Chapter 1

My thesis project was designed to inform habitat restoration for Species in Greatest Conservation Need within the Anoka Sand Plan Subsection of Minnesota. The Anoka Sand Plain has been under increased conservation focus since the publication of the Minnesota Department of Natural Resources (hereafter, MN NDR) Minnesota State Wildlife Action Plan and Anoka Sand Plain subsection profile, where the Anoka Sand Plain was identified as containing some of the last remnants of high quality dry oak savanna, dune, and prairie habitats in the state (MN DNR 2006). The plan described 97 Species in Greatest Conservation Need that have been documented or are predicted to occur within the subsection; 39 of these species are federal or state endangered, threatened, or of special concern. Habitat loss, fragmentation, and degradation were identified as the key challenges facing Species in Greatest Conservation Need within the Anoka Sand Plain, and the plan highlighted the apparent relationship between documented rare species occurrence and conservation management lands.

Sand Dunes State Forest (hereafter, Sand Dunes) (4,486 ha) is located in central Sherburne county within the Anoka Sand Plain. It has been managed primarily for timber production and recreation since the 1930s, and much of the area has been planted with pines (primarily *Pinus strobus* and *Pinus resinosa*) with the original intent of stabilizing the soil during periods of drought, although timber profitability has also emerged as a management goal. Although native habitat has not been a primary management focus within Sand Dunes, natural features, communities, and native species still remain. Surveys by the MN DNR have documented four globally-ranked native plant communities, five sites ranked by the Minnesota Biological Survey as sites of outstanding biodiversity significance, six sites ranked as high biodiversity significance, five state-listed species of plants, and nine state-listed species of animals within Sand Dunes (MN DNR 2009).

In 2013, the MN DNR divisions of Forestry, Ecological and Water Resources, and Fish and Wildlife approved an operational plan for Sand Dunes with a new focus on restoration, preservation, and management of rare native habitats. Portions of Sand Dunes were designated to be restored to an approximation of vegetation that was present before Euro-American settlement and permanently managed for native plant communities including oak savanna, prairie, and oak woodland. The desired outcome was a balance between recreation, economic investment, water quality, biodiversity, and wildlife habitat. The management plan included immediate and eventual conversion areas; immediate conversion areas (208 hectares) were slated for restoration by appropriate means (prescribed burning, invasive species control, and forest management) beginning in 2014. Eventual conversion areas (537 hectares) were primarily areas that contained dunes or other rare features that made them appropriate for restoration, but had been planted to pines which would be allowed to mature to rotation age and harvested, after which restoration would occur (MN DNR 2013).

When the operational plan was written, very little was known about the specific requirements of habitat specialist fauna within Sand Dunes. My project was designed to function in conjunction with the operational plan and to provide baseline information about species’ habitat requirements and responses to management activities that would contribute to ongoing management. Of our 40 original survey plots within Sand Dunes, nine were intentionally placed within immediate conversion areas with the intention of documenting species’ responses to management and subsequent refinement of management techniques in an iterative and scientifically informed process. Unfortunately, very little of the scheduled management took place. Further, harvest that was not part of the 2013 plan occurred in several areas of Sand Dunes during the course of the study, and this harvest did not necessarily fulfill the desired outcomes of the plan. For example, one of the main proposed management strategies was to thin mixed forest stands to remove undesirable woody species and reduce canopy cover to desired levels. However, on several occasions I encountered stands that had been completely cleared or stands where desirable species hardwood species such as oaks had been removed. Additionally, the 2013 operation plan was revised in 2016 and a moratorium was placed on all restoration activities within Sand Dunes. These complications significantly compromised the original scope of my study to directly evaluate and inform management for rare species. As such, I subsequently modified my research goals to identifying relationships between individual habitat covariates and species’ occupancy and/or abundance.

Chapter 2 of my thesis was written to conform to the submission requirements of the *Journal of Ecological Restoration*, where I intend to submit my thesis. I wrote Chapter 2 in collaboration with my academic advisor Dr. Todd Arnold and Dr. Althea ArchMiller, both of whom will be co-authors on any resulting publication. My use of plural pronouns throughout Chapter 2 is reflective of this collaboration, but I take individual responsibility for the full content of my thesis.