*Incorporating migratory data into species distribution models improves conservation of American Woodcock habitat*

Target: Journal of Applied Ecology

*Introduction*

Animals frequently use different habitats in certain stages of their life or annual cycle. This principle has been a component of wildlife management since Leopold (1933), and multi-stage habitat use has been incorporated into the management of animals ranging from white-tailed deer (Voigt et al. 1997) to greater sage-grouse (Fedy et al. 2012). These insights have been a popular focus of studies on migratory birds (Norris 2005, Marra et al. 2015), which postulate that conserving migratory birds throughout their full annual cycle is necessary to slow population declines. These concerns are reflected in recent migratory bird management plans which advocate for international conservation of breeding, stopover, and wintering habitat (Rosenberg et al. 2016). This range wide approach to management is an important step forward in migratory bird conservation, but conserving habitat during the full annual cycle is a local issue as much as it is an international one. Much of a species’ migratory range, for example, can overlap with its breeding and wintering ranges, especially for short distance migrants or species with widespread breeding or non-breeding distributions. Most regions that are typically considered to be part of a bird’s breeding range, for example, might be more accurately considered to be in the joint breeding and migratory range, and full annual cycle conservation in these areas would require consideration of both the breeding and migratory habitat requirements of that species.

During the migratory season, bird habitat use occurs at migratory stopover sites, which Mehlman (2005) defines as any place where a bird can land and survive until the next migratory flight. However, those sites which have more resources can either improve or be less detrimental to a migratory bird’s condition and can increase the bird’s probability of successfully completing migration. As migratory survival is believed to be a limiting factor for many species of birds (Sillett and Holmes 2002, Rockwell et al. 2017, Robinson et al. 2020), conserving migratory stopover sites is assumed to be an important step in slowing bird declines (Faaborg et al. 2010). Habitat selection for stopover sites is frequently different from habitat selection during the breeding and wintering seasons (Allen et al. 2020, Stanley et al. 2021), which can result in birds using areas during migratory stopovers that they normally would not reside in during other portions of the year. These differences in seasonal space use can now be tracked with some ease due to recent technological advances in radar (Larkin and Diehl 2012), animal tracking (Bridge et al. 2011), and eBird data (Lin et al. 2020). These technologies can allow for the creation of migratory stopover habitat distribution models, which can be compared and used in conjunction with breeding and wintering habitat distribution models in much the same way that multi-season habitat use is examined for other wildlife species. Here we show an example of how this migratory stopover data can be used in combination with breeding season data to enable multi-seasonal management for a common migratory bird species in its breeding range.

Our case study focuses on American Woodcock (*Scolopax minor*) in the state of Pennsylvania. American Woodcock are a short distance migrant, most of whose migratory stopover habitat overlaps with their breeding and wintering range (eBird range figure tk). Pennsylvania provides both breeding habitat and stopover habitat for birds migrating to and from the northern extent of their range. However, Allen et al. (2020) suggests that woodcock stopover habitat often differs from habitat used during other seasons. Therefore, management for breeding season habitat alone may not be enough to protect woodcock stopover habitat. To determine whether additional management for stopover habitat is necessary, we first model migratory and breeding season woodcock habitat in Pennsylvania and examine the overlap between the two. If there is significant overlap between migratory and breeding season habitat, then existing management strategies for woodcock in Pennsylvania (which have been based on breeding season data) may be adequate to protect migratory stopover habitat. If not, then additional management may need to take place to additionally protect stopover habitat. We then demonstrate one possible method for incorporating stopover habitat into a habitat management framework by combining migratory and breeding season habitat suitability models into a single habitat prioritization tool. This tool allows users to manually decide their priorities for migratory and breeding season management and identify areas that provide woodcock habitat during both seasons, allowing users to incorporate full annual cycle conservation into a straightforward conservation prioritization framework.

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