Amphibian Populations on Reclaimed Mined Lands: A Progress Report

Kevin P. Jansen, Candice Oakes, and Franklin D. Colyer
Department of Natural Sciences
The University of Virginia's College at Wise
Wise, Virginia, 24293

The use of distinctly different habitats throughout the life history of a specific organism is not particularly surprising to biologists. Many semi-aquatic and migratory organisms often require multiple ecotopes for reproduction, hibernation, aestivation, metamorphosis and/or feeding. For example, numerous salamanders and anurans breed in temporary wetlands yet maintain juvenile and adult populations in the surrounding uplands (Duellman and Trueb, 1986). The use of both terrestrial and aquatic habitats during the life cycle of many insects is also well documented (Pennak, 1978). Migratory bird species utilize not only different ecotopes, but often different biomes (Gill, 1990). These examples highlight the diversity of organisms that require more than one ecotope during their life cycles and should be familiar to biologists. Indeed, the critical habitats encompassed by all life history stages of a species are often individually recognized; they are, however, seldom discussed in a holistic sense. For instance, the use of terrestrial habitats by freshwater turtles for such vital activities as nesting (Burke and Gibbons, 1995; Wilson, 1998), long-term aestivation (Buhlmann, 1995), and feeding (Moll and Jansen, 1995) has only recently been recognized. Similarly, the amphibian literature has long focused on the aquatic activities or requirements of an organism (e.g., pH, hydroperiod, predator/prey relationships) or the use of peripheral habitats (e.g. perch sites, winter retreats, burrows) without providing an integrated view of the complete habitat requirements of the study organism (but see Dodd, 1996; Dodd and Cade, 1998; Semlitsch, 1998). Developing such a view is further complicated by prior habitat alteration. The primary goal of the current study is to assess the ability of modern restoration practices to support sustainable populations of native amphibian species.

The varied projects currently underway at the University of Virginia's College at Wise have been designed to provide an integrated view of the study organisms as called for above. Because of the spatial scale, diversity of terrestrial and wetland types, and history of mining and restoration at the Powell River Project's Education Center (PRP-EC) in Wise County, Virginia, the site is being used as the principle location for this work. As stated in last year's preliminary report, the study has three specific foci: the effects of the distribution of habitat types within the landscape on resident amphibian populations, the characteristics of restored habitats conducive to reestablishment of these populations, and the movement patterns of native amphibians from surrounding undisturbed forests to restored habitats. Specific projects developed to address these foci are outlined below.

Anuran Diversity Among Pond Types

Numerous studies have focused on the value of temporary wetlands in maintaining vegetative (e.g., Kirkman et al., 1998), invertebrate (e.g., Collinson et al., 1995), and vertebrate (e.g., Dodd, 1992) diversity as well as providing flood control and water quality enhancement (Robinson, 1995). Indeed, the survival of many anuran populations depends upon the temporary nature of these breeding pools (Woodward, 1983; Brönmark and Edenhamn, 1994). The PRP-EC is home to constructed and accidental wetlands/ponds, as well as retained settling ponds, that differ markedly in characteristics that may affect species diversity (e.g., amount and type of surrounding and emergent vegetation, water depth, and seasonal permanence of wetlands). Therefore, anuran call surveys have been conducted approximately three times per week during the 2002 and 2003 activity seasons for each of fourteen distinct wetlands/ponds (see Table 1). These surveys will continue in the coming years. Parameters collected during each survey include call intensities for each species, observation time, air and water temperature, cloud cover, precipitation, temporal fluctuations in water depth, relative humidity, and wind speed. Although present, correlations among individual species and specific environmental variables will not be discussed here. Data from the call surveys, however, do support trends that are of importance to increasing amphibian diversity on restored mined lands. Importantly, some species do well in relatively deep, permanent ponds (e.g., *Rana catesbeiana*, *R. palustris*), whereas others require relatively shallow, temporary ponds (e.g., *Bufo* spp., *Hyla chrysoscelis*). In addition to the differences in permanence of ponds, the presence of vegetation in and around ponds appears to correlate with anuran diversity. A restoration plan that fails to account for these differences ultimately would support fewer amphibian species than one that does. Interestingly, retained settling ponds on the PRP-EC site

Table 1. Call intensities for seven frog species found at the PRP-EC during the 2002 and 2003 activity seasons. Call intensities were estimated using a metric from 0-3, with 0 representing no frogs calling, 1 representing < five frogs calling, 2 representing > five frogs calling but individual frogs could be differentiated with gaps among calls, and 3 representing a full chorus (i.e., gaps among individual calls were absent and individual frogs could not be differentiated). Numbers represent mean intensity +/- one standard deviation. Wetland #7 was excluded from the anuran survey (but used in other projects at the PRP-EC).

Pond/Wetland	*Bufo americanus*	*Bufo fowleri*	*Hyla chrysoscelis*	*Pseudacris crucifer*	*Rana catesbeiana*	*Rana clamitans*	*Rana palustris*
1	0	0	0.41 +/- 0.78	2.02 +/- 1.33	0.04 +/- 0.19	0.66 +/- 1.01	0.30 +/- 0.46
2	0	0	0.09 +/- 0.34	1.33 +/- 1.34	0	0.23 +/- 0.54	0.02 +/- 0.13
3	0	0	0	1.28 +/- 1.23	0	0.04 +/- 0.19	0.02 +/- 0.14
4	0.17 +/- 0.38	0	0.31 +/- 0.70	1.69 +/- 1.24	0	0.15 +/- 0.36	0
5	0	0	0.24 +/- 0.61	2.22 +/- 1.22	0	0.43 +/- 0.63	0.07 +/- 0.26
6	0	0	0	0.80 +/- 1.02	0.06 +/- 0.23	0.56 +/- 0.69	0.19 +/- 0.39
8	0.07 +/- 0.26	0	0.05 +/- 0.23	0.77 +/- 1.06	0	0	0
9	0.18 +/- 0.50	0.26 +/- 0.74	0.53 +/- 0.91	1.26 +/- 1.32	0.04 +/- 0.26	0.42 +/- 0.60	0.02 +/- 0.13
10	0	0	0.23 +/- 0.66	0.98 +/- 1.21	0.04 +/- 0.27	0.09 +/- 0.44	0
11	0	0	0.47 +/- 1.00	1.09 +/- 1.25	0	0.13 +/- 0.39	0.02 +/- 0.13
12	0	0	0.14 +/- 0.52	2.09 +/- 1.16	0.41 +/- 0.85	0.66 +/- 0.98	0.57 +/- 1.02
13	0.09 +/- 0.29	0.11 +/- 0.31	0.45 +/- 0.85	0.38 +/- 0.68	0	0.02 +/- 0.13	0
14	0.13 +/- 0.33	0.02 +/- 0.13	0.14 +/- 0.52	1.48 +/- 1.29	0	0.07 +/- 0.32	0.11 +/- 0.37
15	0	0	0.07 +/- 0.26	1.67 +/- 1.29	0.20 +/- 0.40	0.78 +/- 0.99	0.58 +/- 0.83

support good anuran populations. Further studies to ascertain the sustainable nature of these populations are in progress.

Habitat Quality Among Pond Types

Several projects are currently underway to better understand why there are differences in anuran diversity among pond types. These are at varying stages of completion and include the following for each pond:

1. Quantification of surrounding and emergent vegetation,
2. Periodic water chemical analyses, and
3. Surveys of presence/absence and diversity of fish species.

Correlations among these variables and the presence/absence and relative abundances of each anuran species on site will produce a much clearer picture of the potential for restoration in supporting species diversity. Much of this work should be completed in the next 1-2 years.

Stress Levels Within and Among Populations of *Rana clamitans*

Constructed wetlands can provide flood control and water quality enhancements (see Robinson 1995), but the construction of wetland areas within an abandoned mine site for water quality control may not be productive wildlife habitat. Indeed, relatively deep settling ponds designed to improve water quality are quite different than a shallow, emergent-plant-depth, temporary wetland (see discussion above for anuran diversity differences among pond types). To better understand the sustainability of abandoned settling ponds in providing anuran habitat (and because such ponds demonstrated an ability to do so currently), a survey of stress within and among populations of the green frog, *Rana clamitans*, is underway. Blood is drawn immediately from a minimum of five individuals from ten ponds (five on the PRP-EC site and five located away from the influence of mining but within Wise County) for analyses. In collaboration with Dr. Robin L. Woodard at UVa Wise, tests of corticosterone levels and white blood cell differentials are being used to ascertain potential stress level differences among ponds of different histories and current condition. Any pattern in stress among ponds should produce new avenues of research and will allow more detailed tests of how the stress is produced and how to ameliorate it.

Population Genetic Survey of *Pseudacris crucifer*

As demonstrated by the call survey results above, many species are obliged to inhabit particular habitat types (e.g., temporary vs. permanent ponds), while others may require a variety of habitats for different phases of their life cycles or fulfill particular life history requirements. Either scenario requires the movement of individuals within the landscape. To understand the potential for movement of individuals within the landscape (and as described in a 2002 preliminary report), a survey of genetic variation within and among populations of the spring peeper, *Pseudacris crucifer,* is currently underway. Along with representative populations throughout the southern Appalachians and eastern United States, twelve populations (i.e., wetlands/ponds) of this small, semi-aquatic frog at the PRP-EC have been sampled. DNA has been extracted from at least twenty individuals within each population for population genetic analyses of microsatellite variation (DNA sequences variable in the number of tandem repeats; Tautz 1989). Because of difficulties with cross-species amplification of existing microsatellite primers, a microsatellite-enriched genomic DNA library is being constructed (see Carleton et al., 2002). Data from this study should provide dispersal capability estimates and a picture of movement patterns through existing habitat patches, both of which yield information about susceptibility of individual frog populations to isolation and extirpation.

Microbial Diversity Within and Among Pond Types

Collaborative work with other faculty at UVa Wise is attempting to characterize, through direct culturing and molecular methods, the microbial diversity within water and substrates of ponds at the PRP-EC. This diversity includes both bacterial and fungal and such surveys should provide a good database to ask further questions about microbe-plant-anuran interactions, as well as a baseline for future studies wanting to document microbial diversity changes throughout the restoration process.

Conclusions

The PRP-EC demonstrates that anuran populations can inhabit once barren (i.e., surface mined) land, an outcome that should be good news to many communities in southwestern Virginia. However, many of the native species found at the PRP-EC require environmental conditions that are incongruent with urban landscapes being designed and constructed today. The stochastic nature of local environments, which has been a driving force in the evolution of these taxa, seems anathema to many urban dwellers. While people may be willing to set aside a preserve for native species, fewer are willing to accept the cluttered appearance that is inherent to natural habitats within their carefully landscaped communities. The habitats needed by many native species with complex life cycles are precisely what urban residents do not like; they are viewed as chaotic and unaesthetic. Current methods of restoring mined lands and abandoned manufacturing zones often do not design landscapes (e.g., connected wetlands and uplands) to accommodate future populations of the species formerly inhabiting the site. We must continue to investigate the effects of habitat alterations on local species and propose solutions to this problem. Otherwise (and without such ventures as the PRP), much of the restoration that occurs in the next few decades will end with urban monocultures, not the species diversity native to the southern Appalachians.

Acknowledgments

This work is supported by the University of Virginia's College at Wise and the UVa Wise Fellowship in the Natural Sciences (FINS) Program. Jon Rockett and Carl Zipper from the PRP-EC continue to be especially helpful to KPJ; Robin Woodard and Kevin Jones from UVa Wise provided support in many ways; and Matt Pickering has been invaluable in the laboratory. A special thanks to David Smith at UVa Wise for his support of this work.

Literature Cited

Brönmark, C. and P. Edenhamn. 1994. Does the presence of fish affect the distribution of tree frogs (*Hyla arborea*)? Conservation Biology 8:841-845.

Buhlmann, K. A. 1995. Habitat use, terrestrial movements, and conservation of the turtle, *Deirochelys reticularia,* in Virginia. Journal of Herpetology 29:173-181.

Burke, V. J. and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina Bay. Conservation Biology 9:1365-1369.

Carleton, K. L., J. T. Streelman, B. Y. Lee, N. Garnhart, M. Kidd, and T. D. Kocher. 2002. Rapid isolation of CA microsatellites from the tilapia genome. Animal Genetics 33:140-144.

Collinson, N. H., J. Biggs, A. Corfield, M. J. Hodson, D. Walker, M. Whitfield, and P. J. Williams. 1995. Temporary and permanent ponds: and assessment of the effects of drying out on the conservation value of aquatic macroinvertebrate communities. Biological Conservation 74:125-133.

Dodd, C. K., Jr. 1992. Biological diversity of a temporary pond herpetofauna in north Florida sandhills. Biodiversity and Conservation 1:125-142.

Dodd, C. K., Jr. 1996. Use of terrestrial habitats by amphibians in the sandhill uplands of north-central Florida. Alytes 14:42-52.

Dodd, C. K., Jr. and B. S. Cade. 1998. Movement patterns and the conservation of amphibians breeding in small, temporary wetlands. Conservation Biology 12:331-339.

Duellman, W. E. and L. Trueb. 1986. *Biology of Amphibians*. McGraw-Hill, New York.

Gill, F. B. 1990. *Ornithology*. W. H. Freeman and Company, New York.

Kirkman, L. K., M. B. Drew, L. T. West, and E. R. Blood. 1998. Ecotone characterization between upland longleaf pine/wiregrass stands and seasonally-ponded isolated wetlands. Wetlands 18:346-364.

Moll, D. and K. P. Jansen. 1995. Evidence for a role in seed dispersal by two tropical herbivorous turtles. Biotropica 27:121-127.

Pennak, R. W. 1978. *Freshwater Invertebrates of the United States*, 2nd edition. Wiley & Sons, New York.

Robinson, A. 1995. Small and seasonal does not mean insignificant: why it's worth standing up for tiny and temporary wetlands. Journal of Soil and Water Conservation 1995:586-590.

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12:1113-1119.

Tautz, D. 1989. Hypervariability of simple sequences as a general source for polymorphic DNA markers. Nucleic Acids Research 17:6463-6471.

Wilson, D. S. 1998. Nest-site selection: microhabitat variation and its effects on the survival of turtle embryos. Ecology 79:1884-1892.

Woodward, B. D. 1983. Predator-prey interactions and breeding-pond use of temporary-pond species in a desert anuran community. Ecology 64:1549-1555.