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OBSERVATIONS OF RAPID COLONIZATION OF CONSTRUCTED PONDS BY WESTERN TOADS (*BUFO BOREAS*) IN OREGON, USA

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Key words: *Bufo boreas*, breeding, colonization, habitat, succession, western toad.

Western toad (*Bufo boreas* complex) populations have declined from multiple portions of their historic range (Ross et al. 1995, Livo and Yeakley 1997, Corn 2003, Davis and Gregory 2003). *Bufo boreas* breeds in a wide variety of aquatic habitats including montane lakes (Nussbaum et al. 1983, Corn et al. 1997, Marnell 1997), ponds created by volcanic eruptions (MacMahon 1982, Karlstrom 1986), beaver impoundments (Corn et al. 1997, Marnell 1997), shifting side channels along lowland rivers (Carpenter 1953, Frissell and Cavallo 1997), and anthropogenic ponds and reservoirs (Nussbaum et al. 1983, Wentz et al. 2005). Despite the diversity of habitats utilized by *B. boreas*, little is known about characteristics that make sites attractive for toad breeding. Improved understanding of breeding site selection and attributes of breeding habitat may be useful for conservation of *B. boreas*.

Other north temperate *Bufo* species such as *B. americanus* and *B. calamita* are reported to colonize new and disturbed ponds (Banks and Beebee 1987, Lehtinen and Galatowitsch 2001, Phillips et al. 2002), but the ability of *B. boreas* to find and breed in early successional sites is less well documented. Here we describe rapid colonization of newly excavated ponds by *B. boreas* in semiarid landscapes of central and eastern Oregon.

We documented breeding use by *B. boreas* in 6 newly constructed ponds (hereafter colonization) as part of ongoing amphibian monitoring in Deschutes and Baker Counties, Oregon (Table 1, Fig. 1). The ponds were between 1265 m and 1348 m in elevation and located in the High Lava Plains and Blue Mountain physiographic regions (Franklin and Dyrness 1973). Most (80%–90%) of the annual precipitation

(30–40 cm) falls between October and May (Franklin and Dyrness 1973). All ponds were surrounded by uplands of ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), and sage (*Artemisia* sp.) or bitterbrush (*Purshia* spp.). Two ponds (Dilman A and Sunriver Golf Hazard) were bordered by a wet meadow and an irrigated golf course, respectively, before grading into ponderosa–lodgepole forest at distances >50 m. Two ponds (Pine A and B) were in a dry gulch in moderately sloping foothill topography (slope along temporary stream ~7%; slope of bordering hillsides 9%–22%). Terrain surrounding the remaining 4 ponds was flat or gently sloping (<3%). All ponds were in forest openings that allowed high insolation and held water throughout the summer in each year of observation.

We confirmed breeding of *B. boreas* by directly observing eggs, larvae, or metamorphic individuals (Table 1). We determined month of breeding either through direct observation of eggs or hatchlings or by comparison of developmental stages with other sites in the region. Pond dimensions were estimated visually or by pacing. We estimated straight-line distance from each new pond to the nearest known *B. boreas* breeding site from USGS topographic quadrangle maps. We have surveyed all known ponds and lakes within 10 km of the colonized ponds, so it is unlikely that *B. boreas* breeding regularly occurred closer than our estimates.

Bufo boreas bred in all 6 ponds in the 1st spring following construction (range 2–9 months after construction; Table 1). Five of 6 colonized ponds were small (≤ 500 m² of surface area), and all ponds had little or no aquatic macrophytic vegetation. Based on numbers of egg

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TABLE 1. Western toad (*Bufo boreas*) breeding in 6 new ponds in central and eastern Oregon.

Variable	Pine A	Pine B	Dilman Meadow	Catholic Pond	Lake Penhollow	Sunriver Golf Hazard
Months between pond construction and <i>B. boreas</i> breeding ^a	9 (Sep 2000–Jun 2001)	2 (Apr 2002–Jun 2002)	6 (Nov 2000–May 2001)	5 (Nov 2001–Apr 2002)	5 (Dec 1997–May 1998)	9 (Sep 2000–Jun 2001)
Earliest life stage detected	<100 late larvae	1 egg string	2 egg strings	1000s of larvae and metamorphs	1000s of larvae and metamorphs	Larvae and metamorphs
Estimated recruitment	<200	None	None ^b	1000s–10,000s	1000s–10,000s	<200
Breeding in years after colonization	No	No	No	2003, 2004	2000–2004	2002
Pond dimensions (length × width × max depth) (m)	20 × 25 × 4	5 × 10 × 1.5	15 × 30 × 3	15 × 10 × 2	150 × 200 × 6	5 × 10 × 1.5
Nearest <i>B. boreas</i> breeding site (km) ^c	0.4	0.4	4.8	2.0	3.0	0.1
Pond habitat	Bare mineral soil substrate, lacking vegetation	Bare mineral soil substrate, lacking vegetation	Bog organic substrate, little macrophytic vegetation	Bare mineral soil substrate, lacking vegetation	Cobble substrate with periphyton but lacking macrophytic vegetation	Bare pumice substrate, limited <i>Typha</i> plantings

^aFirst date is pond construction; 2nd date is observed or estimated month of *B. boreas* breeding.

^bEggs died.

^cStraight-line distance on USGS 1:24,000 topographic maps

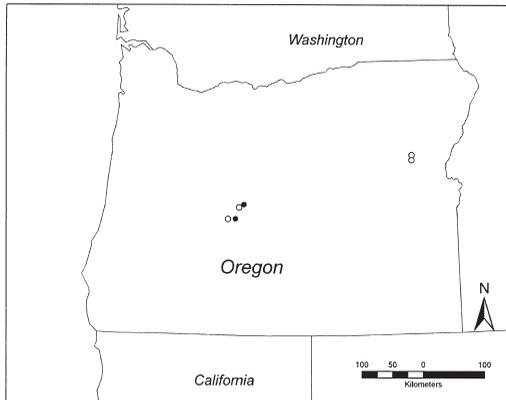


Fig. 1. Locations of *Bufo boreas* colonization sites in Oregon. Filled circles are sites with moderate to high breeding and recruitment (Catholic Pond, Lake Penhollow); open circles are sites with limited breeding.

strings, larvae, and juveniles, we estimated that breeding effort was small (≤ 3 clutches) in 4 of 6 ponds. We observed little or no recruitment of juveniles (< 100 observed) at these 4 sites. Large numbers of juvenile *B. boreas* were recruited at the other 2 sites: 10,000s at Lake Penhollow and 1000s–10,000s at Catholic Pond. Juvenile recruitment at Lake Penhollow was similar in the 1st and 2nd years after colonization, and we observed ≥ 20 pairs of *B. boreas* breeding at that site in the 2nd year. *Bufo boreas* continues to breed in both sites that supported substantial juvenile recruitment in their 1st year (Catholic Pond, Lake Penhollow). Both sites are lined with impermeable substrate and lack macrophytic vegetation. With the exception of 2nd-year breeding at Sunriver Golf Hazard, we have not observed subsequent *B. boreas* breeding in any of the 4 sites that had limited or no recruitment in the 1st year.

In the Pine Creek drainage, *B. boreas* bred in each of 2 new ponds in their respective 1st year after excavation (2001, 2002). The local historic breeding pond, which supported breeding from 1997 to 2000, was unused in 2001 and 2002. Breeding resumed at the historic site in 2003 and 2004.

Our observations indicate that *B. boreas* can rapidly locate new breeding sites in semiarid landscapes where no surface water existed prior to pond excavation. Data from Washington and Montana also suggest *B. boreas* can colonize new and recently disturbed aquatic sites (Karl-

strom 1986, B. Hossack personal communication). For example, within 1 year after the May 1980 eruption of Mount St. Helens buried the valley containing the North Fork of the Toutle River in avalanche debris > 75 m deep, *B. boreas* bred in at least 1 valley site (Jackson Lake; Karlstrom 1986). By 1985 *B. boreas* was the most common anuran breeding in 22 newly created ponds along the North Fork of the Toutle River (Karlstrom 1986). In the year immediately following 3 wildfires in Glacier National Park, Montana, *B. boreas* bred in 30 wetlands where the species had not been detected previously (Hossack personal communication). The nearest known breeding of *B. boreas* to many of the newly colonized sites was ≥ 1 km (Hossack personal communication). In both cases, terrestrial habitat around breeding ponds was predominately dry substrate with sparse or no vegetative cover (Karlstrom 1986, Hossack personal communication).

In our observations *B. boreas* bred in new sites located 0.1–4.8 km from the nearest potential source breeding sites. These distances are similar to those traveled by translocated *B. boreas* in the northern Rocky Mountains. Adult *B. boreas* in Idaho (Bartelt et al. 2004) and Colorado (Muths 2003) use extensive home ranges (5.8–24.6 ha) and can travel 1–4 km to and from breeding sites within a year. Our observations and the interpond movements of 0.9–5.0 km reported by Thompson (2004) both indicate that movements to new breeding sites can be similar in magnitude to seasonal ranges. A link between capacity for long distance movements and ability to colonize new ponds has been hypothesized for both the American toad (*B. americanus*) in Minnesota (Lehtinen and Galatowitsch 2001) and the common toad (*B. bufo*) in Britain (Baker and Halliday 1999); the link may also apply to *B. boreas* in Oregon. Further work is needed to understand how factors such as topography, vegetation, surface moisture, and availability of existing ponds influence detection and use of new ponds.

We estimate that colonization events ranged from < 3 pairs (2 sites) to > 20 pairs of *B. boreas* (1 site; Table 1). Our small number of observations, combined with uncertainty about the locations of colonists' natal ponds, limit conclusions about factors affecting numbers of colonists. That the site with the largest numbers of colonists (Lake Penhollow) was among

the farthest from potential historic breeding habitat suggests that factors other than distance can affect colonization intensity.

The Lake Penhollow case is of particular interest because it is >3 km uphill and downwind from the nearest historic or potential breeding habitat; railroad tracks traverse direct routes between the two. More *B. boreas* bred in Lake Penhollow in the 1st and 2nd years after construction than in any nearby ponds during the same period or the previous 5 years (J. Bowerman unpublished data). The large cohort of *B. boreas* that colonized Lake Penhollow could reflect (1) the use of cues to detect this isolated site, (2) a reservoir of adult *B. boreas* residing in the surrounding forest, or (3) both. Breeding site selection by *B. calamita* in Britain is thought to be influenced by biotic (e.g., presence of competitors) and abiotic (e.g., warm shallows) attributes (Banks and Beebee 1987), but the cues used by *B. boreas* to assess these conditions are poorly known. Location of breeding sites by displaced *B. calamita* in Germany varied with sex: males used visual, olfactory, and magnetic cues to home toward breeding ponds, whereas females moved toward the nearest pond with a male chorus (Sinsch 1992). Many Pacific treefrogs (*Pseudacris regilla*) call in Lake Penhollow, although we do not know if treefrog presence preceded *B. boreas* colonization. Whether adult *B. boreas* can use the calls of other anurans to locate new ponds deserves investigation.

Ecological incentives may exist for *B. boreas* to colonize new ponds that differ from older or undisturbed ponds in attributes such as within-pond vegetation density, canopy shading, food quality, and predator and competitor communities (Baker and Halliday 1999, Lehtinen and Galatowitsch 2001). Vegetation succession in and around wetlands is an important factor in breeding site suitability for a variety of north temperate anurans, including *B. americanus* and *B. calamita* (Banks and Beebee 1987, Skelly et al. 1999, Werner and Glennemeier 1999, Phillips et al. 2002). Both of these congeners are reduced in older or undisturbed ponds (Banks and Beebee 1987, Petranka et al. 1994, Bardsley and Beebee 1998, Werner and Glennemeier 1999). Two of our colonized ponds (Catholic Pond, Lake Penhollow) have supported *B. boreas* breeding and juvenile recruitment every year since construction. Both ponds

were constructed with an impermeable liner and, to date, have little or no macrophytic vegetation.

Our observations suggest that constructed ponds can be attractive to *B. boreas* in central and eastern Oregon, but that productivity and duration of breeding use can vary markedly between sites. Further research on the relationships between in-pond vegetation and breeding site suitability may clarify factors influencing colonization and juvenile recruitment. Whether colonization of new ponds benefits local and regional *B. boreas* populations also merits investigation.

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