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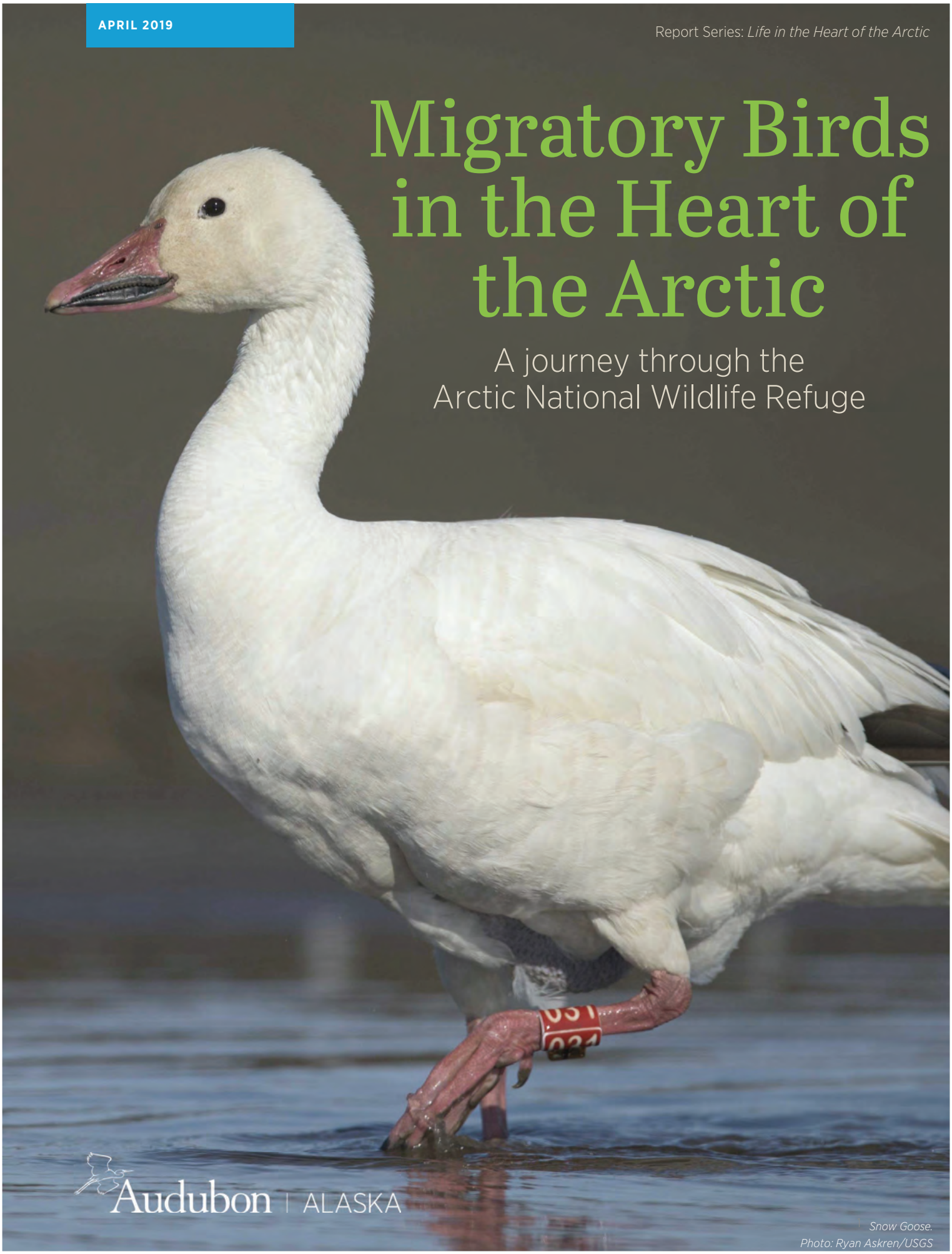
Report Series: *Life in the Heart of the Arctic*

Migratory Birds in the Heart of the Arctic

A journey through the Arctic National Wildlife Refuge



Audubon | ALASKA

Snow Goose.
Photo: Ryan Askren/USGS

Contents

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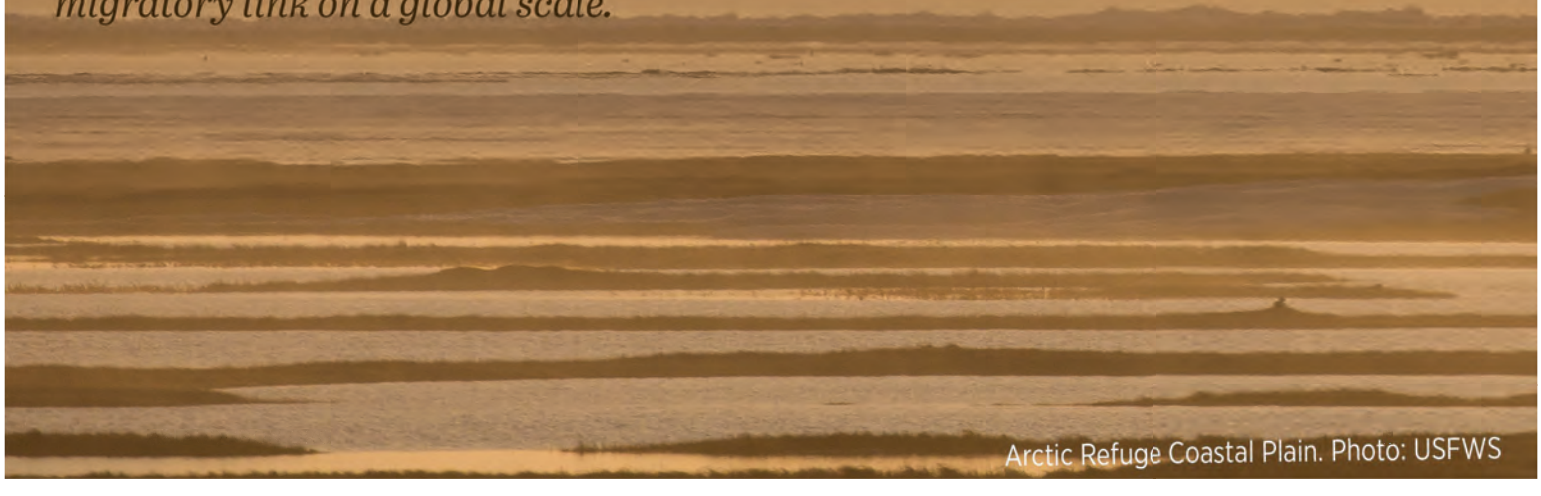
Dunlin.
Photo: Kyle Dudgeon/ APA 2017

OVERVIEW

For Arctic migratory birds, the world is their home, and the Arctic is both their nursery and rest stop. Through long-distance movements, birds follow seasonally abundant resources from place to place. The Arctic National Wildlife Refuge provides critical resources that fuel these birds as they embark on long journeys across states, countries, and even continents. Birds spend time in the Refuge before continuing on to Africa, Antarctica, Asia, Australia, South America, and North America. These international journeys can be loosely grouped into flyways, which are akin to bird migration highways. The Arctic Coastal Plain is the hub of six of the world's flyways.

Within a general flyway, birds approach migration in different ways. Species like Greater White-fronted Geese use many brief stops and short hops between breeding, non-breeding, and in-between habitats. Other species—such as Semipalmated Sandpipers—regularly travel thousands of miles between stops. Birds within the same species and same flyway may use distinct routes and destinations based on where they breed. Some Arctic-breeding Brant, for example, winter in Baja, whereas others fly only as far south as Washington State. Even an individual bird might use different migration strategies within its lifetime. Juvenile Golden Eagles waiting to compete for prime breeding habitat in Denali National Park, for example, may spend summers hunting and scavenging caribou on the Arctic Coastal Plain before finding a regular nest site further south.

Regardless of specific strategy, the extraordinary phenomenon of bird migration not only links birds to places around the world, it also connects people. People from Arkansas, Florida, China, Venezuela, and Nigeria all share direct connections with the Arctic National Wildlife Refuge when they experience the same birds at home that travel to the Arctic Coastal Plain during the summer months. As illustrated in the following maps and narratives, the Arctic Refuge is a vital migratory link on a global scale.



Arctic Refuge Coastal Plain. Photo: USFWS

The Annual Cycle of Bird Migration

Over the course of a year, close to a million birds representing over 200 species rely on the Arctic National Wildlife Refuge (Brown et al. 2007; Johnson and Herter 1989). Aside from year-round residents such as Snowy Owls (*Bubo scandiacus*), American Dippers (*Cinclus mexicanus*), and ptarmigan (*Lagopus* spp.), the vast majority of these birds are seasonal inhabitants. The immense summer productivity and unparalleled nesting habitat on the Arctic Refuge's Coastal Plain inspires birds to undertake journeys spanning thousands of miles and hundreds of days. Understanding these migratory connections brings the Refuge's ecological importance into a broader spatial context and highlights its close links with places across the world.

Over the course of a year, close to a million birds representing over 200 species rely on the Arctic National Wildlife Refuge.

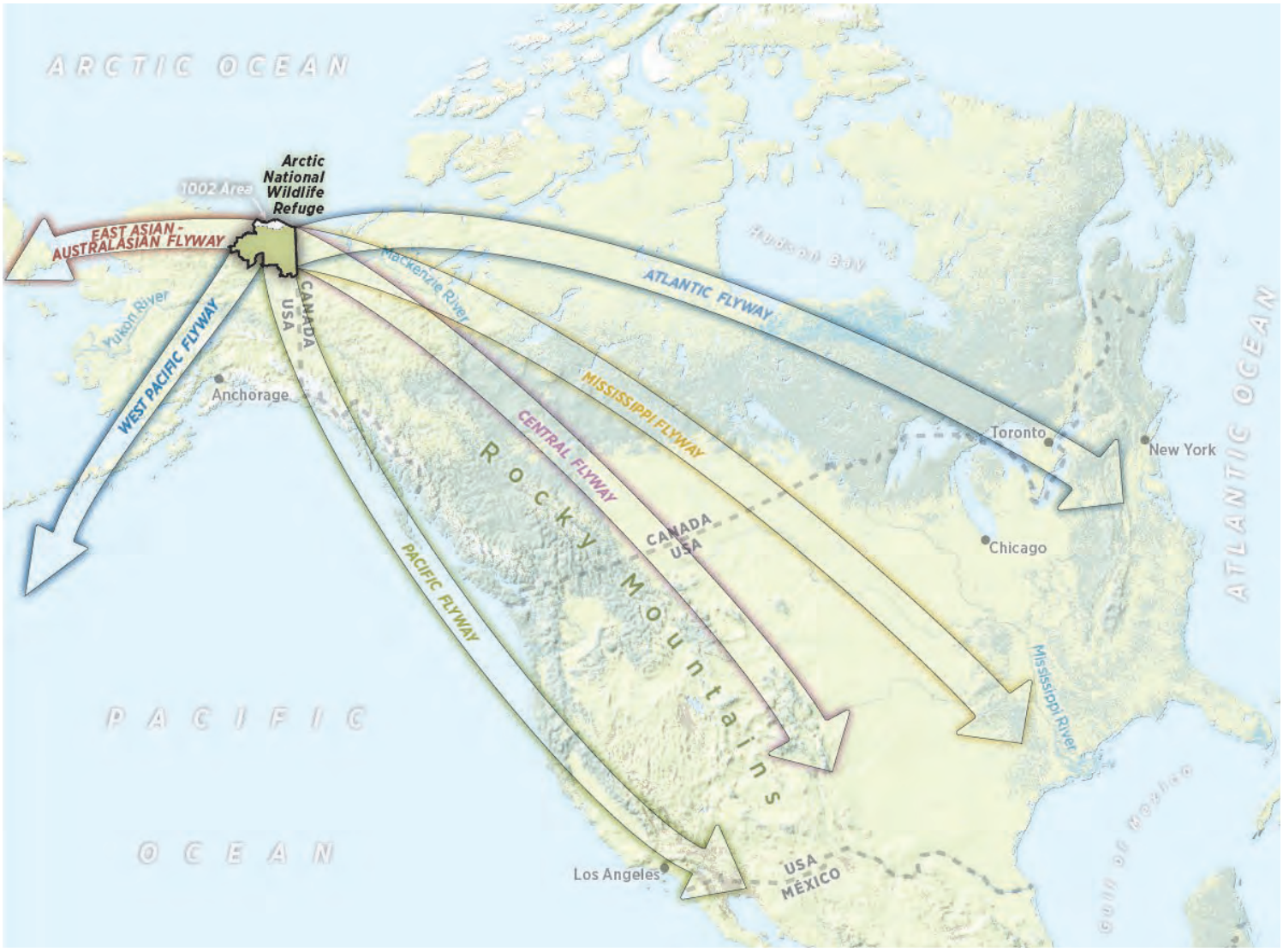
The annual cycle of bird migration varies widely by species and by inter-annual conditions. Migratory bird arrival in the Arctic Coastal Plain each spring is driven by food resources and suitable nesting conditions (Johnson and Herter 1990). Early migrants–Glaucous Gulls (*Larus hyperboreus*) and Common Eiders (*Somateria mollissima*)–arrive as early as mid-April, well before snow typically melts. By mid-May, most ducks, shorebirds, and passerines begin to arrive and locate nest sites (Sullender 2017; Ward et al. 2016). Generally, bird activity peaks in June and July (Sullender 2017).

The post-breeding time period—between completing the nesting season and departing the Arctic for fall migration—is used differently by different bird species. Some birds, like Dunlin (*Calidris alpina*), will shed and regrow their flight feathers in the Arctic (Warnock and Gill 1996), a process called molting. Others, like Semipalmated Sandpipers (*Calidris pusilla*), wait to molt until they reach their wintering grounds (Hicklin and Gratto-Trevor 2010). Whether birds molt or not, the post-breeding period almost always involves steady foraging to gain sufficient energy reserves for migration.

Even as breeding birds leave, however, non-breeding birds arrive and utilize habitats across the Arctic Refuge's Coastal Plain.

Migratory bird departure dates vary based on environmental conditions and myriad other factors (Johnson and Herter 1990). Male eiders are among the first to depart breeding areas, generally in mid-June (Larned et al. 2012), and most nesting birds depart by August. Not all birds are successful breeders every year, and individuals that did not nest or had an early nest failure may initiate fall migration before successful breeders. Even as breeding birds leave, however, non-breeding birds arrive and utilize habitats across the Arctic Refuge's Coastal Plain. For example, hundreds of thousands of Snow Geese (*Chen caerulescens caerulescens*) arrive through August and September and remain foraging until snow and freezing temperatures force their departure (Hupp and Robertson 1998; Robertson et al. 1997).

Common Eider. Photo: Ron Knight/Creative Commons



Map 1. Major flyways involving Arctic Alaska.

Migration Strategies and Routes

Migration allows birds to capitalize on seasonally abundant resources across broad areas. However, migration also introduces significant uncertainty and potential mortality into avian life histories (Klaassen et al. 2014). Birds can suffer individual, demographic, or even population-scale impacts due to factors such as a mistimed departure (Ross et al. 2017) or reliance on degraded habitat within an otherwise intact migration corridor (Melville et al. 2016). Birds have adapted to the inherent uncertainties of migration through a number of strategies, from use of familiar flyways to differing stop durations to site fidelity.

Migratory birds generally move north and south along migratory flyways, which are geographic links between a series of seasonal habitats. Birds in Alaska's Arctic Refuge use Eurasian flyways (the East Asian – Australasian Flyway) to access wintering grounds in the south Pacific and Asia; and North American Flyways (the Pacific, Central, Mississippi, and Atlantic Flyways), to access wintering grounds in the southern U.S. and South America (see Map 1). The flyway is a useful concept to generally understand bird migration, although some species do not conform to a specific flyway.

Flyways cover enormous distances, with many birds that nest on the Arctic Coastal Plain making annual migrations well over 7,000 mi (11,000 km). Alaskan Arctic-nesting Tundra Swans winter in waters off the eastern seaboard, including the Chesapeake Bay as well as ponds and wetlands in

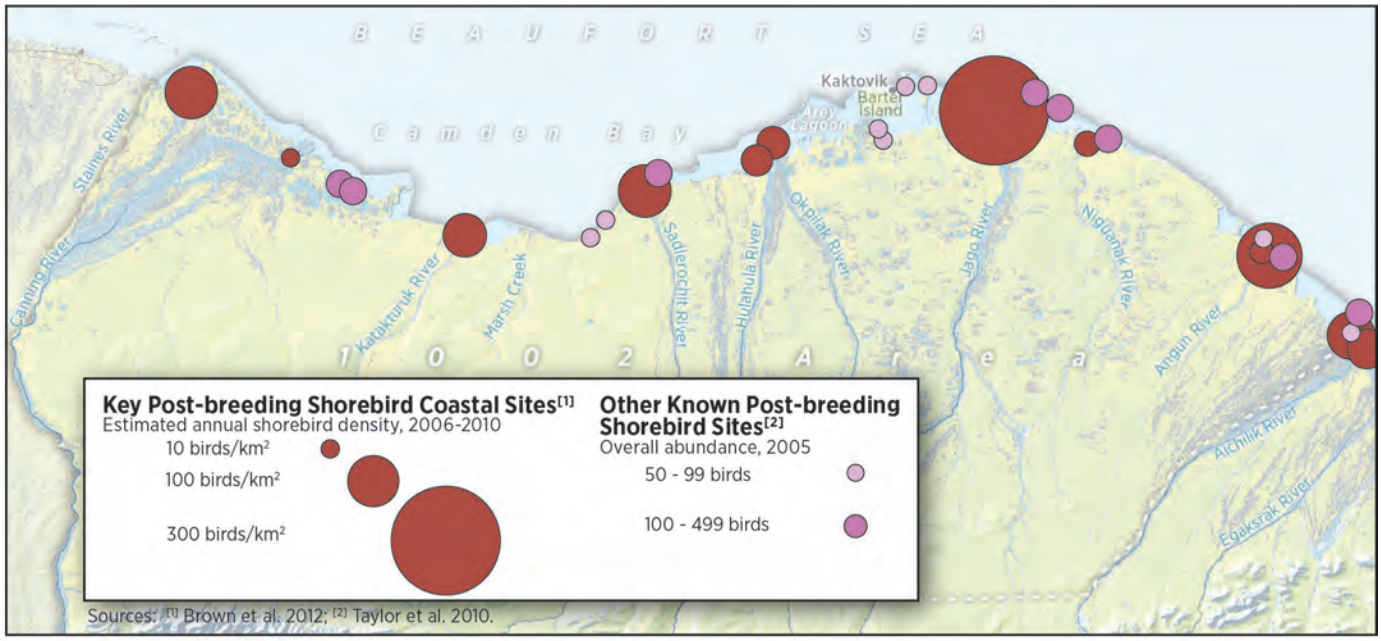
North Carolina, Maryland, and Virginia (Ely and Meixell 2016). Despite their small size, shorebirds also undertake long-distance migrations after breeding in or near the Arctic National Wildlife Refuge: Dunlin (*Calidris alpina arcticola*) travel to South and East Asia (Warnock and Gill 1996), American Golden-Plovers (*Pluvialis dominica*) overwinter in Argentina and Uruguay (Johnson et al. 2018), and Pectoral Sandpipers (*Calidris melanotos*) travel to Peru, Bolivia, and southern South America (Farmer et al. 2013).

The Arctic Refuge provides a network of both stopover and staging sites for various species.

Passerines also exhibit long-distance migrations to and from the Arctic Refuge. Smith's Longspurs (*Calcarius pictus*) are sparrows that fly up through the Great Plains states from wintering grounds in mid-western states along the Mississippi Flyway (Briskie 2009). Bluethroats (*Luscinia svecica*) are a thrush that migrate west of the Alaskan Arctic across the Bering Strait, where experts presume they winter somewhere in China (Guzy and McCaffery 2002). The sub-species of Northern Wheatear found in the Arctic Refuge (*Oenanthe oenanthe oenanthe*) winters in tropical Africa, using oases in the Middle East as stop-over habitat (Kren and Zoerb 1997).

Given the long distances traveled and the long duration of migration, individual birds use a wide variety of strategies to move between seasonal habitats. Some species use a "hop" strategy by stringing together a series of short flights between stopover sites (Warnock 2010). These birds only stay for a short duration during stopovers. Other species use a "jump" strategy by only taking one or a few big flights between summer and winter areas. Between these longer flights, migrating birds rely on extended foraging bouts at staging sites that provide predicable and abundant food resources (Warnock 2010). The Arctic Refuge provides a network of both stopover and staging sites for various species (Martin and Moitoret 1981; Robertson et al. 1997; Taylor et al. 2011).

Bluethroat.
Photo: Mick Thompson



Map 2. Post-breeding shorebird distribution across the Arctic National Wildlife Refuge's Coastal Plain. In addition to the coastal areas shown above, the Kongakut River delta (not pictured; about 8 miles [13 km] east of the Egaksrak River delta) supported an average of 100.6 shorebirds/km² from 2006-2010 (Brown et al. 2012).

Staging Habitat

After breeding at various sites both inland and close to the coast, many species of shorebirds congregate along the Arctic Refuge's coastline due to high prey availability and abundance (Andres 1994; Brown et al. 2007; Taylor et al. 2011). Arctic coastal staging areas for shorebirds are mainly located on or near river deltas along the Beaufort Sea (see Map 2), including notably high densities on the Jago (248 birds/km²), the Angun (136 birds/km²), the Sadlerochit (104 birds/km²), the Staines (103 birds/km²), and the Kongakut (101 birds/km²) river deltas (Brown et al. 2012).

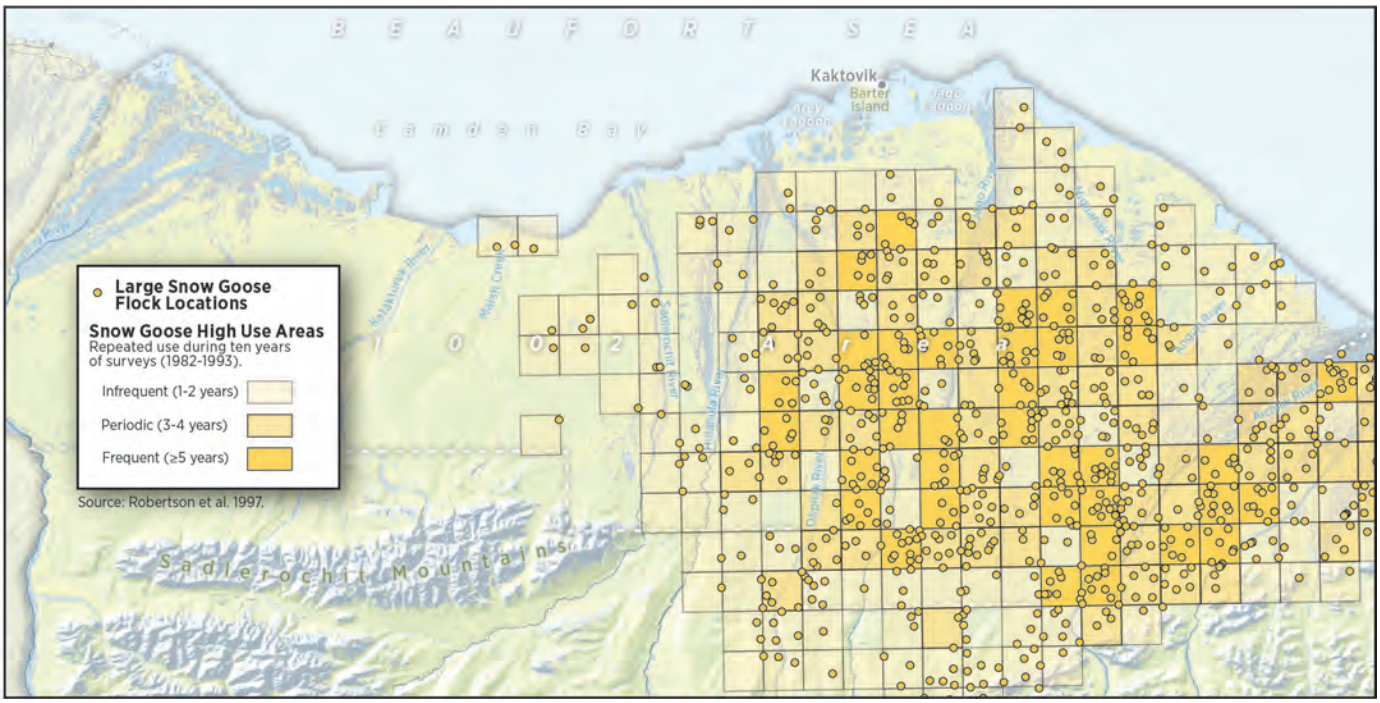
Many species of shorebirds congregate along the Arctic Refuge's coastline due to high prey availability and abundance.

The Arctic Refuge's Coastal Plain provides a wide variety of habitats—for example, gravel bars, mudflats, wetlands, and lagoon shorelines—for different foraging guilds (Taylor et al. 2010). The use of these sites is varied within and across years, and post-breeding shorebird movements many involve a wide array of sites across broad areas (Brown et al. 2012; Taylor et al. 2010). These staging sites form an interconnected migratory network, with multiple breeding populations of different species using sites simultaneously or consecutively (Taylor et al. 2011).

In addition to shorebirds, other taxa also converge on the Arctic Refuge's Coastal Plain for critical staging habitat. Snow Geese travel from nesting sites further northeast—primarily Banks Island, Canada—to stage for their long-distance migration (see Map 3). Staging Snow Geese target nutritious tundra plants such as cotton-grass (*Eriophorum* spp.) to rapidly gain weight before departing the Arctic (Hupp and Robertson 1998). Between 150,000–450,000 Snow Geese typically arrive between late August and early September and spend several weeks foraging, usually departing before October (Johnson and Herter 1989; Robertson et al. 1997). After summer growth, Arctic plants commonly mobilize nutrients to underground parts for overwinter storage (Hupp and Robertson 1998). Snow Geese capitalize on

this concentration of nutrients and target the underground stembase and roots of plants, a foraging behavior called grubbing. However, grubbing reduces forage condition in future years as vegetation slowly recovers (Hupp et al. 2000). Because of this, geese must rotate between larger staging areas across years in order to prevent resource exhaustion at any one site (Hupp and Robertson 1998; Hupp et al. 2000).

While Snow Geese stage further inland and shorebirds stage along the coast, waterbirds such as loons (including Yellow-billed Loons [*Gavia adamsii*] and Red-throated Loons [*Gavia stellata*]) and Black Brant (*Branta bernicla nigricans*) aggregate near river deltas in late August during fall migration as they travel westward (Martin and Moitoret 1981). King Eiders (*Somateria spectabilis*) use marine waters just offshore of the Arctic National Wildlife Refuge as a regular pre-breeding stopover (Phillips et al. 2007) or spring staging site (Dickson and Smith 2013), and Long-tailed Ducks (*Clangula hyemalis*) use similar nearshore marine areas for fall staging (Bartzen et al. 2017).



Map 3. Staging Snow Goose distribution in the Arctic National Wildlife Refuge's Coastal Plain. Snow Geese arrive from breeding areas in the Canadian Arctic to prepare for south-bound migration.

Representative Species

Modern technology has greatly advanced the ability to track specific routes and individual birds. Bird banding, whereby scientists attach metal bands with unique numbers to birds' legs, probably started in the 1500s and remains an important baseline for identifying seasonal use areas and broad connections. Since the 1960s, radio telemetry—where a transceiver is mounted to a bird through a variety of methods—has provided continuous information about individual birds' movements. Bird species with larger body sizes are more able to safely carry trackers and backpacks and have generally pioneered tracking technology such as satellite transceivers. Newer, lightweight options like light-level geolocators have allowed scientists to track smaller birds, including shorebirds, but are less precise than heavier GPS-based transceivers. A combination of these technologies deployed on four focal species illustrates the global connections and the key

migratory values of the Arctic National Wildlife Refuge.

Although some Brant breed in the Arctic National Wildlife Refuge, many also use the Arctic Refuge's coastal habitats during their fall migrations (Boyd et al. 2013; Ward et al. 2005). Despite a wide distribution across the northern hemisphere, Brant (*Branta bernicla*) found in Alaska are from the Pacific or Black Brant (*B. b. nigricans*) subspecies (Lewis et al. 2013; Ward et al. 2005). The Brant migration routes illustrated in Map 4 highlight stopover sites in the Arctic National Wildlife Refuge. A series of sheltered lagoons, barrier islands, and coastal wetlands provide safe resting and foraging sites for birds from the Canadian High-Arctic population as they migrate west along the Alaskan Beaufort coast (Boyd et al. 2013).

Habitats in the Arctic National Wildlife Refuge provide the abundant food resources and minimal disturbances required for birds to quickly gain sufficient fat reserves before undertaking long migrations.

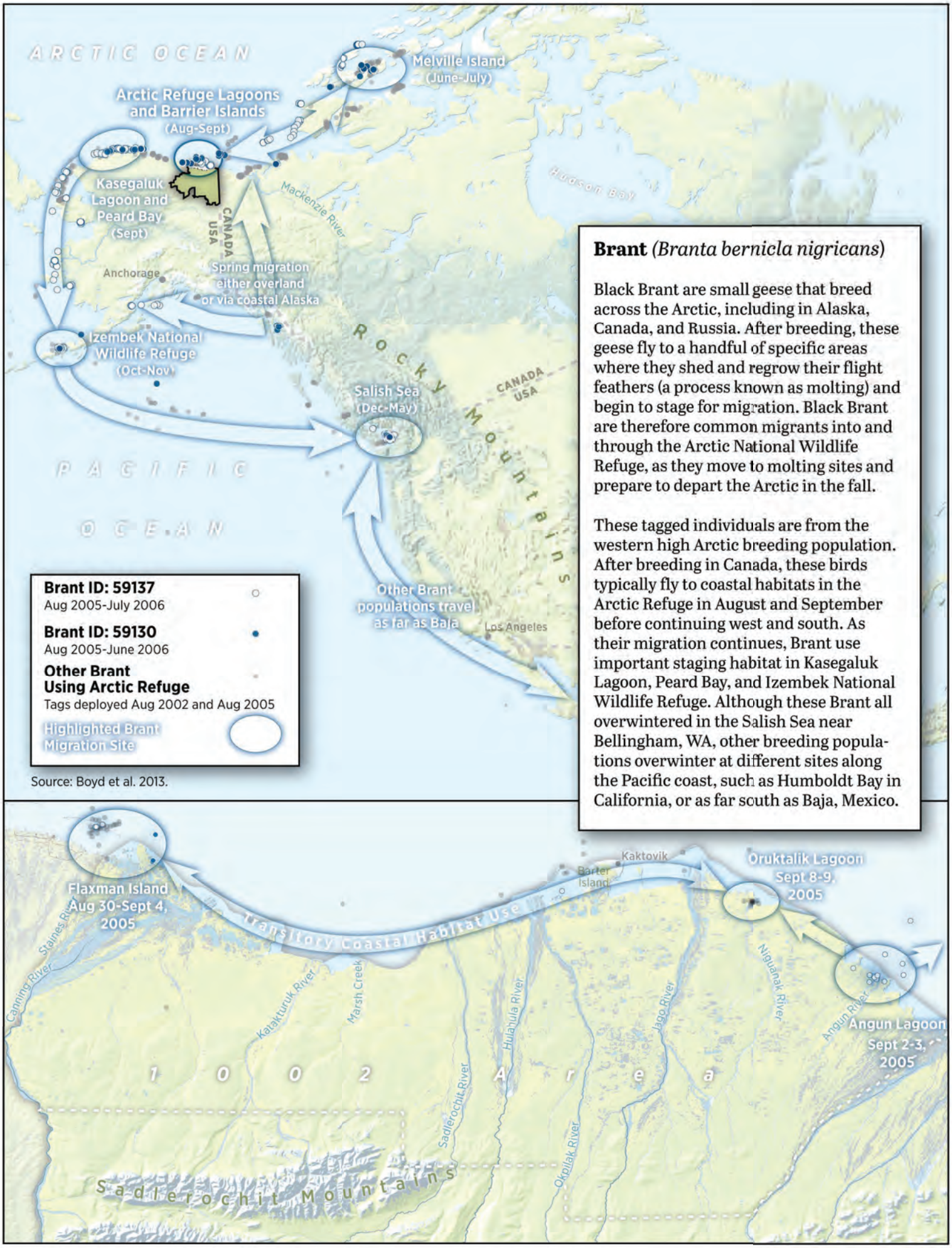
Greater White-fronted Geese (*Anser albifrons*) breed across the Alaskan, Canadian, and Russian Arctic, and migrate south using a number of distinct flyways (Wilson et al. 2018). The individuals highlighted in Map 5 were tagged outside of the Arctic National Wildlife Refuge, near their nest sites in the National Petroleum Reserve-Alaska (Meixell 2018). However, as with the tagged Brant, these geese stopped during fall migration to rest and forage for several days during late August and early September.

Although small in size, shorebirds have some of the longest known migration routes. Shorebirds undertake large continuous flights over open water, relying on extreme physiological changes such as gaining up to 50% body fat and physically shrinking digestive organs to provide sustained energy (Gill et al. 2005; Piersma and Gill Jr 1998; Warnock 2010).

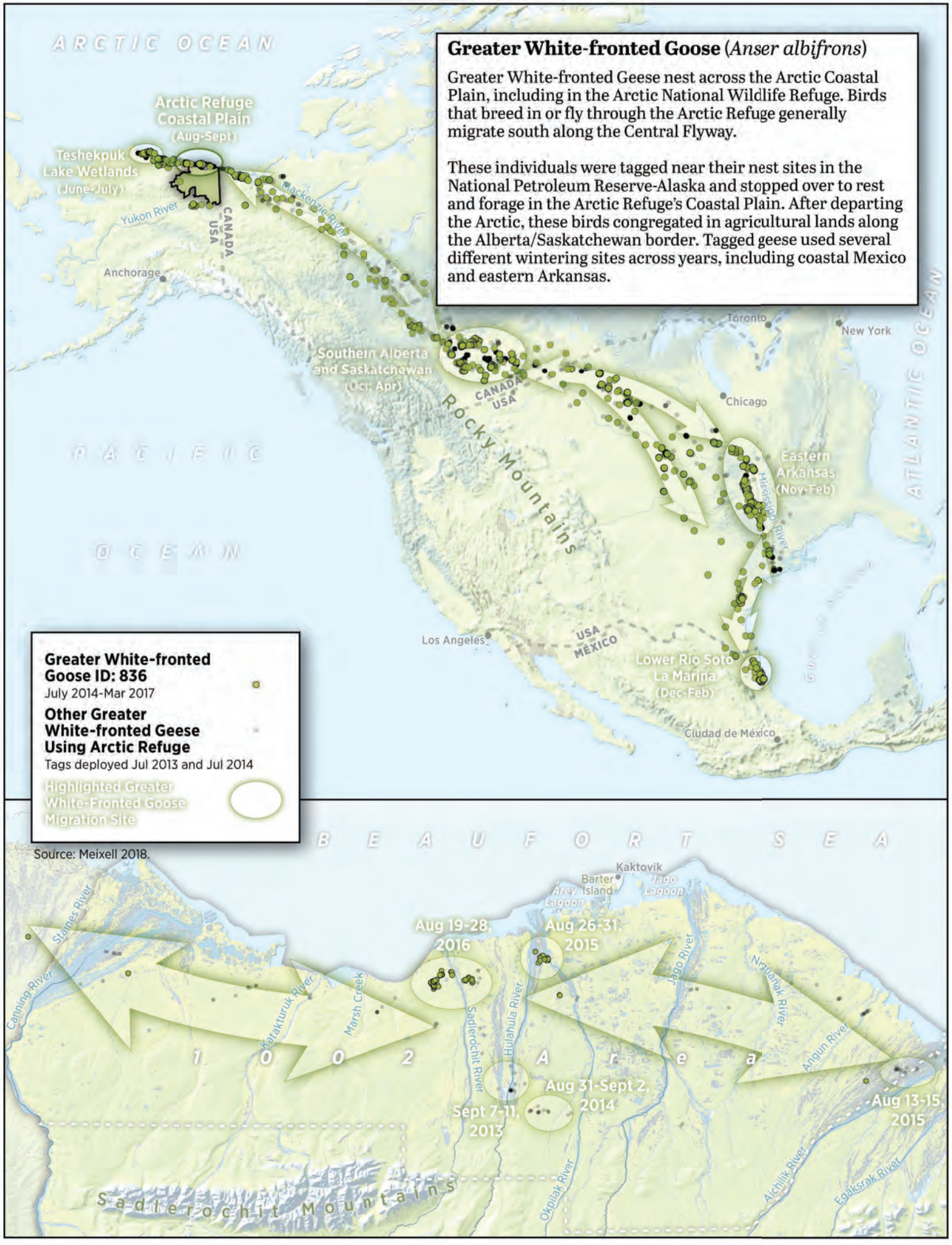
Habitats in the Arctic National Wildlife Refuge provide the abundant food resources and minimal disturbances required for birds to quickly gain sufficient fat reserves before undertaking long migrations. Semipalmated Sandpipers (*Calidris pusilla*) were tagged in the Canning River delta and migrated to the northeast coast of South America, seen in Map 6. On average, these birds completed a round-trip distance of over 11,000 miles (17,800 km), including several open-water segments over the Caribbean Sea and Atlantic Ocean (Brown et al. 2017).

Golden Eagle (*Aquila chrysaetos*) summer migration coincides with the peak of a very different seasonal resource: caribou calves. Although sparsely distributed on the Arctic Coastal Plain, Golden Eagles consistently nest in the Arctic National Wildlife Refuge, likely taking advantage of the Porcupine Caribou Herd (Young Jr et al. 1995). Juvenile Golden Eagles tagged in Denali National Park and Preserve have been recorded spending summers along the Canning River, Sadlerochit Mountains, and the Canadian portion of the Arctic Coastal Plain (McIntyre et al. 2008). These birds traveled along the Rocky Mountains into the Lower 48 to overwinter before returning north (see Map 7).

Black Brant. Photo: Tim Brown/USFWS



Map 4. Black Brant.



Map 5. Greater White-fronted Goose.

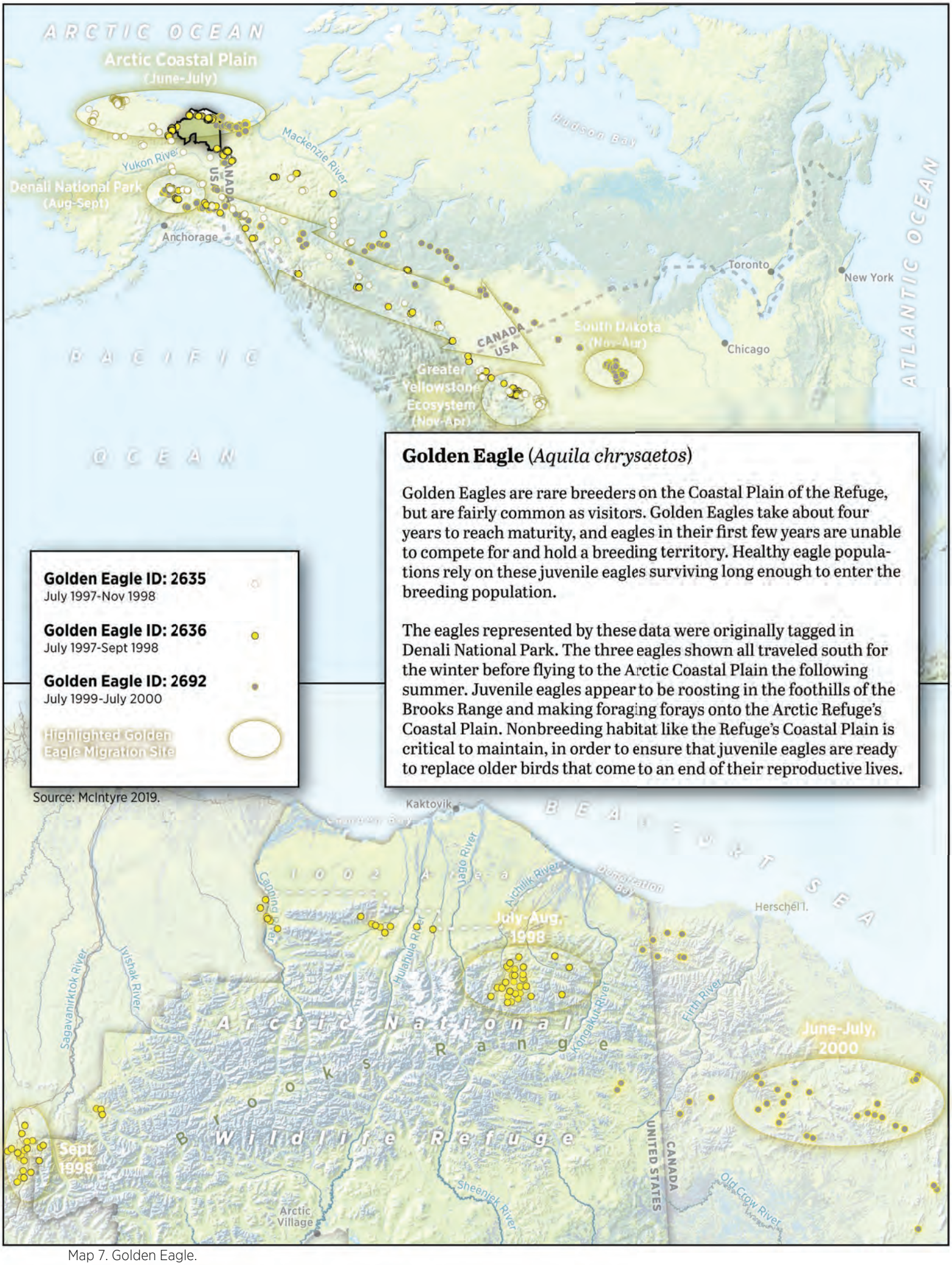
Source: Brown et al. 2017.

Semipalmated Sandpiper (*Calidris pusilla*)

Semipalmated Sandpipers are small shorebirds that undertake migrations spanning thousands of miles. These sandpipers wait to molt until they are on their wintering grounds, but as a consequence, they begin to depart the Arctic very soon after they finish breeding. After breeding, sandpipers move along the Beaufort Sea shoreline and congregate at coastal sites dispersed throughout the Arctic National Wildlife Refuge's Coastal Plain. As with many other shorebird species, post-breeding movements are focused around an expansive network of habitats that provide vital resources for the long journey south.

Tagging data indicate four main migration routes, with distinct breeding and non-breeding areas, for Arctic-nesting Semipalmated Sandpipers. The birds shown above represent one of the four breeding populations. These individuals bred in the Canning River area, staged in the northern Great Plains, and used distinct eastern (fall) and western (spring) Caribbean migration routes to reach overwintering habitat in northeastern South America. The round-trip migration distance for these birds averaged over 11,000 miles (17,800 km).

Map 6. Semipalmated Sandpiper.



Map 7. Golden Eagle.

Semipalmated Sandpiper. Photo: Mick Thompson

Conservation Issues

MIGRATORY SITE CONNECTIVITY

The conservation issues impacting migratory birds span their entire ranges, underscoring the spatial connections between places. If seasonal habitat is compromised in the Arctic National Wildlife Refuge, those impacts will cascade throughout migratory corridors, from South America to the Gulf Coast to the Great Plains of North America. Even transient areas have an important role in bird migration: habitat loss at staging sites has already been linked to population declines in Arctic shorebirds along the East Asian–Australasian Flyway (Szabo et al. 2016).

Within the Arctic National Wildlife Refuge in particular, the network of migratory sites should be considered as an integrated whole, rather than as discrete units that could be analyzed piecemeal. For example, post-breeding shorebirds have widely varying densities as well as seasonally, annually, and geographically variable habitat usage (Brown et al. 2012). On an individual level, shorebirds rely on many dispersed sites to adequately prepare for migration (Taylor et al. 2011). The availability and usage of multiple sites can be seen as a necessary component of successful Arctic shorebird migration, by maximizing the chances for optimal environmental conditions and enabling the use of multiple sites

within a single migration (Brown et al. 2012; Taylor et al. 2011). Similarly, successful staging for abundant grazers such as Snow Geese relies on rotating through a large area across multiple years. Although geese may be concentrated at a single, smaller site in a given year, these birds would exhaust the forage resources if forced to return to the same site before vegetation has completely regrown (Hupp and Robertson 1998; Hupp et al. 2000).

Given the high degree of connectivity between multiple migratory sites, an oil spill even hundreds of miles away could have significant effects on birds.

Designating only one of many staging sites as habitat for Snow Geese or shorebirds would fail to address their need for a broader, integrated network, as exists currently across the Arctic Refuge's Coastal Plain. Impacts to any portion of the network could compromise the entire habitat complex. These impacts could involve any number of potential or emerging threats, from oil and gas development-related aspects (habitat loss, oil spills, and disturbance) to the already tangible consequences of climate change.

Equipment at Prudhoe Bay oil field. Photo: John Schoen

HABITAT LOSS

Proposed oil and gas development in the Arctic Refuge has the potential to dramatically reshape the Coastal Plain's landscape. Gravel roads, airstrips, pipeline support members, gravel drill pads, gravel mines, and causeways would all result in direct destruction of natural habitats (Truett et al. 1997). A variety of indirect impacts could also arise, including interruption of hydrological regimes, vegetation alteration due to dust fallout, changes in invertebrate prey availability, increases in predator abundance, permafrost degradation leading to thermokarst, and other side effects of gravel placement reviewed in part by Sullender (2017).

OIL SPILLS

Oil or toxic chemical contamination would be one of the most pernicious forms of habitat loss, as well as a source of acute mortality. Coastal and nearshore habitats are particularly important for bird migration across many taxa, and chemical spills have a higher chance of being carried downriver, advected by marine currents, or transported by wind into these same critical habitats. Given the high degree of connectivity between multiple migratory sites, an oil spill even hundreds of miles away could have significant effects on birds breeding across northern Alaska (Taylor et al. 2011).

DISTURBANCE

Many lines of evidence suggests that birds are highly sensitive to disturbance during certain periods of migration. In particular, at staging sites, birds nearly continuously forage in order to gain sufficient energy reserves to reach their next stop. Even low levels of disturbance could interrupt foraging enough to disrupt birds' ability to gain mass (Ward et al. 1994). Fall staging Snow Geese were unable to compensate for energetic losses if disturbed two or more times per hour (Bélanger and Bédard 1990).

Sources of anthropogenic disturbance could include nearby humans, boats, vehicles, and aircraft. Staging birds flush easily due to aircraft overflights, and will alter behavior even at large distances from the source of disturbance (Bélanger and Bédard 1989; Ward et al. 1999). Staging Snow Geese respond to aircraft 3.1 miles (5 km) away, and can be displaced up to 3.7 miles (5.9 km) away from feeding sites (Bélanger and Bédard 1989; Gunn et al. 1974). Staging Brant respond to aircraft at similar distances (as far as 3 miles [4.8 km] away; Ward et al. 1999), and post-breeding King Eiders react when an aircraft approaches within 1.9 miles (3 km; Mosbech and Boertmann 1999). All of these thresholds vary

across taxa and across regions, indicating that Arctic Refuge-specific studies must be done to determine whether regulations based on these distances would be effective in mitigating disturbance.

BARRIERS TO MOVEMENT AND COLLISIONS

Structures—such as drill rigs, processing facilities, and other oil and gas extraction-related infrastructure—have been shown to alter migratory bird movements in some settings (Day et al. 2005). Beyond simply altering movements, structures can also be an acute source of injury or morality (Drewitt and Langston 2008; Ellis et al. 2013). While in the Alaskan Arctic, eiders, loons, and most other observed bird species generally fly at altitudes close enough to the ground (on average less than 30 feet [<10m] above the ground) to collide with structures (Day et al. 2015), which is consistent with observations of collision-based mortality at oil infrastructure such as nearshore drill pads (Day et al. 2005). Collisions are an issue primarily in the fall, when the sun sets at night. Lights designed to reduce collisions served as attractants for some species (Day et al. 2005), and gas flaring in particular attracted hundreds of Long-tailed Ducks and other birds from over a mile (>2 km) away (Day et al. 2015).

CLIMATE CHANGE

Climate change stands to impact the Arctic Refuge's migratory birds, not only during post-breeding and staging within the boundaries of the Refuge, but also far beyond the Arctic on their stop-over and wintering grounds. Warming in the Arctic may change the timing of critical ecological events on which Arctic migratory birds rely. For example, the phenology (or timing) of spring snowmelt and food availability (plants and insects) could be mismatched with bird arrival in the spring (Tulp and Schekkerman 2008). However, these potential mismatches between migration and seasonal resource peaks may be dampened by other site-specific factors (Senner et al. 2017), and many migratory birds appear to be able to adapt migration timing based on environmental cues along their routes (Ely et al. 2018; Liebezeit et al. 2014; Taylor et al. 2010). Regardless of the specific mechanisms, predicted reproductive declines in Arctic-nesting shorebirds have not yet been observed (Weiser et al. 2018). Given these mixed results regarding climate change forecasting, it is essential to incorporate uncertainty, spatial variability, and an overall precautionary approach when assessing how climate change might alter the Arctic ecosystem (Hartsig 2016; Van Hemert et al. 2015).

Arctic Refuge, Jago River. Photo: Dave Shaw

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