SALAMANDER COLONIZATION OF CHASE LAKE, STUTSMAN COUNTY, NORTH DAKOTA—Salt concentrations in lakes are dynamic. In the western United States, water diversions have caused significant declines in lake levels resulting in increased salinity, placing many aquatic species at risk (Galat and Robinson 1983, Beutel et al. 2001). Severe droughts can have similar effects on salt concentrations and aquatic communities (Swanson et al. 2003). Conversely, large inputs of water can dilute salt concentrations and contribute to community shifts (Euliss et al. 2004).

Chase Lake is a large, shallow, alkaline lake in east-central North Dakota most famously known for supporting one of the largest breeding colonies of the American white pelican (*Pelecanus erythrorhynchos*) in North America (Sovada et al. 2005). Chase Lake was designated as a National Wildlife Refuge in 1908 to protect the American white pelican breeding colony, and in 2003 it was identified as a Globally Important Bird Area by the American Bird Conservancy. The physiographic region around Chase Lake has experienced a prolonged period of above normal precipitation that began in 1993 (Winter and Rosenberry 1998). The resulting increase in water levels and associated dilution of salt concentrations in the closed basin of Chase Lake has led to a reshaping of the lake's aquatic community.

While the Chase Lake pelican colony has been the focus of numerous scientific investigations (e.g., Bennett 1926, Johnson and Sloan 1978, Lingle and Sloan 1980, Sidle and Ferguson 1982, Sovada et al. 2008), studies of other biotic components of the lake's ecosystem are lacking. However, studies of the Chase Lake pelican colony typically note the lack of an aquatic vertebrate (e.g., fish, amphibian) community as a result of the lake's high alkalinity. In an early description of Chase Lake, Bennett (1926) described the lake as being "so strongly alkaline that white salts were piled up six inches deep in some places along its shores." Salt levels in the lake historically have exceeded tolerance limits of aquatic vertebrates endemic to the region. Moreover, salt concentra-

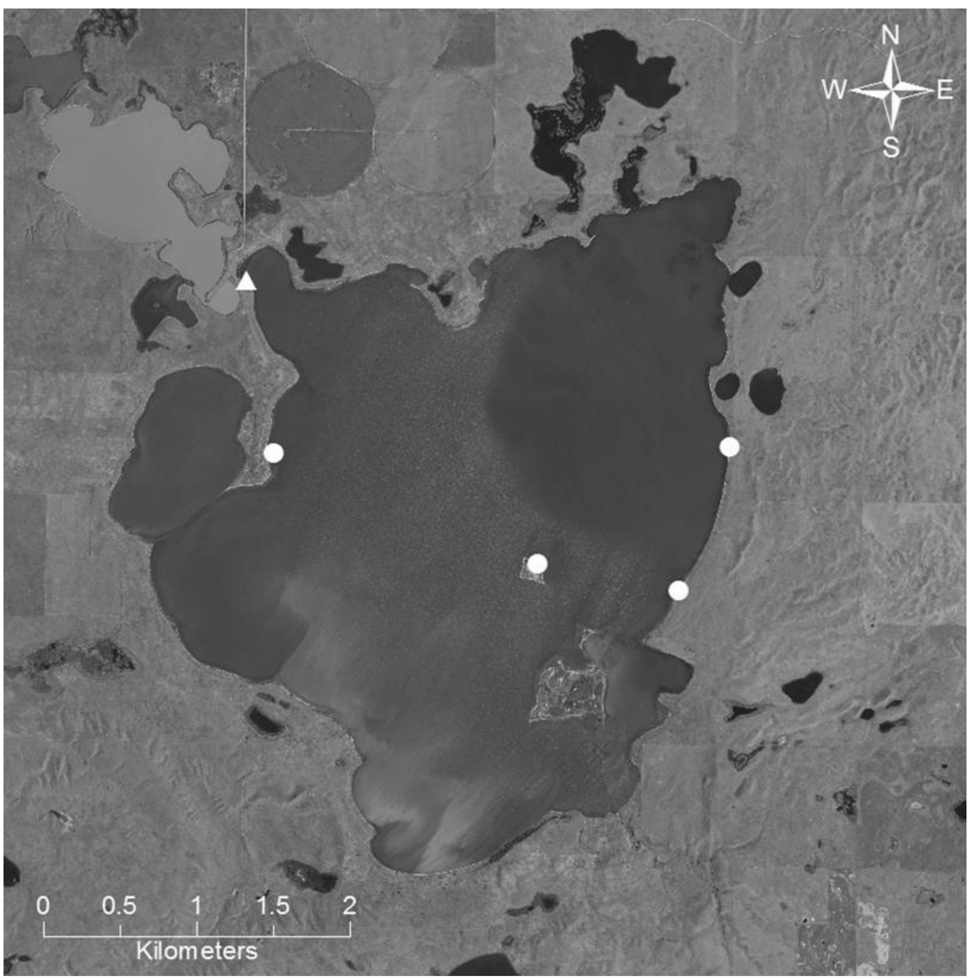

Figure 1. Sites where aquatic vertebrates were sampled in Chase Lake, Stutsman County, North Dakota, USA. The triangle indicates where sampling was conducted 22–23 June 2012. This and four additional locations (solid circles) were again sampled 20–21 August 2012 (base photo from 2010 National Agriculture Imagery Program, U.S. Department of Agriculture).

tions have exceeded the limits of all but three invertebrate taxa: brine shrimp (*Artemia salina*), brine flies (*Ephydra* spp.), and water boatmen (Corixidae; Swanson et al. 1988). Chase Lake is a closed basin, which can facilitate evaporative processes leading to the high salt levels.

On 22 June 2012, we sampled a location on the northwestern edge of Chase Lake (Fig. 1) with seven funnel-type salamander traps (Mushet et al. 1997) deployed at 30-m intervals and at a water depth of approximately 1 m. Each trap was placed so that the 2-m drift net extending from the trap opening ran parallel to the shoreline. We checked each trap for captures after approximately 24 hrs. Surprisingly, we captured 10 tiger salamander (*Ambystoma mavortium*) larvae. Snout to vent length (SVL) of the larvae ranged from 5.7–15.4 cm ($\bar{x}$ = 12.1, SD = 3.42). Two of the larvae were relatively small (SVL = 5.7 cm and 6.2 cm) and likely came from a 2012 cohort. However the other eight were large (SVL range = 11.9–15.4 cm) and were likely products of previous seasons. In addition to the salamander larvae, we also captured 15 fathead minnows (*Pimephales promelas*) that averaged 6.5 cm in length (SD = 0.75; range = 5.2–7.3 cm).

Scientists conducting pelican research at Chase Lake had recently noted the presence of fathead minnows in the lake (M. Sovada, U.S. Geological Survey, Northern Prairie Wildlife Research Center, personal communication). However, the barred tiger salamanders captured on 22 June 2012 were the first amphibian larvae known to occur in Chase Lake. The salamander larvae were captured near a fresh water spring seep (Swanson et al. 1988). If the spring was diluting salt concentrations, the area around the seep potentially could harbor vertebrates that would not survive in other areas of the lake not influenced by a freshwater inflow. Therefore we conducted a second trapping effort expanding our sampling to include other areas in the lake.

On 20 August 2012, we set four amphibian traps at each of five sites. In addition to the original site, locations sampled in August 2012 included a site south of the original site near the end of a peninsula, a site along the shore of an island, and two sites along the eastern shore of the lake (Fig. 1). Similar to our June sampling, traps were placed at 30-m intervals parallel to shoreline at a water depth of approximately 1 m and pulled after 24 hrs. This second trapping session revealed that salamander populations have become established throughout much of Chase Lake. We captured 39 salamander larvae at four trapping locations; we did not capture salamander larvae at the island site in the lake's interior. Snout to vent lengths (SVL) of the larvae ranged from 7.0–15.9 cm ($\bar{x}$ = 10.8, SD = 1.87). As with our June sampling, larvae could be divided into two size classes. Thirty-four were in the 7–12 cm SVL size range and were likely from 2012 cohorts. The remaining five larvae were much larger (≥13.5 cm SVL) and likely products of previous seasons. We only captured a single fathead minnow (length = 7.1 cm) in this second trapping event. This individual was captured at the same location as our original sampling.

During our second trapping period, we recorded electrical conductivity (EC) of the water at each of these five sampling locations. Electrical conductivity is an expression of dissolved ions in solution and is commonly used in limnology as a measure of salinity since dissolved ionic concentration and salinity vary directly. Sidle and Ferguson (1982) state that the water of Chase Lake can have EC values approaching 50 mS cm^{-1}. Swanson et al. (1988) reported an EC value for Chase Lake of 38 mS cm^{-1} from a May 1973 sample. By contrast, the maximum EC value we recorded in 2012 was 12.94 mS cm^{-1} (range = 12.86–12.94 mS cm^{-1}). In their sampling of south-central North Dakota lakes, Swanson et al. (1988) found salamanders only in lakes with EC values less than 12.5 mS cm^{-1}. Although slightly higher, our August EC measurements are near the value at which salamanders could be expected to colonize Chase Lake. The small range of EC values at our five sample locations suggests that presence of a freshwater seep in one part of the lake was not influencing salt concentrations to a level that would alter aquatic communities.

Our finding that barred tiger salamanders have become established in Chase Lake may be especially important due to the role that salamanders play as both predator and prey in aquatic ecosystems. There may be cascading effects resulting from the addition of salamanders to the aquatic community of Chase Lake. Additionally, if salt concentrations continue to decline, it is possible that fathead minnows and other species will flourish in the changing conditions of Chase Lake. Further study of the newly colonized salamander population of Chase Lake may provide insights on the role of salinity mediated community structure.

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