2018 Eco-Meet

Audubon Station
"Bird Migration"

Migration

When many of us think about migration, the image of geese winging their way south in their wrinkled V-shaped flocks is one that often comes to mind. The migration of geese is an example of the annual, large-scale movement of birds between their breeding (summer) homes and their nonbreeding (winter) grounds.

More than 650 species of birds nest in North America. Some are permanent residents and live in the same area year-round. The majority of the species, however, are migratory.

Why do birds migrate?

Birds migrate to move from areas of low or decreasing resources to areas of high or increasing resources. The two primary resources being sought are food and nesting locations.

Birds that nest in the northern hemisphere tend to migrate northward in the spring to take advantage of burgeoning insect populations, budding plants and an abundance of nesting locations. As winter approaches, and the availability of insects and other food resources drops, the birds move south again.

Escaping the cold is a motivating factor but many species, including hummingbirds, can withstand freezing temperatures as long as an adequate supply of food is available.

Types of migration

The term *migration* is used to describe movements of populations of birds (or other animals). One way to look at migration is to consider the distances traveled.

- Short-distance migrants: May move only a short distance, as from higher to lower elevations on a mountainside.
- Medium-distance migrants: Some species may cover distances that span from one to several states.
- Long-distance migrants: Birds that typically have ranges that extend from the United States and Canada in the summer to Mexico and further south in the winter.

The **pattern of migration** can vary within each category, but is most variable in short and medium distance migrants.

Origins of migration

The origin of migration is related to the distance traveled. For short-distance migrants it is as simple as a search for food. The **origins of long-distant migration** patterns are more complex and include the development of the genetic make-up of the bird.

Migration triggers

The mechanisms initiating migratory behavior vary and are not always completely understood. Migration can be triggered by a combination of changes in day length, lower temperatures, **changes in food supplies**, and **genetic predisposition**. Different species of birds and even segments of the

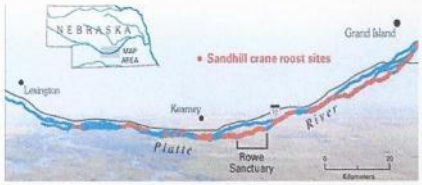
population within the same species may follow different **migratory patterns.**

Navigation

Migrating birds can cover thousands of miles in their annual travels, often traveling the same course year after year with little deviation in the path followed. First year birds may migrate unescorted to a winter home they have never before seen and return the following spring to the area in which they were born.

The secrets of their amazing navigational skills remain largely hidden. Birds appear to navigate using a **variety of techniques**, including navigation by the stars, sensing changes in the earth's magnetic field, and even smell.

Some species follow **preferred pathways** on their annual migrations. These pathways are often related to important stopover locations that provide food supplies critical to the birds' survival.



Each spring approximately 500,000 **Sandhill Cranes** and some endangered **Whooping Cranes** use the Central Platte River Valley in Nebraska as a staging habitat during their migration north to breeding and nesting grounds in Canada, Alaska, and the Siberian Arctic.

Migration hazards

Taking a journey that can stretch to a round-trip distance of several thousand miles is a **dangerous and arduous undertaking**. It is an effort that tests both the birds' physical and mental capabilities. The physical stress of the trip, lack of adequate food supplies along the way, bad weather, and increased exposure to predators all add to the hazards of the journey.

In recent years long-distant migrants have been facing a growing threat from communication towers and tall buildings. Many species are attracted to the lights of tall buildings and millions are killed each year in collisions with the structures.

Studying migration

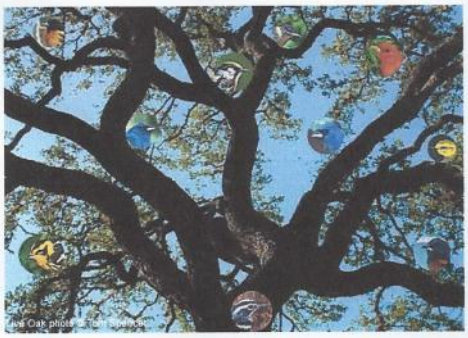
Scientists use several techniques in **studying migration**, from banding to satellite tracking. One of the goals is to locate important stopover and wintering locations. Once identified, steps can be taken to protect and save these key locations.

Migrant traps

Migrating birds can sometimes be found in certain areas in larger than normal numbers. This may be the result of local weather conditions, an abundance of food or the local topography.

For example, small songbirds may migrate north in the spring, flying directly over the Gulf of Mexico to the coastlines of Texas and other Gulf Coast states. Under favorable weather conditions they may continue inland for many miles before stopping to rest and feed. However, storms and headwinds can often leave the birds near exhaustion when they reach land. In such cases they will head for the nearest location offering food and cover. Many of the motts along the gulf coast can provide these needs and become a temporary home to large numbers of birds in a very short time.

These **migration traps** have become very popular with birders, even earning international reputations.



Giant live oak trees, like those found at High Island, Texas, attract many of our most beautiful birds as they reach the coast after their journey across the Gulf of Mexico each spring.

Spring migration is an especially good time for those that feed birds in their **backyard** to attract species they normally do not see. Offering a variety of food sources, water, and adding natural food sources to the landscape can make a **backyard** attractive to migrating songbirds.

Range maps

Many birders use the **range maps** in their field guides to help determine if and when a particular species might be in their area. Range maps are especially useful when working with non-resident species.

Range maps can be confusing and have limitations. Ranges of birds can vary year-to-year, as with several of the **irruptive species** such as redpolls.

The range of some species can expand or contract fairly rapidly, with changes occurring in time periods shorter than the republication time of a field guide.

*Introduced into the Bahamas in the mid-1970s, the **Eurasian Collared-Dove** is now established throughout the southeastern United States. Its range has rapidly spread north and west, all the way to the west coast of the United States. It prefers an urban or suburban habitat.*

Migration and the spread of disease

Wild birds have historically played a very limited role in the **spread of disease** to humans. West Nile virus has had an impact on bird populations, with Corvid species such as crows and jays being the most susceptible. The mosquito is responsible for the transfer of West Nile virus to humans.

Bird or avian flu can also be carried by migrating birds and is often fatal to the bird. To date (May, 2006) there are no confirmed cases of the spread of avian flu from wild birds directly to humans.

Additional resources

Migration is a fascinating study and there is much yet to learn. The Lab of Ornithology's Miyoko Chu has published a book titled **Songbird Journeys** that explorers many aspects of migration in an interesting and easy-to-read style. The Cornell Lab of Ornithology's Handbook of Bird Biology provides even more information on the amazing phenomenon of bird migration.

Migratory Patterns

Migratory patterns vary by species and sometimes within the same species. Almost any possible pattern is possible and can be seen in one or more species.

Permanent residents

Some species do not migrate. They are able to find adequate supplies of food throughout the winter. The Northern Cardinal and Northwestern Crow fall into this category.

Short distance migrants

Adding to the diversity of migration patterns are birds that migrate short distances. This often includes species that are permanent residents in most of their range, but with migratory tendencies on the edges or in pockets of their range.

Northern Bobwhite
Populations are typically sedentary, year-round residents. However, in the Smoky Mountains of the southeast United States seasonal movements between low-elevation wintering and high-elevation breeding habitats have been observed.

Hairy Woodpecker
Hairy Woodpeckers are primarily nonmigratory. They are permanent residents throughout their breeding range. However, northernmost populations display irregular and unpredictable wandering in winter. Local post-nesting short-distance movements take place in some areas. In some situations individuals breeding at higher altitudes seem to disperse to lower altitudes during nonbreeding season or from inland to coastal locations.

Bridled Titmouse
Generally non-migratory except for some movements to lower elevations. In Arizona, many individuals move to riparian communities in late September and return to higher elevations in early April.

Blue Grouse
The Blue Grouse of the Northern Rockies reverses the pattern of moving to lower altitudes in the winter. These birds move higher in the mountains in the winter to feed on conifer needles, then back down to the valleys in the spring where a wider variety of food sources exist for feeding their young.

Medium distance migrants

The ranges of some species may cover large parts of the United States and Canada. Medium distance migrants tend to exhibit a variety of irregular patterns of north/south migration but remain in North America.

Blue Jays
Blue Jays really mix it up. Blue Jay migration is an obvious phenomenon in some areas, with thousands moving past certain points along the East Coast each fall. Much remains a mystery, however. Some jays are present throughout the winter in all parts of the range. No one knows for sure which Blue Jays move and which stay put, or why. Although young jays may be more likely to migrate than adults, many adults do migrate. Some individual jays may migrate south in one year, stay north the next winter, and then migrate south again the next year. Many people who feed birds in their backyard may be seeing one population of Blue Jays in the winter and an entirely different population of jays in the summer.

Eastern Bluebird
Eastern Bluebirds (and several other species) have a flexible approach to migration. They may move only as far south as is needed for food and shelter and may move further south if local conditions become less conducive to their survival.

This migration pattern is not consistent with all Eastern Bluebird populations. In the southern part of their range the Eastern Bluebird is a permanent resident.

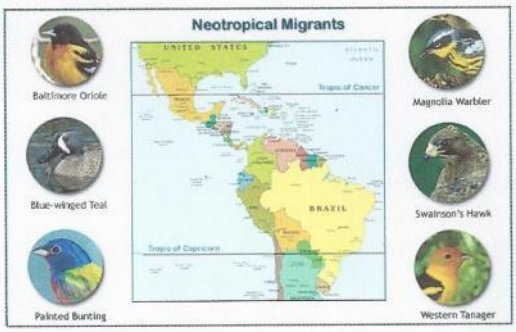
White-crowned Sparrow
Several subspecies of the White-crowned Sparrow have been studied. The northernmost breeding population migrates from Alaska and the Yukon to the southern plains of the United States and into northern Mexico. A different subspecies breeds farther south, ranging from British Columbia to northern California. These white-crowns migrate a shorter distance to the lowlands of central and southern California. Finally, a third subspecies is a permanent resident in parts of coastal California.

Killdeer
Killdeers are classified as medium-distance partial migrants, another way of saying their movements are complex and poorly understood. Banding records suggest general southward fall migration in North American birds, with no strong directional orientation. Birds from northern areas in eastern North America winter in gulf-coast and south Atlantic states. Some Killdeers migrate through western North America and Central America while others winter in the coastal and wetland areas of California.

Long distance migrants

Many species undertake migratory journeys that can take weeks to complete and cover thousands of miles.

Neotropical migrants
Approximately 350 species fall into the Neotropic migrant category. These birds breed in the United States and Canada. They winter in the Caribbean, Mexico, Central America and South America. Neotropical migrants include raptors, vultures, waterfowl, shorebirds, and passerine species such as hummingbirds, thrushes, warblers, orioles, and tanagers.



The term *neotropical* comes from "neo" referring to new and the new world, e.g. the Americas. Tropical is defined as the latitudinal region between the Tropic of Cancer and the Tropic of Capricorn.

Other long-distant migrants

Whooping Crane
Each fall Whooping Cranes that nest in Wood Buffalo National Park in Saskatchewan undertake a 2,500 mile flight south to the Aransas National Wildlife Refuge in Texas. By gliding on wind currents, they can stay aloft for 10 hours and cover up to 450 miles. The trip takes anywhere from eight to 30 days and the cranes arrive on the wintering grounds between late October and mid-December.

Arctic Tern
The champion of long distance migration is the Arctic Tern. Arctic Terns can travel as much as 24,000 miles (round trip) each year from their breeding grounds in far northern Canada to their winter home in Antarctica. The terns follow two major pathways on their trips back and forth to the poles.

Terns that breed near Alaska and Canada migrate down the western coast of North, Central and South America. Birds from Greenland and Siberia take a route along the western coasts of Europe and Africa. Some birds in this group splinter off at the Horn of Africa and cross the Atlantic. They then fly down the east coast of South America. After spending only about two months in Antarctica they start their northward journey. The Arctic Tern can live to be at least 34 years old, in which case it may have flown more than 800,000 miles in its lifetime!

Origins of Migration

Why do birds migrate and how did migration over long distances evolve? The answers are hidden within the vast diversity of bird behavior, weather, geography, and the availability of seasonal food sources. At a basic level, migration evolves when birds that move from one area to another produce more offspring than those that do not. When migratory patterns evolve over hundreds or thousands of years the urge to migrate becomes part of the birds genetic make up.

There is still much to be learned regarding the evolution of long-distant migration and the origins of such migratory behavior.

Climatic changes

Over very long periods of time changes such as glacial advances and retreats or even the shifting of continents may have played a role in the development of long-distant migratory behavior.

Gradual dispersement--Neotropical migrants

Neotropical migrants are a group of birds whose migration patterns may have evolved over long periods of time. Their winter homes seem rich in food supplies and nesting locations, so why do they make the arduous and dangerous return trip north in the spring?

One idea is that through many generations the tropical ancestors of these birds dispersed from their tropical breeding sites northward toward the United States and Canadian temperate zones. The seasonal abundance of insect food and greater day length allowed them to raise more young (four to six, on average) than their stay-at-home tropical relatives (two to three young on average). As their breeding zones moved north, the birds continued to return to their ancestral home as cold weather and the related decrease in food supplies made life more difficult. Supporting this theory is the fact that most North American vireos, flycatchers, tanagers, warblers, orioles, and swallows have evolved from Neotropical forms.

In certain species, the evolution of migratory behavior over such long periods of time has resulted in a genetic disposition that favors migration.

Rapid changes in migratory patterns

Under certain environmental conditions migratory behavior can change rapidly, and the origins of the new migratory behavior can be seen.

The new migrants

In the early 1940s House Finches from a nonmigratory population in California were released on Long Island, New York. The harsher New York winters appear to have encouraged the development of migratory behavior. Within twenty years large numbers of House Finches were migrating south to the Gulf Coast states in winter and back north each spring.

This story illustrates how little is really known about the evolution of migratory behavior. How did migratory behavior really evolve in these House Finches?

Presumably a lack of food in the winter was the initial motivating factor and migration may have evolved according to one of these theories.

Theory 1. The Dumb Luck Theory.
This theory assumes House Finches, in search of food, fanned out in all directions from the city.

- Those that went north did not survive the cold.
- Those that flew east fell into the ocean.
- Those that flew west apparently did not find enough food to survive.
- Those that flew south survived. They were able to return to New York in the spring, repeated the behavior in subsequent years, and gradually built a population of finches that migrated south each fall.

Questions still arise. Do all offspring of the migratory finches immediately exhibit migratory behavior or do some take off in the wrong direction and perish? What about the residual population of Houses Finches? Are a certain percentage of those birds going through the same process, with some birds fanning out in all directions each year, or do they learn from the birds that head south?

Theory 2. The Inherited Knowledge Theory
Maybe House Finches have an inherited "knowledge" of which direction to fly to find warmer weather and larger food supplies. The decision to act upon this knowledge is influenced by outside elements such as food and temperature.

This theory is supported in a couple of ways.

1. Young birds of many species know to fly south in the fall without support from adult birds. It seems possible that adult House Finches may have the same capability governed by a retained genetic memory that can be triggered by external conditions. This memory points the birds in a southerly direction.

2. The note below on a population of Dark-eyed Juncos is also supportive. Upon arriving on an island with apparently very agreeable conditions, some juncos elected not to return to their migratory behavior and became permanent residents of the island. It may be that they were able to turn off their migratory nature upon arrival at a location that provided adequate resources. If certain species are able to turn off migratory behavior when it is not longer of benefit to them, then perhaps some species can revert to inherent migratory behavior if conditions change to make such behavior beneficial.

Theory 3. The Wireless Internet Theory
Maybe birds have an as yet undiscovered interface to the world around them. Somehow they are able to sense which directions lead to warmer weather and know that more food will be available in warmer areas.

If this seems far-fetched, consider the Monarch Butterfly. It takes four, five or more generations of Monarch butterflies to travel from their winter homes in Mexico to a short summer in Canada. Yet that final generation lives nine months, migrating back south to the very same valley in Mexico that its great, great, great, great, great grandparents left in early spring. No less a remarkable feat than the idea that birds might have the equivalent of a wireless Internet connection that keeps them in touch with the world around them.

The December 26th, 2005 tsunami caused massive devastation, yet few animals were killed. Elephants have been credited with being able to sense low frequency vibrations in the earth and were able to move to safety in response. With such intense vibrations being so unusual, how did the elephants know that the vibrations were a sign of danger and which way to run? How did flamingos and other animals also know to move to higher ground or other locations? Was their knowledge part of the same special sense that provides first-year shorebirds born in northern Canada with the knowledge that warmer weather and food may be found in the south, and in which direction they should fly to head south?

Tired of the trip

The opposite situation can also occur if conditions are just right. Migrating Dark-eyed Juncos apparently wandered off course and found themselves on Guadeloupe Island, about 155 miles from the coast of Baja California. The environment apparently suited the juncos so well that they abandoned their typical migratory behavior and became permanent residents of the island.

So why did the juncos not migrate north in the spring?

Theory 1. Maybe at least two juncos had weak migratory tendencies and passed on that weak tendency to their offspring.

This theory assumes that the genetic make up supporting migratory behavior can be lost in a single generation.

If this was the case then why have similar populations not appeared in other parts of the junco's winter range? Dark-eyed Juncos winter throughout the southern United States and into Mexico. If juncos with weak migratory tendencies can find themselves on an isolated island, surely over the years similar juncos will have found themselves in winter locations in Mexico or the southern United States with adequate food supplies and nesting locations. Why did they not elect to abandon their migratory behavior?

Theory 2. Maybe the variances in temperature were so small that there was not a significant enough spring warm-up to trigger migration. Without a sufficiently strong temperature delta, hormonal changes in the juncos did not occur, and the birds did not feel an urge to migrate.

Theory 3. Maybe birds always have the ability to migrate and inherently know which direction they should head in winter months (maybe it is the genes or some 6th sense). The urge to migrate operates like a very sticky switch. It can be turned on or off, but it takes a lot of muscle to do so.

A combination of environmental variables control the flipping of the switch. An overwhelming change in the environment must occur to have the power to flip the biological switch in one direction or the other.

On a point system, it might work like this.

Change in the amount of daylight: 1 to 10 points
Change in low temperature over a 30 day period: 1 to 10 points
Change in high temperature over a 30 day period: 1 to 10 points
Lowest temperature in the past 3 days: 1 to 5 points
Change in food supply of past 30 days: 1 to 10 points
Current food supply: 1 to 10 points
Numer of nesting locations: 1 to 10 points
Quality of nesting locations: 1 to 10 points
Lack of competition for nest locations: 1 to 10 points
Lack of competition for food: 1 to 10 points

The bird assigns a value to each variable and adds it all up.

The urge to migrate is 50 points.

If the total does not exceed 50, the environmental changes do not have enough power to flip the switch and the bird migrates. If the total exceeds 50 the urge to migrate is overpowered and shuts down, and the bird does not migrate.

For the House Finches, the situation is the reverse. Non-migratory behavior is controlling. When the number of points supporting migratory behavior becomes overwhelming, the migratory behavior switch is clicked back on, and the bird knows to head south.

Navigation

Staying on course

Birds have a remarkable homing instinct, allowing them to return to the same area year after year, even when their migration takes them halfway around the world. How this remarkable feat is accomplished has been the topic of many studies.

Young birds

Research indicates that young birds that do not migrate with their parents have an innate knowledge of the direction and distance they should travel, but lack a specific goal. After it arrives at its wintering grounds, the young bird will select a winter range to which it imprints during that winter. After the first year the bird has the ability to return to the same area, even if blown off course during migration.

Adult birds

Adults seem to have even more homing skills. Two classic experiments illustrate this point.

Manx Shearwaters were flown by plane from their nesting island off the coast of Great Britain to two different locations. One group was released near Boston, MA, and another near Venice, Italy. Shearwaters do not fly over land so both groups must have taken an over water route, which would be especially convoluted from Venice. Both groups of birds returned to their nesting burrows within 14 days, covering approximately 250 miles per day. How they were able to achieve this remarkable return is not fully understood.

In another experiment, several hundred *White-crowned Sparrows* were captured in their winter grounds near San Jose, California. One group was flown to Baton Rouge, Louisiana, and released, while a second group was flown to Laurel, Maryland, and released. The following winter thirty-four of the birds were recaptured in the same 1/4 acre plot in California they had been captured in originally, presumably after having visited their northern breeding grounds during the summer.

Homing pigeon studies

Homing pigeons have been used extensively as test subjects in order to develop a better understanding of migration and homing abilities. They have exhibited almost unbelievable navigation skills.

In one noted experiment, German scientist Hans Wallraff transported homing pigeons to a very distant location. To ensure that the birds did not receive any external navigational information, they were transferred under stringent conditions. The pigeons were transported in closed, airtight cylinders and provided bottled air. Light was turned on and off at random times and loud white noise was played. The cylinders were enclosed in magnetic coils that provided a changing magnetic field. Finally, the cylinders were mounted on a tilting turntable connected to a computer that varied both the rotation and tilt of the cylinders. After release at the distant and completely unknown area, the birds were able to fly home to their

roost, apparently without trouble (other than an initial case of nausea).

The pigeons' ability to fly home from a totally strange and distant location indicates that somehow the birds have both an internal compass and an internal map. A compass by itself would not be helpful, since the bird would not know if it were north, south, east or west of its home. The question of how a bird has a map of a location to which it has never been before (and was transferred to under such isolated conditions in the above test) and the sense of the direction it must take to return home remains a puzzle. Some possible explanations have been proposed, as follows:

Internal maps

The nose knows theory

How could a bird possibly have a map of places it has never been? One very surprising theory suggests that homing pigeons may use an olfactory map.

Visualize a pigeon in its home loft with the smell of pine trees from one direction and the smell of an onion farm in another. If the bird moves closer to the pine trees, the odor of pine will presumably grow stronger while the odor of onions grows weaker. In theory, a gradient map of odors could be created that would provide some directional information, even if the pigeon were suddenly dropped into a new location. Floriano Papi and others from the University of Pisa initiated this theory and have some evidence that olfactory navigation may extend to a distance of 310 miles. This theory remains controversial.

Magnetic map theory

A second theory suggests that birds use the earth's magnetic field to obtain at least a partial map of its position. The earth's magnetic field becomes stronger as you travel away from the equator and toward the poles. In theory, a bird might be able to estimate its latitude based on the strength of the magnetic field. While the change in strength is very small from one location to the next, there is some indication that homing pigeons have the sensitivity to detect even tiny changes in the strength of the magnetic field. Even if true, this would provide only a limited indication of the bird's latitude.

At this time there is no clear evidence that either of these theories is the complete story and the mapping skills of birds remains largely unexplained.

The Compass:

The other half of the navigation requirement is the compass. The internal map provides a bird with the general location of where it is relative to its homing or migration goal and its internal compass guides its flight and keeps it on course. Migrating birds are apparently utilizing several different compasses.

The sun compass

In 1951 Gustav Kramer discovered the sun compass. He performed his experiments by placing European Starlings in orientation cages and then used mirrors to shift the apparent location of the sun. In response, the birds shifted their migratory restlessness to match the compass direction indicated by the apparent new position of the sun.

Further research revealed that the bird's sun compass is tied to its circadian rhythm. It seems birds have a time compensation ability to make allowances for changes in the sun's position over the course of the day. This theory is supported by another experiment in which pigeons were placed in

a closed room with an altered cycle of light and dark. Over a period of a few days their circadian rhythm was reset. The birds were then released on a sunny day. Because their "internal clock" had been reset, they misinterpreted the position of the sun and made a predictable error in their homing direction. The pigeons actually ignore the position of the sun relative to its position in the sky, relying on its azimuth direction, i.e. the compass direction at which a vertical line from the sun intersects the horizon.

Further study has also revealed that pigeons have to learn the sun's path to use it in navigation. Young pigeons allowed to see the sun only in the morning lack the ability to use the sun for navigation in the afternoon.

The star compass

The sun compass plays a role in homing and may be used by birds that migrate during the day. Many songbird species, however, migrate at night. For many years scientist suspected that birds use the stars for navigation. In 1957 Franz and Eleanor Saur collected data from a series of experiments in which birds were placed inside an enclosed planetary dome. The Saurs were able to demonstrate that birds do use the stars for migration but not, as it turns out, in the way they thought. The common belief at the conclusion of the Saur experiments was that birds have a genetically coded map of the stars. In 1967 Cornell scientist **Stephen Emlen** used Indigo Buntings to prove that the actual story was a little different.

Dr. Emlen also used a closed planetarium for his tests. He started by collecting young birds and then hand raising them in a lab. His research included the following:

A. One group of birds was raised in a windowless room and was never exposed to a point source of light.

B. A second group also never saw the sun but was exposed on alternate nights to a simulated night sky in the planetarium, with normal rotation around the North Star.

C. A third group was also raised in a windowless room, but on alternate nights was exposed to a simulated night sky in the planetarium. In this case, the sky was manipulated to rotate about a different start, Betelgeuse.

When the fall migration period started, the birds were released into a special cage inside the planetarium.

Group A was placed in the planetarium under a normal fixed sky. The birds oriented themselves in random directions, showing no ability to recognize a southerly migration direction.

Group B was placed in the planetarium with a normal rotation around the North Star. The birds oriented themselves away from the North Star, in the appropriate southern direction for migration.

Group C was also placed into the planetarium. They had been raised with Betelgeuse as the central point of rotation. When exposed to a normal sky these birds oriented themselves away from Betelgeuse.

This research indicates that young birds do not learn star patterns themselves but learn a north-south orientation from a rotational star pattern.

The Magnetic Compass

Another German team did research with the European Robin in the early 1960s. In their tests, robins in a migratory mood were placed in covered cages to eliminate sun, star and other light clues. Despite the lack of visual clues, the robins were observed hopping in the correct migratory direction.

Helmholtz coil

As an additional refinement to the test, a **Helmholtz coil** was placed around the covered cages. The coil allowed the researchers to shift the direction of the earth's magnetic field. When the direction of the magnetic field was changed, the robins changed their hopping direction.

Further research indicates that while birds can sense the north and south ends of a compass, they cannot tell the difference between the two. To determine which direction is north, the birds apparently have the capability to sense that the magnetic lines of force align toward the poles of the earth. They can also detect the dip in the lines of force as they approach the earth and, through some currently unknown method, seem to be able to detect and make navigational decisions based on the dip angle.

The sunset cue

Patterns of polarized light also appear to play a key role in navigation. Many of the nocturnal migrants start their flights at sunset or a little after. Birds apparently use the polarized light patterns to provide information on initial migratory flight directions.

Landmarks

Birds that migrate during the day often follow, and may recognize, natural landforms such as mountain ranges, rivers, and lakes.

There is some indication that birds use multiple compass methods and calibrate them against each other. Some species use one type of compass as the primary navigational aid while others rely on a different primary system. The complexity of migration and the skill with which it is accomplished is one of the many marvels that make birds so interesting to study.

Migration Pathways

Each migratory species has its own characteristic route between its nesting and winter ranges. These paths are often rather broad. Waterfowl tend to follow a more restricted path, which can vary based on availability of stopover habitat. It was thought at one time that birds followed specific flyways, such as the Mississippi Flyway or Atlantic Flyway. Banding studies have shown, however, that migrating songbirds fly across broad areas and are not tightly grouped into specific flyways.

Visit the National Geographic Web site to navigate and zoom in on this migration map.

Nevertheless, some general patterns can be observed. In North America, many songbird and shorebird species follow an elliptical migration path. For example, a number of shorebird species that winter in South America will take a northern migratory path through Central America, the center of the United States and eventually to their summer homes in Northern Canada. In fall the birds fly southeastward, first to the Canadian Maritimes, followed by a long non-stop flight across the Western Atlantic Ocean to their wintering grounds. The route takes advantage of seasonal wind patterns that take some of the sting out of the long ocean stretch.

The third dimension

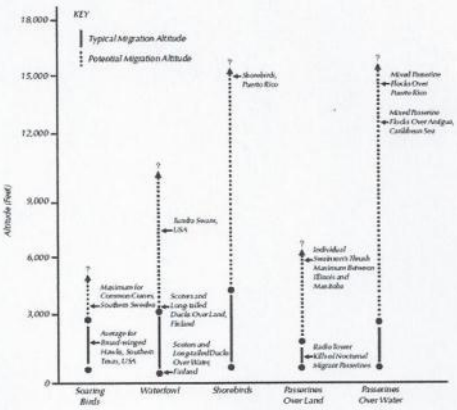
Birds do more than fly back and forth. Their migrations include a third dimension... how high they fly.

Different bird groups tend to fly at different altitudes during migration. Soaring migrants such as hawks and vultures usually look for the advantage that thermals offer and typically migrate at 3,000 feet or less. Migrating waterfowl use a wide range of altitudes, from as low as 300 feet to as high as 10,500 feet.

Most passerine species migrate at night. Over land, they usually fly at 2,100 to 2,400 feet but sometimes much lower. Over water, migration takes place at a much higher altitude, from 6,000 to 12,000 feet. Weather conditions often affect the migratory altitude as birds may fly higher or lower to avoid or take advantage of prevailing winds.

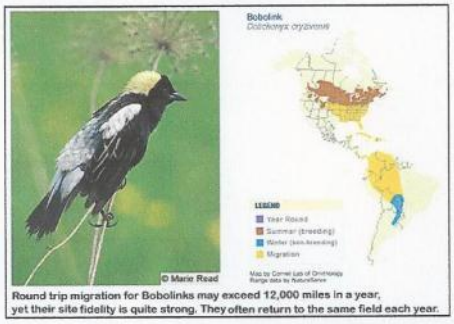
Some birds have been recorded at extremely high altitudes. Bar-headed Geese migrate over the Himalayas and have been recorded as high as 27,880 feet. It has been reported that a Ruepell's Griffin (a large African vulture) collided with an aircraft at 37,000 feet, or about 5 miles high!

The table below provides additional information on the flight height for several different species groups.



Site fidelity

Individual birds show amazing consistency to their migratory pathways and their nesting locations from year to year. Banding studies indicate that birds may track their migration path almost exactly from one year to the next and often return to the very same field or nesting location. This site fidelity extends to stopover points along the migration route and to wintering locations. Individual Wood Thrushes, for example, winter in the same area each year in Veracruz, Mexico, and demonstrate fairly consistent site fidelity in their U.S. breeding grounds.



Round trip migration for Bobolinks may exceed 12,000 miles in a year, yet their site fidelity is quite strong. They often return to the same field each year.

Fidelity to stopover points is particularly visible among some of the larger bird species. Sandhill family groups are a good example. They gather into large flocks at traditional stopover points each year. A spectacular event occurs each spring when 80-90 percent of the mid-continent population of Sandhill Cranes stops in the North Platte and Platte River Valleys of Nebraska.

Important stopover locations

Shorebirds comprise another group that utilize key stopover locations during migration. In 1974 the Manomet Center for Conservation organized the International Shorebird Study. After studying over 600 sites, and with thousands of census reports, it became clear that many species of shorebirds rely on a few, very important staging areas. The loss of these areas or the related food supplies could be extremely detrimental to shorebird populations.

A prime example is the current situation at Delaware Bay in New Jersey.

In mid-May, hundreds of thousands of shorebirds including Red Knots, Ruddy Turnstones, and Sanderlings stop on the shores of Delaware Bay to refuel before continuing their journey to their breeding grounds on the Arctic Tundra. The migrating birds stuff themselves on the eggs of horseshoe crabs before their final rush north.

In recent years the dynamics of the area have begun to change. Eel and whelk have become more popular food items in both the U.S. and other countries. Eels and whelk are also very fond of the eggs of the horseshoe crab. Fishermen have started taking large numbers of female horseshoe crabs to use as bait. Pick-up truckloads of horseshoe crabs can be seen leaving the beach. Some fishing boats have been equipped to drag nets across the sea floor, taking tens of thousands of horseshoe crabs in a single day.

The harvesting of the horseshoe crabs has dropped their populations significantly. In turn, a critical food supply for migrating shorebirds has been severely limited with the result that many shorebirds are not able to add the body fat needed to successfully complete their migration. About 80% of the North American population of Red Knots passes through Delaware Bay each spring. The lack of crab eggs has resulted in a precipitous drop in Red Knot populations. The result has been so severe that a coalition of conservation groups has petitioned the U.S. Fish and Wildlife Service to list the Red Knott as endangered. Some research indicates that the *rufa* subspecies of the Red Knot could be extinct by the year 2010 if steps are not taken to reduce the harvest of horseshoe crabs. Horseshoe crabs are relatively long-lived and do not start to reproduce until about ten years of age. Even if conservation efforts to rebuild crab populations are started immediately there will be a significant lag before the populations increase substantially.

Migrant Traps

As birds migrate they are often attracted to specific areas in larger than normal numbers. For example, when birds migrate north across the Gulf of Mexico they arrive first at the Gulf Coast states. If the winds are favorable, the birds may continue well inland before stopping to rest and refuel. On the other hand, if they have been fighting head winds and storms, the birds can be exhausted by the time they reach the coast. In such cases the birds head for the nearest areas offering cover and food. These areas are often referred to as*migrant traps* because they attract so may birds.

There are many famous migrant traps around the country. Several attract hundreds or even thousands of birders each year, anxious to enjoy the concentrated bird populations. Some of the better-known areas include High Island, Texas; Cape May, New Jersey; and Point Pelee, Ontario, Canada. The number of birders visiting the popular migrant traps is so great that perhaps these locations should really be called *birder traps*.

The geography around a particular location often has a significant effect on the number of migrants found in the area. The southern tip of Texas is host to thousands of migrating vultures and raptors twice a year. As migrating raptors from the eastern half of the U.S. move south, they avoid migrating over the Gulf of Mexico by funneling along the Texas coast or moving across the state directly to the southern tip of Texas before continuing south into Mexico and beyond. The Texas Rio Grande Valley is famous for the thousands of Broad-winged Hawks and other raptors that can be seen migrating through the area.

Migrating hawks will also skirt the edge of the Great Lakes, resulting in several locations that offer exceptional opportunities for observing migrating raptors.

Migrant traps are not limited to nationally-recognized locations. Local parks, refuges, and even cemeteries can attract large numbers of migrating species and may be popular birding locations. These local areas are sometimes referred to as birding *hotspots*.

Migrant traps can be found in any state. Here are links to a few of the other areas.

Cleveland Migrant Traps

Hawk Mountain in Pennsylvania

Indiana Migrant Traps

New York City Migrant Traps

San Antonio, Texas Migrant Traps

Many additional locations can be found by using your favorite search engine and searching for *migrant traps* or *birding hotspots*.

The Lab's staff has also listed some of their favorite birding locations.

Range Maps

The All About Birds **bird guide** and most field guides include range maps for each species. These maps use a color-code system to indicate the range and sometimes migration pathways for the selected species.

Range maps should be used with the understanding that the information provided is general in nature and is not intended to reflect exact limits of range. The accuracy of range maps is limited by several factors:

Ranges change

Some species expand their ranges over time, sometimes very quickly. The Eurasian Collared-Dove has spread from Florida to the U. S. west coast in just a few years.

Irruptions

As noted on the **irruption** page, some species may remain relatively far north in some years and suddenly expand their winter range the next. In non-irruption years a particular species can be totally absent from a state, only to become quite common in an irruption year.

Migration

Birds (especially young birds) often wander from the traditional migration path and end up in the "wrong" location.

The migration paths for some species are still not well known.

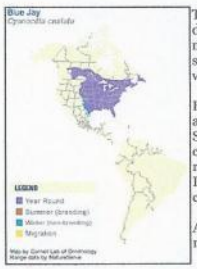
The color code shown on the range map of the Black-throated Green Warbler shows three of the four typical location zones.

The brown color indicates where the bird can be found in the summer, which is its typical breeding range.

The yellow indicates areas through which the species normally migrates. In this case, the warbler migrates through much of eastern U.S. and into Mexico.

The blue area indicates the wintering range of the species.

As this map illustrates, some Black-throated Green Warblers continue to migrate through the southern part of Central America and into northern South America.

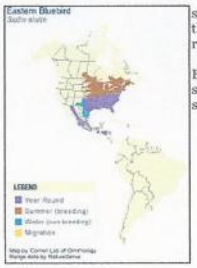


This range map for Blue Jays is deceptively simple and does not reveal the complexity of Blue Jay migration. The map indicates a fairly static year round range for the species, with a slight extension to the southwest in the winter.

Hidden in the solid purple area of the year-round range are the migration paths of large numbers of Blue Jays. Some Blue Jays migrate while others do not. In some cases it appears that one population of Blue Jays may replace another. For example, Blue Jays that summer in Illinois might move further south during the winter and could be replaced by Blue Jays from Canada.

As described in the **Bird Guide**, the details of Blue Jay migration are not well understood.

The Eastern Bluebird map shows both a summer and a winter range, indicating that a yellow migration color



should be somewhere on the map. In this case, however, the migration route includes areas where birds are year round residents.

By studying the map, one could guess that the Gulf Coast states' winter bluebird population is larger than the summer population.

The Cattle Egret map provides a good example of the complexity of illustrating seasonal changes in bird populations.

In this case the map shows a "winter (non-breeding)" range in blue that covers a large portion of the United States. After breeding, Cattle Egrets disperse throughout the U.S. and into Canada, resulting in the range shown. Confusion is created by combining the winter and non-breeding ranges. The egrets that spread throughout the U.S. after nesting eventually migrate south into limited winter ranges.

When studying range maps it is a good idea to read any accompanying text. For the Cattle Egret the species description in the Bird Guide section includes the following:

Winters in southern California, coastal Texas, Florida, and southward.

Understanding the range map of a species is often dependent on an understanding of the bird's complete migratorial behavior.

Range maps are a useful tool in determining if a certain bird can be found in your area at a particular time of year, just be cognizant of their limitations.

One of the best ways to obtain current information on which birds are being seen where is to visit Cornell's **eBird web site.** By using eBird, birders from all over the country can report sightings. The data collected provides a current look at where and when different species are being seen.

Irruption Year!

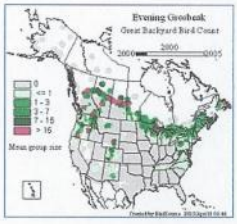
Another type of migration is not necessarily tied to the seasons, although there is some correlation. Irruptive migration occurs in species that respond to irregular changes in food supplies. For example, the availability of seeds and buds consumed by species such as redpolls and Pine Grosbeaks can vary substantially from year-to-year and from location-to-location. In some years the food supplies in the north may be adequate and the birds remain in the northern forests during the winter. In other years the food supplies are low and the birds move south or to other locations outside of their typical range. These movements outside their normal range are called irruptions.

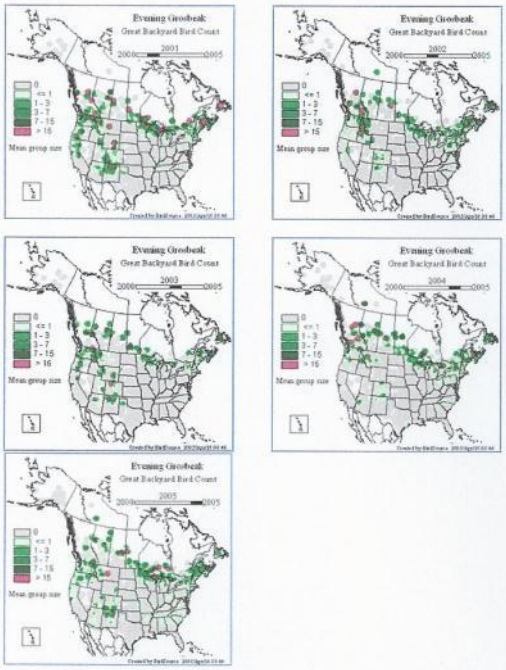
Raptors

While not in the seed and berry category, some raptors also exhibit irruptive behavior. Northern owls such as the Great Gray Owl and Snowy Owl sometimes exhibit this behavior. Most remain in their Canadian homes throughout the winter. In irruptive years, presumable as the result of poor food supplies, large numbers of these species may move into the northern United States.

Evening Grosbeaks

Evening Grosbeaks are another species that demonstrate irruptive behavior patterns. The following maps were created from **Great Backyard Bird Count** data for the years noted. While general patterns are consistent from year to year, in certain areas Evening Grosbeaks can be common one year and completely missing the next.





Cornell's eBird project collects sighting records from all over North America. Peruse the **data on eBird** to study irruptive species, including a prediction of **winter finch irruptions**.

Migration and the spread of disease

Migratory birds can play a role in the spread of infectious diseases. Their ability to travel over long distances and through a variety of habitats exposes them to a wide range of microorganisms.

In most cases they have developed natural immunities and the risks posed by exposure to disease is limited. In a few rare cases, however, the birds are exposed to diseases for which they have no immunity. This can be caused by the introduction of new pathogens within their ranges or mutation of an existing pathogen.

The introduction of West Nile Virus into North America is a recent example of a disease that was not particularly dangerous to birds or people within its historic range. Once it moved to North America, where it was not previously known, birds and mammals without a natural immunity were placed at risk. Thousands of birds have died from West Nile Virus and the long-term effects are still unknown. While the disease spread rapidly across North America, its spread was slowed by cold winter weather, which temporarily eliminates mosquito populations. There is great concern on the long-term affects of West Nile Virus as migratory birds carry the disease to their tropical winter homes. There is no known natural resistance to West Nile Virus in Central and South American bird species. The situation might be significantly worse than in North America as mosquitoes have a year round presence in the tropics.

Avian Flu (bird flu, avian influenza)

Avian flu is an infection caused by avian influenza viruses. These viruses occur naturally among birds. While present in wild birds on a worldwide basis, the viruses do not usually cause illnesses. The avian flu virus can be very contagious between birds and bird species. Various strains can make some domesticated birds, including chickens, ducks, and turkeys, ill or even cause death.

Reports of human infection by the avian flu virus have been monitored since 1997. In most cases it appears the spread of the virus was the result of direct contact with infected poultry or contaminated surfaces. To date (February, 2006) there have been no indications of sustained human-to-human spread of the disease.

Because the avian flu virus may change and become more infectious among humans, close monitoring of both domestic and wild birds is being conducted on a worldwide basis. This includes the monitoring of migratory species such as ducks and geese.

The situation regarding avian flu changes rapidly. The following links can be used to obtain current information.

The Cornell Lab of Ornithology's Bird Flu web site

Center for Disease Control

World Health Organization

National Public Radio--Avian Flu

From the UK--Bird migration tracker to help fight avian flu

From Project Feeder Watch--What North American bird watchers should know about the "bird flu"

West Nile Virus

In the case of West Nile Virus, the birds serve as a carrier of the disease but do not typically spread the disease directly. There are no known cases of West Nile Virus in humans that are the result of direct contact between birds and humans. Instead, mosquitoes spread the disease by first biting a bird infected with West Nile Virus, then biting a human or other mammal.

Current information on West Nile Virus is available from the following resources.

Center for Disease Control - West Nile Virus
National Audubon - West Nile Virus

Migratory Birds and Spread of West Nile Virus in the Western Hemisphere