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PREFACE

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Each year billions of landbirds migrate between the northern and southern hemispheres of both the New and Old World. In eastern North America alone, over two thirds of all the breeding bird species migrate from temperate breeding grounds to more tropical wintering areas in the Caribbean, Mexico, and Central and South America. The benefits of intercontinental migration, regardless of whether they accrue through increased survivorship by overwintering in the tropics, increased productivity by breeding in seasonally rich temperate areas, or both, must be balanced against costs of migration. Traveling long distances between temperate and tropical areas comes with considerable risks, and the mortality associated with intercontinental migration, though difficult to estimate, may be substantial. Consider some of the problems a migrant faces during passage, not the least of which is the energetic cost of transport. Migrants must also adjust to unfamiliar habitats, conflicting demands between predator avoidance and food acquisition, competition with other migrants and residents for limited resources, unfavorable weather, and orientation errors. To the extent migrants solve those problems they experience a successful migration, one measured ultimately in terms of survival and reproductive success.

The long-distance movements and biology of migratory birds during stopover has generated considerable interest in recent years, in no small part because of threats to their populations. Although reports of drastic declines for the group as a whole are exaggerated, some migrant landbirds are showing long-term population declines. Decline in populations has been attributed to events on the wintering grounds, fragmentation of breeding habitat, and to changes in the suitability of *en route* (stopover) habitat. For a Red-eyed Vireo or a Yellow-billed Cuckoo, the choice of habitat must be made in tropical wintering quarters, temperate breeding areas, and repeatedly during migration. Consequently, factors associated with the stopover ecology of migrants must figure in any analysis of population change and in the development of a comprehensive conservation "strategy" for landbird migrants. Protect all the breeding woodland in North America and all of the appropriate habitat on the wintering grounds and populations of intercontinental migrants will still decline unless habitat requirements during migration are factored into the conservation equation.

The contributions to this issue of *Studies in Avian Biology* focus on migrant-habitat relations during passage and on the conservation implications of that relationship. Few migratory birds engage in nonstop flights between points of origin and destination; rather they stopover periodically—they land for a few hours or a few days before resuming migratory flight. A stopover site is any place where a migratory bird pauses for some length of time between migratory flights. What is the value of a stopover site for a migrating bird? What factors determine the quality of a particular stopover site? The answer to those non-trivial questions depends on understanding the migrant's relationship to habitat.

When contemplating the stopover ecology of migratory birds, it is essential to recognize that migration occurs over a broad geographic scale, but over a relatively short temporal scale, and that a migrating bird's relationship to habitat is scale-dependent (i.e., different factors, some extrinsic to habitat *per se,* operate at these different scales). Intrinsic constraints on habitat use are those factors thought to determine habitat quality and upon which migrants made decisions about habitat use (e.g., food, presence of predators). As the spatial scale broadens, factors intrinsic to habitat give way to factors largely unrelated to habitat (extrinsic constraints), such as synoptic weather patterns during passage. The study of the landbirds during migration should reflect the hierarchical nature of the migrant's relationship to habitat. In the first contribution to this issue, Ted Simons and his colleagues ask us to step back and view this relationship at the landscape scale. The movement of birds across the Gulf of Mexico each spring and fall provides the geographical context for application of spatially explicit models to the stopover of landbird migrants.

Daniel Petit asks what types of habitat are important to migrating songbirds when they pause during passage. Over the course of a season's migration, a migratory bird encounters a variety of habitats, most of them new habitats with associated new food, new competitors, and new predators. After a night's passage it finds itself in a habitat that may be very different from the one occupied the previous day, let alone the previous year. Moreover, favorable *en route* habitat, where migrants can rapidly accumulate energy

stores, is probably limited in an absolute sense, or effectively so because migrants have limited time to search for the "best" stopover site. Nevertheless, evidence indicates that migrants prefer certain habitats and select among alternatives during stopover, presumably in response to differential suitability. Suitability of *en route* habitat depends largely on three factors: (1) foraging opportunities, (2) competition with other migrants and with residents, and (3) shelter against predators and adverse weather. Beyond those generalities, our understanding of the determinants of habitat suitability is not very refined and open to speculation.

Whereas evidence reveals that habitat selection occurs during migration, little is known about how migrants made decisions about habitat use during stopover. David Aborn and I ask about the mechanisms of habitat selection: How do migrants distinguish one habitat from another? How is habitat quality assessed? What cues do migrants use when deciding to settle in a particular habitat? We are only beginning to understand migrant-habitat relations during migration, much less appreciate the mechanisms migrants use to identify habitat attributes on which habitat choices are made during passage.

Mark Woodrey calls attention to age-dependent aspects of stopover biology. If the high cost of migration (i.e., reduced fitness; increased mortality) is absorbed largely by inexperienced, hatching-year birds, differential costs should be reflected in age-dependent differences in stopover biology. Presumably yearling migrants experience more trouble solving *en route* problems than older, more experienced migrants. What is the empirical basis for this supposition? Exactly which problems are most likely to create an age-dependent consequence? Moreover, individuals with different levels of migratory experience can be expected to respond differently to the exigencies of migration.

Migration is an energetically demanding task, and fat is the essential source of energy to fuel migratory flights. In anticipation of the energetic demands of migration, birds become hyperphagic and deposit as much as 50% of the normal body mass in fat stores. For intercontinental migrants the energy requirements necessary to reach their destination exceed even this amount several times over, so migrant landbirds stop periodically to rest and refuel. Although it seems obvious that the single most important constraint during migration is to acquire enough food to meet energetic requirements, satisfying energy demand is not simply a matter of hyperphagia. The availability of nutrients specific to a particular need, such as calcium in relation to egg formation for females during spring migration or certain fruits that facilitate fat deposition, must be taken into account when considering food availability. Such constraints could affect not only the rate at which migrants replenish energy stores, but also the migrant's susceptibility to predator attack. Jeffrey Parrish examines the dietary flexibility of migratory birds during passage and the conservation implications of food choice.

The coastal woodlands and narrow barrier islands that lie scattered along the northern coast of the Gulf of Mexico provide important stopover habitat for landbird migrants. They represent the last possible stopover before fall migrants make an 18–24 hr, nonstop flight of greater than 1,000 km, and the first possible landfall for birds returning north in spring. Yet, the northern coast of the Gulf of Mexico is experiencing significant human population increases and concomitant development. The southward migration of industry coupled with changing demographics will increase pressure on stopover habitats in the decades ahead. As stopover habitat is transformed or degraded and the cost of migration increases, there is a commensurate increase in the value of unaltered habitat to migratory birds, which makes the creation of new habitats to replace those lost to coastal development a major conservation challenge in the next century. Wylie Barrow and his colleagues address restoration of stopover habitat in relation to the chenier plain of southwestern Louisiana.

Information on the spatial and temporal pattern of migration, not to mention migration volume ("traffic rate"), is not readily available for the southwestern United States or the West in general. Yet, it is clear that riparian or riverine habitats in the southwestern United States are vital to landbird migrants, notably woodland species. Deborah Finch and Wang Yong examine the vegetational and human history of the middle Rio Grande River in relation to its importance to landbird migrants during passage. Their contribution prompts us to recognize that corridors of riparian habitat may represent critical stopover areas regardless of geographical region.

The spatial scale over which migration occurs coupled with the variety of habitats migrants encounter during passage made the challenge of conserving stopover habitat for landbird migrants uniquely different from that of protecting breeding or wintering habitats. Sarah Mabey and Brian Watts correctly point out that most conservation strategies focus on large tracts of public and private lands. What of threats on the aggregate of relatively small, private land parcels? The authors describe the use of policy and management tools that take us beyond the bound-

aries of public land and illustrate their application on the lower Delmarva Peninsula, Northhampton County, Virginia.

In the closing contribution, Richard Hutto calls attention to several issues, some peculiar to the migratory period, that are important to the conservation of landbird migrants: (a) patterns of geographic distribution during passage, (b) patterns of habitat use during passage, (c) stopover events in relation to population regulation, and (d) the story-telling power of migration. He reminds us that the success of our conservation efforts is tied to our attitudes about conservation. Our fascination with the sheer drama and beauty of the migratory journey contributes tangibly to the development of a conservation ethic.

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