands (ranged in size from 150–67,700 m^2) that we judged to have been large enough and deep enough ($\geq$9 cm maximum depth) for amphibian breeding in the pre-agricultural landscape. Of the 14, two are permanent bodies of water, eight are ephemeral and still hold enough water for amphibian breeding and four no longer held sufficient water for successful amphibian breeding. Four of the wetlands had no detectable human alterations, five had been drained by a ditch, and five had berms which originally served as dams. Two of the berms were associated with a road, the other three were eroded so that less water was currently being held than was held by the wetland before the berm was constructed.

A CLNA herp inventory (Dancik 1991) found the following spe-

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Table 1. Person hours of revitalization effort by wetlands and year.

Wetland	Year					5-yr total person hours
	1993	1994	1995	1996	1997	
Pool 13	58	6	1	12.2	7	84.2
Pool H/J	None	42	0.5	None	12	54.5
ELP	None	None	7.5	1.5	0.6	9.6
5-yr Grand Total Effort						148.3

cies: Central newt (*Notophthalmus viridescens*), Blue-spotted salamander (*Ambystoma laterale*), Spotted salamander (*Ambystoma maculatum*), Eastern tiger salamander (*Ambystoma tigrinum*), American toad (*Bufo americanus*), Western chorus frog (*Pseudacris triseriata*), Northern spring peeper (*Pseudacris crucifer*), Bullfrog (*Rana catesbiana*), Green frog (*Rana clamitans*) and Northern leopard frog (*Rana pipiens*). Subsequent to his survey Dancik and DN have seen and heard the Eastern gray treefrog (*Hyla versicolor*). The current distribution of amphibians in Cook County, IL has been described by Anton (1999).

Methods of Restoring Hydrology and Vegetation

Pools with ditches.—Wetland ELP (41°42.55′N, 87°51.26′W) has a wetland perimeter of 103 m and an area of 684 m^2. This wetland had many American elms within its border, but almost all of the elms have died since 1988. Currently, sedges, *Leersia oryzoides* and *Iris* dominate the vegetation within the wetland. ELP was drained by a ditch about 30 m long, 40–70 cm wide and 20–30 cm deep. The ditch empties through a ridge into a wetland along the banks of the outlet of a slough "improved" for fishing. The closest pool with calling frogs is the largest (and non-ephemeral) pool; it is 121 m away.

In May and October of 1995 the ditch was partially filled. In May 1995 material from the sides of the ditch were used to make it more shallow. In October 1995 woody debris was added to the head of the outlet and soil was taken from the dried out center of the pond and dumped in the outlet channel. Subsequent work has dumped bentonite (cat litter) and clay into the outlet ditch. The total effort at ELP from 1995 thru 1997 was 9.6 person hours (Table 1). There are still parts of the ditch that have not been filled.

Vegetation management in the area surrounding ELP has been of moderate intensity. In the early 90s, *Rhamnus cathartica* and *R. frangula,* invasive shrubs, in the vicinity of ELP were girdled. *Alliaria petiolata* (garlic mustard) has been greatly reduced by hand pulling. The loss of elms to Dutch elm disease has dramatically reduced shading of the pool.

Pools with berms.—All three of the berms not associated with the multi-use trail had been cut by erosion. Apparently, the increased pool depth behind the berm stores considerable potential energy and eventually heavy rainfall events result in erosive cutting into the berm. In all three cases at CLNA, the localization of erosive force resulted in a deep V-shaped outlet channel so that the wetland currently held less water than it did before the construction of the berm. The first two projects attempting to revitalize wetlands worked on those with eroded berms.

Wetland H13 (41°42.59′N, 87°51.80′W) had a berm that had eroded so much that the bottom of the V-cut was 50 cm below the original land contour. Wetland H13 is filled with large Buttonbush, *Cephalanthus occidentalis,* topped by a couple Cottonwood, *Populus deltoides,* and a few willow, *Salix nigra.* The surface area is less than 1514 m^2; the perimeter of the wetland is 155 m. Wetland H13 is located in an area in which the natural vegetation was highly altered. The surrounding vegetation is a mixture of hawthorns and non-native woody vegetation belonging to *Berberis, Lonicera* and *Rhamnus.*

The work to restore the hydrology of the pond 13 outlet, was based on the idea that a broader, flatter outlet would have a reduced maximum velocity of flow. Reduced velocity of flow reduces erosion. Three rows of sticks (3–6 cm diameter) were driven in with a sledgehammer, perpendicular to the channel and about 4 cm apart. Their purpose was to support the soil that was moved into the channel. Material from the berm, supplemented by bentonite, was used to fill the V cut. The material was packed by walking on it and tamping it with a sledgehammer. All work was done with hand tools. The initial work was done in March 1993. The initial work attempted to fill the V-cut to the width of the berm, about 1.5 m. Subsequent work, as recently as 1997, has moved more material from the berm into the outlet channel, eliminating the berm and the channel at the same time. H13 was the first wetland worked on and the total amount of work from 1993–97 has been 84.2 person hours. Work subsequent to 1993 has made the outlet wider and thicker and has not affected the pool level.

Vegetation surrounding pond 13 has also been modified. Non-native woody vegetation has been girdled or cut. These removals focused on the margin of the pond. The amount of *Berberis thunbergii* was so great that many individuals still persist within 5 m of the pond edge.

Wetland H/J (41°42.29′N, 87°51.77′W) is a large sedge meadow with a perimeter of 292 m within an oak woodland community. There was a small pool (perimeter less than 89 m) with Buttonbush immediately above the severely eroded berm. The highest parts of the old berm were about 50 cm above the winter ice level in 1993. Downstream from the eroded berm, the outlet is cutting a ravine. Pond H/J is the CLNA wetland furthest (>800 m) from a parking area.

Work on this eroded berm began in May 1994. The drainage basin upstream of this berm is considerably greater than that of H13 and considerable volumes of flow are possible. The initial work drove in a single into-the-flow arc (about 10 m long) of sticks 2–6 cm diameter. The upstream side of this arc was covered with burlap before the soil from the berm was added to the "dam" of sticks. The berm material was friable, like top-soil, rather than heavy like subsoil. Woody debris was added to the V-cut prior to filling with soil (later interpreted as a mistaken action). Some plugs dug from the wetland were added to the fill area in an attempt to establish vegetation there. There was a long drought after moving the vegetation plugs and considerable effort was devoted to hauling water for the plugs. There were 42 person hours of effort expended in 1994 (Table 1). While the plugs were successfully established, in 1996 they were eroded away during a 15 cm in 24 hrs rain storm. Though that storm undid a significant amount of work, the outlet did not return to its pre-work level.

Repair work on Pond H/J in 1997 emphasized the use of rock (10–20 cm diameter, collected from downstream parts of the outlet ravine), "pea" gravel (carried in from off site) and clay packed into burlap bags (50 cm long, 20 cm dia). A new outlet has been dug by cutting through the berm 8 m west of the eroded outlet. Twelve person•hours of effort were expended in 1997 (Table 1).

Management of the surrounding vegetation included girdling 20% of the white ash within 5 m of the wetland edge to let in more light, pulling Garlic mustard and seeding the dug areas.

Methods for Calling Frog Inventory

Our frog calling inventories began in 1994 after the purchase of a tape of calls (Elliot 1992). Before 1997 the inventories did not include all pools and were not part of a systematic inventory. Instead the data for those years is based on observations recorded in diaries of DN. When a student, IL, expressed interest in this project, more orderly protocols were followed. We listened for 5 min for calling amphibians, trying to get to as many pools as possible on a relatively warm and calm evening. Observations were concentrated in the month of April, when Chorus frogs and Spring Peepers were calling, but before most *Rana* started calling.

RESULTS

The maximum depth of the water at ELP was increased from about 12–20 cm by the deditching work. The maximum depth of the H13 pool has been increased from about 25 cm to about 35 cm by the work in 1993. The maximum water level at pool H/J has also been increased by about 10 cm. All three pools have completely dried in all years subsequent to the hydrological work as they had done prior to the work, so the hydrological changes are subtle. The following changes have been observed; all three pools have a greater area of ice and are holding water later into the year, more light is reaching the edge of the pools and the abundance of graminoid vegetation has increased, especially at ELP.

Records of observations of frog calling activity do not exist prior to 1994. Thus we do not have a solid base of "before" data, actually none in the case of H13. For pool H/J, on one night prior to the beginning of work no calling was heard and on the other night chorus frogs were heard. Subsequent to the May 1994 work, visits in 1995 and 1996 always heard spring peepers calling and once heard chorus frogs and once heard the northern leopard frog. There were four listening visits to pool ELP prior to the hydrological work and on only one of those visits were chorus frogs heard. On all 3 visits to ELP in 1996 chorus frogs were heard. In 1997 the single listening assay heard chorus frogs and a gray tree frog. Other evidence relevant to the issue of whether the work resulted in enhancement of populations or creation of new metapopulations is the listening results at pools 11S and Q. Both of these pools have a total area/depth similar to ELP (Lerner 1998) and are drained by ditches. No hydrology revitalization was done at either pool prior to 1998. No frogs were heard at 11S during four listening assays in 1995 and 1997. Similarly, no frogs were heard at pool Q during two listening assays in 1997. In Table 2 all of the 12 observations subsequent to repair (to the right of the thin line) had at least one frog calling, but only 2 of the twelve observations prior to repair work (below and to left of line) had calling frogs. If the alterations made no difference and the probability of not hearing any calling was 0.5, then the probability of observing 12 of 12 after repair is 1 in 4096 and the probability of observing 2 or less of 12 before repair is 79/4096 (= 0.019).

Table 2. **Frog calling activity at pools.**

Pool	Pool Status	Year 1994	1995	1996	1997
H13	Repaired in 1993	2 of 2	1 of 1	1 of 1	2 of 2
H/J	Repaired in 1994	1 of 2	1 of 1	1 of 1	NA
ELP	Deditched in 1995	1 of 2	0 of 2	2 of 2	2 of 2
11S	Ditched	NA	0 of 2	NA	0 of 2
Q	Ditched	NA	NA	NA	0 of 2

Each entry is the number of assays with one or more calling frog species out of the number of assays in that year.

DISCUSSION

While science investigates and analyzes the causes of declines of natural populations, the owners of conservation land are, or should be, interested in the potential of management actions to mitigate or reverse the effects of these changes. Even when the major component contributing to a population decline was something that can not be controlled locally, the local population might still be enhanced by providing altered or more habitat. Success stories of wetland mitigation (Mierzwa 1998) support this hypothesis. The natterjack toad was an amphibian in decline whose populations have been enhanced by habitat alterations (Denton et al 1997). Many years of study eventually revealed the decline of the natterjack toad to be primarily due to successional vegetation changes that favored the congeneric *Bufo bufo*. Constructions of ponds, pH and grazing management has successfully reversed the trend of population decline (Denton et al 1997).

At CLNA there was no specific concern that amphibian populations had declined in recent years. Rather, our actions were taken because we noticed that the natural topography had been altered; sufficiently so that some pools had no calling amphibians. We assumed that a more natural topography, in this case one that would hold more water, would enhance a number of native species, including amphibians. We also assumed that removal of non-native vegetation would enhance native animal populations. We have chosen the term "revitalization" to describe our management activities because we have emphasized reversing human alterations from earlier eras. To us, restoration includes a broad range of human activities usually focused on actions to solve a perceived problem. Revitalization is only possible where the natural topography, flora and fauna are all reasonably intact. Human actions associated with revitalization include that more gentle subset of restoration activities that attempts to reverse environmental alterations which inhibit native plant and animal communities from flourishing. The success of a revitalization action can not be judged solely by its effect on a single species for revitalization's goal includes the whole native community. The calling of frogs represented a relatively assessable attribute which hopefully represents positive population changes in salamanders and aquatic insects.

Once ELP held more water it was quickly colonized. Colonization and local extinction are frequent events in ephemeral pools (Hecnar and M'Closkey 1997). At least when source populations are not >300 m, colonization occurs rapidly (Laan and Verboom 1990).

We offer the following suggestions/recommendations to anyone attempting similar work. Smaller drainage basins are easier to work than larger ones; small ones should be worked on first. Widening the area over which water flows at the outlet is an effective way to reduce erosion; the longer the length over which the flow stays wide and shallow, the better. Don't think of the work area as a dam, such a structure will eventually erode. The driving of sticks as stakes probably did not help functionally to hold the soil, but did serve as a visual marker to the work crew. The soil in the berms was not heavy and was significantly eroded by high flows. Soils with a high clay content are more resistant to erosion. Clay soils should be sought. Packing a high clay soil into a burlap bag and using the 50 × 20 cm burlap bag to fill the lowest areas seems very effective. Putting a layer of "pea" gravel on top of the clay, especially when it is partially embedded into the clay, reduces the chance of significant erosion of the fill material. Rock works fine as capping material, but heavy clay is the best material for filling channels that carry significant flow. The work needs to be monitored during overflow periods; according to the patterns seen during the overflow adjustments are made to assure that the flow stays broad and slow.

In view of the large natural fluctuations that have been observed in frog populations (Duellman and Trueb 1986) it is reasonable to question if we have presented sufficient evidence that the frog populations have actually been increased. If the pools are considered individually doubt is possible, but in aggregate the evidence that calling activity has been increased subsequent to our work is strong. We ourselves have found the evidence sufficiently strong to have devoted time and energy initiating projects at two of the remaining ditched pools. We encourage natural area managers to look for signs of human alterations and to figure out how to revitalize the areas they are responsible for by taking action to reverse earlier human actions.

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