



## Chapter 2:

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# The Kittatinny Corridor: An Important Migration Flyway

by Laurie Goodrich

**SUNDAY,** *September 23. Kramer and I on duty all day. Nothing to do in the morning; weather uncertain. Clearing skies in the early afternoon brought a number of cars up the mountain, among them four that contained hawk-hunters, all of whom departed obligingly. And no bird until three o'clock, then a spectacle – for a half hour a steady stream of Broad-wings passed overhead; I counted 427 of them! ... I also saw a Bald Eagle.” Maurice Broun, Hawk Mountain Curator, 1934 journal.*

In late September 1934, Maurice Broun began one of the first daily counts of migrant hawks ever to be conducted, and in so doing began revealing the natural wonder and importance of the Kittatinny Ridge. His counts were significant in that they chronicled daily numbers and patterns of movement along with weather conditions at a single site – Hawk Mountain in Berks County. His reports of migrant Golden Eagles – a species never before known to occur in the eastern United States –

drew much scientific and bird-watcher attention to the little-known mountain ridge.

As scientific acclaim for the migration grew, new hawk-watch sites, such as Sterrett's Gap near Carlisle, sprung up all along the Kittatinny Ridge, often supplanting hawk-shooting stands of days past.

One of the earliest published records of hawk migration in Pennsylvania occurred in 1887 when Witmer Stone reported a sighting of 250 hawks over Germantown on September 29, 1886.

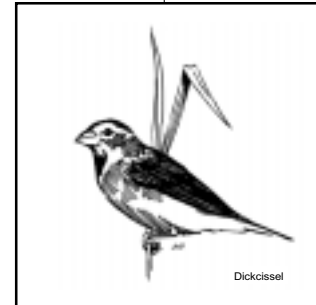
In 1908, three other authors commented on migration along the Shawangunk/Kittatinny Corridor, noting "thousands of hawks" passing from the northeast to fly along the ridge from the Delaware Water Gap south in the fall. One author observed that blackbirds, crows and nighthawks seemed to follow the Delaware River southward to the Gap, then turn and follow the ridge southwest.

Broun's arrival to the Kittatinny was prompted by several other key events. In 1928, the eminent ornithologist George Mikacsh Sutton published a note in the *Wilson Bulletin* detailing the plumage variations and stomach contents of 158 raptors of four species killed on a ridgetop in Schuylkill County, Pennsylvania.

The note provided valuable details on the food habits of hawks, but also alerted the ornithological community to a phenomenon worth noting. Praise for the Hawk Mountain site had spread locally through the early 1900s; the interest was not for a great hawk-watching site, but rather for a premier hawk-shooting spot. During this time, Pennsylvanians climbed to the mountaintop near Kempton and in other spots on the ridge in increasing number to shoot hawks during the fall. As numbers and acclaim for this "sport" increased, word spread to Pennsylvania cities and towns, and eventually to scientists such as Sutton.

In 1929, the Pennsylvania Game Commission offered a bounty on Northern Goshawks of \$5 apiece, further increasing the number of guns blazing atop Pennsylvania's ridges. Because identification was difficult, many other species were also shot in large numbers. Shooters often carried more than one gun, as a single rifle would get too hot to hold after some time on the mountain. No one knows how many raptors were killed along Pennsylvania's ridges early this century, but estimates range to the thousands each year.

On a fall weekend in 1932, a young ornithologist from Philadelphia – Richard Pough – intrigued by the *Wilson Bulletin* article and other newspaper reports of hawks along the ridge at a place called Hawk Mountain, drove to Dreherstown, and hiked to the mountain lookout. Although it was a sunny windless day, the remains of a prior day's slaughter were evident. In a few hours, he and his brother and friend



Henry Collins collected 230 dead and dying hawks, lined them up by size and took several photos. The photos were published in *Bird Lore*, and his report related that 150 men were shooting hundreds of birds in a day at the site called Hawk Mountain. These photos were a turning point in raptor conservation and galvanized attention and eventually conservation action to protect raptors on migration.

The establishment of Hawk Mountain Sanctuary by Mrs. Rosalie Edge and the Emergency Conservation Committee of New York City was the first step toward lasting protection. Mrs. Edge hired a young naturalist, Maurice Broun; together with his wife Irma and other volunteers, they worked to stop the hawk-shooting on the ridge and to educate the public about birds of prey. Broun established a systematic, daily raptor migration count that today stands as one of the world's longest-running databases on raptor populations. Through education and advocacy, Hawk Mountain and other groups gained final

Ten-year Average of Hawk Mountain Sanctuary's Fall Raptor Counts		
SPECIES	1987-1996	RECENT TRENDS
Black Vulture	38	+
Turkey Vulture	121	+
Northern Goshawk	68	?
Sharp-shinned Hawk	6,758	-
Cooper's Hawk	606	+
Red-tailed Hawk	3,901	-
Red-shouldered Hawk	280	-
Broad-winged Hawk	7,428	-
Rough-legged Hawk	12	?
Swainson's Hawk	<1	?
Golden Eagle	70	+
Bald Eagle	77	+
Northern Harrier	296	-
Osprey	648	+
Peregrine Falcon	36	+
Merlin	94	+
American Kestrel	640	-
Gyr Falcon	<1	?
<b>TOTAL</b>	<b>21,251</b>	<b>-</b>
"+" = increasing counts; "-" = decreasing counts, ? = unknown.		

protection for all raptors throughout the entire year by the early 1970s.

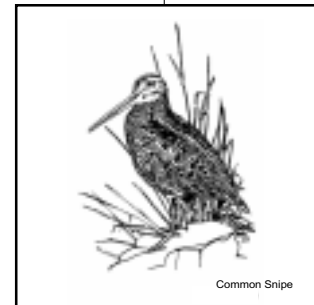
Today, more than 20 sites are monitored for hawk migration in Pennsylvania alone, and 200 more sites across the continent. The combined data from these sites has illuminated the importance of the Kittatinny Ridge as a migration pathway for eastern populations of raptors and other birds. The entire ridge has been designated a Pennsylvania Important Bird Area, and the place where hawk-watching was born – Hawk Mountain Sanctuary – has been designated a national Important Bird Area.

## Role of Topography

Place yourself above a topographic map of the eastern United States and imagine yourself to be a Sharp-shinned Hawk nesting in the slopes of the Green Mountains of Vermont, or an Osprey aside the shores of Lake Champlain, or a Golden Eagle on a cliff in Quebec. Imagine you're seeking a route to follow to your wintering grounds in the southeastern United States or Central America. Your eye cannot avoid the Appalachian Mountain chain as it arches prominently out of the northeast. The Kittatinny, starting in New York as the Shawangunk Mountain, is particularly riveting.

The Kittatinny Ridge is the eastern-most ridge of the central Appalachian Mountains. It and the other parallel ridges that snake through central Pennsylvania, are part of the Ridge and Valley geological province, with the Kittatinny, or Blue Mountain, forming the boundary between the Appalachian and Great Valley sections of this geological province. Soils of the ridges date from 300 to 570 million years of age and are comprised primarily of sandstone, shale and limestone. The Endless Mountain, or Kittatinny, arose during a great mountain-building event about 225 million years ago. In this event, the mountain was pushed skyward and folded and twisted. This dramatic event, coupled with subsequent erosion of softer sediments, left us with the dramatic spine-backed ridge we see today.

The Kittatinny Ridge today is largely comprised of Tuscarora sandstone or quartzite, a hard, gray rock. Ridgetop outcroppings are characterized by a jumbled pile of large angular boulders, and rock slides or boulder fields appear regularly along slopes. The softer soils and shales eroded into the valleys sustain a rich agricultural heritage nestled against the mountain slopes throughout the state. At the southern edge of the Great Valley Section of the Ridge and Valley Province lies a smaller, older mountain range – the South Mountain. A small gentle ridge or series of hills 20 to 30 miles south of the Kittatinny, the South Mountain also offers an occasional vantage point on the migration, particularly on the southerly winds of spring. Many of the other ridges of the Appalachian chain are similar in topography and geology to the Kittatinny. In some cases, such as Second Mountain near Harrisburg, their proximity may dominate the profile of the main Kittatinny Ridge



Common Snipe

and steal the migration stream for a time. Other ridges, such as Bald Eagle Ridge near State College, have significant flights of which we are just beginning to learn. Yet, throughout the state, it appears that Kittatinny – home to more than 15 sites with an estimated annual fall flight of more than 15,000 hawks, and spring flights of several thousand hawks, reigns in significance as a migration pathway for birds.

## Riding the Ridge

The Appalachians are comprised of many ridges running parallel in a southwesterly arc through the state, but the Kittatinny is distinct as a migration flyway for several reasons. First, the ridge is the southeastern-most ridge of this mountain system. The topography further south and east in the Great Valley Section is comprised of a disarray of low, rolling hills. Significant air turbulence occurs over this type of landscape, which can prove difficult for a hawk to negotiate, particularly on windy days. Secondly, the Kittatinny is one of the more prominent ridges of the system, rising 1,000 feet or more above the valley floor along much of its extent. This prominence and the aspect of the ridge slopes creates air currents ideal for migration. Also, it's one of the most continuous of the ridges in the chain, extending with few breaks from New Jersey and New York west and south to Maryland, providing ideal conditions for migration all along its face. Lastly, the ridge follows a route that many of the hawks need to travel, curving south and west to the southern United States. All of these factors combine to make the Kittatinny a key route for northeastern raptors – a highway for hawks.

Thousands of northeastern raptors annually converge on the Kittatinny Corridor on their way to wintering areas from Maryland south through South America. They are drawn to the ridge by the wind currents that are created along its steep rocky slopes. Hawks and vultures, being large birds, need to save energy wherever possible on their long migration journey. After a cold front passage through the northeast, strong northwest winds often prevail. These winds strike the Kittatinny along its northerly face and are deflected upwards. Migrant raptors ride these updrafts much as a surfer might ride a wave along the shoreline, letting the wave of air carry them southwest along the ridge.

Other ridges in the Appalachian chain also create updrafts during cold front passage. The continuity of the Kittatinny and its position as the southeastern-most ridge are key in concentrating hawk migration streams along its front. The dramatic relief of its slope produces a strong updraft current for the hawks to use, and its continuous nature carries migrants with few disruptions in the stream. Large breaks in the ridges (as seen on other ridges) can disrupt the updraft current created with the autumn northwest winds. And, some birds may be blown off course or off ridge. Also, as the southeastern-most ridge before the Great Valley, the Kittatinny is the ridge of last resort during the fall migration and thus captures remaining birds from other ridges

to the north and west. Birds that have been blown off of other ridges may sense the arduous turbulence of air currents over the Great Valley, hugging the Kittatinny longer and harder than they might the others. Thus, the Kittatinny collects the migrants from other northern ridges and holds its migrants longer.

When north winds ebb, the hawks converge on the south slope of the Kittatinny ridge, where a second energy-saving current is created – thermals. Thermals are hot, rising bubbles of air that are created wherever the earth's surface is heated at differential rates. The south-facing slope of the mountain warms faster than the valley floor or north slope, and rock slides warm particularly well. Thus, the south face of the Kittatinny Ridge forms a “thermal street” with lines of thermals created along the south face. Hawks use these thermals by circling upward or soaring in the hot, rising air current until they reach the top and then gliding southwest along the ridge until they find the next thermal and rise upward again. Thermal-soaring is a slower migration technique, as the birds spend significant time circling upward. However, it is an effective energy-saving way to move southward, and highly important for buteos and other large-winged birds such as eagles.

During thermal flight, many migrant hawks appear to migrate over a wider pathway, taking advantage of the prevalence of thermals over the Great Valley, and suburban areas of southeastern Pennsylvania. Hawks also fly higher and are harder to spot at ridgetop hawk-watch sites during thermal flight.

In the spring, the Kittatinny can provide an ideal migration front-line on strong southerly winds. Spring raptors migrate north on warm fronts and concentrate on the Kittatinny with southerly winds to take advantage of updrafts on the south slope. Overall, spring raptor numbers are reduced as compared to the fall, but more research is needed on defining spring pathways through the Appalachians, as few Pennsylvania sites have attempted continuous coverage.

## The Migration

Sixteen species of hawks and two species of vulture can be sighted annually on the Kittatinny Corridor. Of these species, two are extremely rare, but sighted nearly every year – the Swainson's Hawk and Gyrfalcon. A seventeenth species has recently been added to the list for a few sites – the Mississippi Kite.

Annual fall counts of visible raptor migration average near 20,000 during recent years, and annual spring totals are estimated at 3,000-5,000 (estimated because most sites do not have daily coverage). Only Hawk Mountain has published consistent, daily coverage over many years; but, it's likely that counts from Hawk Mountain represent the migration occurring along most of the eastern half of the ridge. The true number of raptors using the flyway is difficult to determine as



many hawks may fly high, well beyond the view of count sites. The published counts of visible migration from any site should be considered minimum estimates of numbers using the flyway.

The most abundant species using the flyway are the Broad-winged Hawk, Sharp-shinned Hawk, and Red-tailed Hawk. The highest one-day count of migrants occurred on September 14, 1978 at Hawk Mountain Sanctuary where a total of 21,448 hawks were seen from North and South lookouts. Normal peak daily counts along the Kittatinny usually vary from 1,000 to 3,000 hawks in a day, with an average daily count of several hundred hawks at the height of the migration from mid-September through mid-November.

Many migrants may fly along the ridge for most of the distance through the state; others may only use the ridge for a short distance. During fall, Broad-wings usually veer southwest off the Kittatinny before Harrisburg and fly down the South Mountain flyway. Some researchers suggest that Broad-wings are following a specific flight line rather than relying on topographic features for lift. On favorable winds (northwest, moderate speed), Hawk Mountain researchers have determined that single Redtails may stay on the ridge for 75 miles or more. Communication among hawk-count sites over the years suggests that some eagles may stay on the ridge from New Jersey well past Carlisle when winds are favorable. When winds are more southerly in the fall, hawks seem to migrate over a broader front away from the ridge, others may rest and feed, awaiting the next frontal passage.

Recent expansion of hawk count site-coverage at Waggoner's Gap, near Carlisle, and other central Pennsylvania sites, has documented that a significantly greater number of Golden Eagles may be seen at Kittatinny Ridge sites north and west of Harrisburg. These data suggest that some migrants may enter Pennsylvania on the more northwestern Appalachian ridges, and skip down to the Kittatinny west of Hawk Mountain, perhaps along the Susquehanna River. The Bald Eagle Ridge near State College records a substantial flight of Golden Eagles in fall and spring. These migrants may never converge to the Kittatinny at all. Such observations, coupled with count results from New York and limited satellite telemetry data, suggest that the main flight line for eastern Golden Eagles may pass through central Pennsylvania. Further research is needed to better define these different flyways and how they may or may not interact. However, excepting Golden Eagle flights, the Kittatinny Corridor receives nearly twice the migration volume of any other Pennsylvania ridge. In summary, Kittatinny sites east of the Susquehanna River tend to record higher counts of all raptors, most notably Broad-winged Hawks. West of the river, Kittatinny sites record higher counts of Golden Eagles and often Red-shouldered Hawks, but lower overall raptor numbers (excepting Waggoner's Gap).

## The Eastern Flyway Source

Raptor migration through the continent can be divided into four main regions – Eastern Flyway, from Lake Ontario east and south to east Texas, Florida, and Mexico; Central Flyway, around the Great Lakes and down to Texas, southern states and eastern Mexico; Inter-Mountain Flyway, through the Rockies, south to west Texas and Mexico; and West Coast Flyway, from British Columbia south to California and Mexico.

Banding data and raptor migration count reports suggest that there are two main corridors to the Eastern Flyway – along the Atlantic coast, and inland down the Appalachians. The breeding range of the birds using the two flyways largely overlaps. Exceptions occur at the edge of the breeding range, as hawks nesting to the farthest east of eastern North America (e.g., Nova Scotia, New Brunswick and eastern Maine) appear to consistently fly south along the coastal route, and birds in central Ontario appear to fly inland along the Appalachians. The separation of hawks into the two flyways in the overlapping region of the northeast appears to occur according to age, with young birds flying down the coast, and adult birds predominantly using the Appalachians.

Band returns from hawks captured on the Kittatinny Corridor suggest that the ridge migrants breed throughout the northeastern United States, from eastern Pennsylvania north and east through New England and eastern Ontario, and east nearly to the coast. In addition, for some eastern raptors, breeding densities are higher at the northern latitudes (e.g., Sharp-shinned Hawk, Broad-winged Hawk) or they may rarely breed south of the Canadian border in the east (e.g., Golden Eagle, Merlin), placing Pennsylvania south of a main portion of the breeding areas for eastern raptors.

Winter ranges vary with the species. Only four Kittatinny migrants fly south into Central and South America – Osprey, Broad-winged Hawk, Peregrine Falcon and Merlin. All others winter from southern Pennsylvania south to Florida and west to eastern Texas. Because many migrants, such as Red-tailed Hawk and Sharp-shinned Hawk, may winter in fairly large numbers from southern Pennsylvania south through Virginia, the volume of raptor migrants diminishes south of the state line. Thus, Pennsylvania migration count sites are uniquely situated geographically to count and monitor eastern raptors populations, as they are south of the main breeding densities of raptors, and north of the main wintering areas.

## Migration Timing

On the first cold front of July, hawk-watchers who venture to the Ridge can spot the first south-bound American Kestrel, Bald Eagle, and Broad-winged Hawk. In 1996, Hawk Mountain counters recorded

the first migrants on July 19. Most fall raptor migration occurs between mid-August and mid-December, with peak species and numbers between early September and mid-November. Different species head south at different times, with Broad-winged Hawks dominating the September traffic, and Sharp-shins and Redtails taking the October and November lead thereafter. Early October days can bring the highest diversity, with accipiters and falcons at the height of their migration.

November is a time for eagles, with both Golden and Bald eagles heading south in notable numbers. Goshawks and Redtails also reach their peak flights in November. In December the daily numbers of migrants are few, but the rarer species, such as the Rough-legged Hawks and the occasional Gyrfalcon, are most likely. Some migration continues into early January as lingering eagles and hawks are pushed south by snow and ice.

Different segments of a species' population often migrate at different times, with immatures migrating first and adults last, or males migrating after females, as with the American Kestrel. In addition, birds from different breeding latitudes may pass through at different times.

Daily timing of migration varies among species as well. Soaring birds such as buteos and eagles tend to fly during mid-day or afternoon hours when lift is at its maximum. Accipiters tend to peak during the late morning along the ridge.

In spring, the migration begins on winter's heel. The last to leave are the first to return, with late February bringing Redtails, eagles, and Rough-legs. By mid-March, the spring parade northward is in full swing. April is the busiest month for spring flights with kestrels, Sharp-shins, Osprey and Broad-winged Hawks hitting their peak flights during mid to late April. Spring flights continue through May with immature Broad-winged Hawks the last to push north.

## Migration and Weather

Broun was one of the first to define the weather patterns that produce large fall flights along the Appalachians. Raptors concentrate on the ridge in large numbers during the fall in the first two or three days following a cold front passage through the northeastern United States. The combination of barometric pressure change and a strong northwesterly wind bring large flights of hawks along the ridge during the fall. Analysis at Hawk Mountain suggests the frontal passage appears to concentrate the existing migration along the ridge, rather than inducing the migration to occur. At more southern sections of the ridge, the wind producing the best flights may vary. Between cold fronts, winds often switch to the south, the flight line widens across the valleys and birds often fly higher in altitude, making hawk-spotting difficult. Recent analyses also suggest that ridge-flying becomes more important later in the fall season as thermal height diminishes. Most

raptors appear not to fly in heavy rain, fog or snow. Some species may fly in a light rain, particularly when accompanied by strong winds. Hawk Mountain counters recorded a record one-day Osprey count, 175, on a blustery, rainy day in 1989.

Spring weather conducive for raptor migration on the Kittatinny seems to occur less frequently. The highest counts of migrants occur on southerly winds where northbound migrants use updrafts along the south face, heading northeast. Spring migrants are often seen cutting across the ridge or riding it only for a shorter distance. Some authors speculate that urgency to return to breeding territories and the abundance of thermals in the spring reduces the concentration of birds in the Appalachians. However, further research is needed into patterns of migration in the spring.

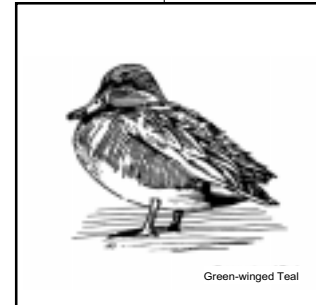
## Along the Slopes

Between fronts, some raptors may continue to push southward at a slower pace. Others appear to rest and feed, waiting the next push south. The choice of strategy may depend on the nature of the migration. Long-distance migrants such as the Broad-winged Hawk and Peregrine Falcon may not have the luxury of waiting for a good migration day. They have too far to travel and often appear to push south even in unfavorable weather. Other species such as the Sharp-shinned and Red-tailed hawks may rest and wait for conducive migration conditions. Research on raptor numbers in the valley adjacent to Hawk Mountain shows a reverse correlation with migration volume at the ridgetop, with more birds being sighted in the valley farm land when weather was not conducive for migration, suggesting that the migrants rest and feed along the Kittatinny slope between migration flights. Radio telemetry conducted on migrant Red-tailed Hawks also confirmed that birds tended to stop and roost along the Kittatinny flanks between weather fronts. Data show single birds may remain for several days or more before moving south again. Further research is needed to define migration stopover timing, habitat use and importance to migrants using the ridge.

## Migration Monitoring: Taking the Pulse

The Kittatinny Corridor and the migration that parades along its spine provide an ideal opportunity for wildlife managers and conservationists to monitor the environment. Because raptors are pinnacle predators, changes in their numbers can reflect ecosystem changes or problems. Maurice Broun's 1934 season count set the baseline for hawk migration counts that now provide one of the longest-running data sets on bird populations anywhere in the world.

These data have often been used to take the pulse of the environment. One historical use was when Rachel Carson used Hawk Mountain's Bald Eagle counts to document the impact of DDT on our environ-



ment. Since that time, the counts have been used regularly by state and federal agencies interested in wildlife populations. Since 1996, federal, state and private wildlife biologists have been working on developing a continental strategy for monitoring raptor populations. Migration counts are expected to play a key role in the strategy, as many raptors are too infrequently encountered on breeding grounds for consistent sampling.

Since the 1960s, raptor-banding stations have joined watchers atop the ridge. The many hours of banding have provided wildlife conservationists with important data on where migrants are coming from and where they are going. Through banding, we have learned many important aspects of the lives of the birds – how long they live, how far they fly, size and weight distributions, etc. We have also begun to discover the extent of overlap among the eastern flyways by distributions of recoveries. The access to the birds provided by the banding sites has also allowed us to investigate population declines and seek out possible causes (e.g., blood sampling of Sharp-shinned Hawks). Banding stations, along with the count stations, provide critical long-term data on raptor populations in eastern North America. Spaced along the Kittatinny Corridor, they work together as a vital research laboratory for compiling data on the health of the environment in eastern North America, ready to warn us before the next silent spring descends.

## Current Trends

In recent years, many of the raptor species that migrate along the Kittatinny have shown a positive trend in their numbers. Bald Eagles, Osprey, Merlin and Peregrine Falcons were once rarities along the ridge. Today, their Kittatinny count numbers show encouraging increases in numbers that parallel known population recoveries. Other species seem to be on a decline. Northern Harrier and Red-shouldered Hawks, two species associated with wetland habitats, are both on a slow steady decline. Red-tailed Hawk and American Kestrel also show a recent decline – perhaps reflecting the decrease in agricultural or open areas in northeastern United States. Broad-winged Hawks also show a possible recent unexplained decline. In most cases, the declines appear linked to changes in habitat or the environment on breeding or wintering ranges, rather than on the migration route.

## The Other Migrants

Two-thirds of all forest-nesting species of the eastern United States migrate to tropical and sub-tropical wintering sites each year. Many other northeastern birds migrate to the southern United States through Pennsylvania. More than 150 non-raptor migrant species have been recorded passing by Hawk Mountain Sanctuary's ridgetop lookouts during fall migration since 1983. Twenty of these are water birds (ducks, geese, herons, etc.) and tend to migrate cross-ridge at a north to south

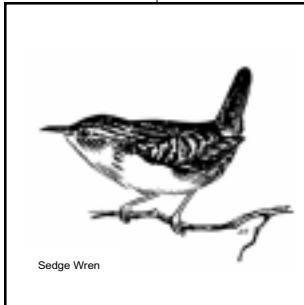
angle, heading to the productive Atlantic coastal bays for the winter. One of the most spectacular of these cross-ridge migrants is the Common Loon, with peak daily flights numbering in the hundreds during early November. Counts of waterfowl and herons have been recorded by hawk-watch sites since the 1930s, and similar to the hawks, form a valuable long-term database on eastern populations. Similar waterfowl flights are observed in the spring as well.

Many diurnal migrants as diverse as the Ruby-throated Hummingbird, Evening Grosbeak, Short-eared Owl and American Crow follow the ridge slope to the southwest, as do the raptors. Data on the nocturnal songbird migration along the ridge are scarce; however, flocks are regularly recorded feeding around the mountaintop lookouts in early morning and at dusk. More than 100 Neotropical songbirds of 20 species or more are regularly recorded at the height of migration in late September. Some continuation of migration into early morning is occasionally noted, as migrants seek appropriate feeding and resting sites.

Research comparing songbird migration from the coast inland at banding locations and communications tower kills suggested that some songbirds may migrate down the Appalachian chain in higher numbers than elsewhere. Species suspected of being more abundant in the Appalachian flyway included the Least Flycatcher, Eastern Wood Pewee, Black-throated Green Warbler, House Wren, Nashville Warbler, Indigo Bunting, American Goldfinch and others. The Appalachian Mountain chain may host a large proportion of the inland migration of Neotropical land birds from the north-central and eastern parts of the continent. The concentration occurs in part because more Neotropical migrant land birds breed in eastern states as compared to western or central states, and birds nesting in central Canada and the United States tend to migrate east of their breeding range. Large numbers of songbirds concentrate along the Atlantic coastline and along the Appalachian Mountains, particularly in fall. For songbirds as well as raptors, some authors suggest a greater proportion of adults can be found inland as compared to at the coast.

For some songbird migrants, numbers appear to increase along the Kittatinny to its southern extent. Comparative counts of Ruby-throated Hummingbird, American Goldfinch and Blue Jay between Hawk Mountain and Allegheny Front, West Virginia, show higher counts of all three species in West Virginia, suggesting more southerly sections of the Appalachians may also receive a greater concentration of non-raptor migrants. For instance, counts of American Goldfinch at Hawk Mountain range from 500 to 1,000 each fall, while counts at Allegheny Front Migration Observatory in West Virginia number from 1,000 to 5,000; and hummingbird counts on the Allegheny Front in West Virginia are two to four times higher than at Hawk Mountain. The Allegheny Front Migration Observatory has banded and counted migrants since 1958 on the Allegheny Front, one of the central

Appalachian ridges originating in central Pennsylvania. This long-term data collection demonstrates the great passerine migration occurring along all the Appalachian ridges. Through 1981, they banded 109 species with maximum annual numbers over 1,000 for some northern nesting warblers (e.g., Blackpoll, Tennessee, Cape May). Some rarely observed migrants are captured as well, with 268 Philadelphia Vireos captured from 1958 through 1981.



## ‘Ridgeside’ Rest Stops

Migration can present considerable risks to birds. They are traveling long distances, traversing unknown areas and encountering inclement weather and other adverse factors along the route. The availability of suitable resting and feedings sites along the route can be critical to their survival. Nocturnal migrants appear to select habitats for resting and feeding between flights according to food availability, predation risk and other factors. If suitable habitat is not available along the migration route, birds may spend up to several hours exploring to find suitable areas for resting. If habitat is dramatically degraded along the route, migrants may have to expend considerable energy to find food when their energy stores are already depleted. The time spent at a stopover site may vary with nutritional status and weather as well as stopover site quality. Some species have been observed to set up temporary territories in a stopover site and defend it for several days (e.g., Northern Waterthrush). Such observations suggest that suitable stopover sites may be limited and worth defending. Migrants in need of refueling or rest seek out the optimum habitat for the resource they demand. The morphology of different groups of birds may determine which habitats they can feed in, even during migration.

In the fall of 1996, a study of Saw-whet Owl migration along the Kittatinny Ridge was conducted just east of Hawk Mountain near Kempton. Seventy-seven migrant owls were captured and banded, a larger number than was observed at more traditional owl-banding locations in Cape May, New Jersey, and Cape Charles, Virginia. Future work may determine the extent to which owls may use the same high-way as the hawks.

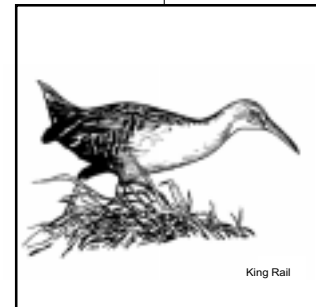
## Migrant Conservation in the Flyway

Because of the regional and state significance of the Kittatinny Corridor to migrant raptors and other birds, protection of these species and this natural spectacle may depend on a careful, integrative approach to management and land use along the mountain. Similar management considerations for other ridges in the Appalachian chain that have documented regular and significant numbers of migrants may be warranted as well (e.g., Bald Eagle Ridge and Allegheny Front).

One of the first conservation priorities is to protect habitat for migrants. Considerable energy is used by migrant birds on their journey.

Most cannot store enough fat to fly between breeding and wintering areas without refueling. The availability of stopover habitat along major migration routes appears critical to the survival of many migrant birds. Some species may actually avoid flying over habitat unsuitable for stopover use (e.g., radio-telemetered migrant Red-tailed Hawks have avoided crossing cities).

Migrants may rest and feed for several hours up to several days. A lack of suitable habitat for stopover feeding and resting can contribute to population declines as migrants may not have the energy to search far and wide for appropriate habitat. Thus, the protection of a variety of natural habitats along the Kittatinny Corridor may be important for providing resting and feeding opportunities for the wide variety of migrants using the flyway. Large undeveloped tracts, with forest, shrub and field habitats provide the diversity and volume of food needed to support the numerous migrants – both raptors and non-raptors.



As migrant raptors and other birds course down the Kittatinny's slopes, they're often flying just above treetop level, using the favorable air currents created along the ridge line. This highway for birds can be dangerously interrupted by towers, poles or buildings that protrude above the tree line. Such structures present dangerous hazards to migrant birds, particularly for nocturnal migrants or birds flying in inclement weather. Recent estimates of the numbers of birds killed by colliding with towers and buildings number more than 1 million per year, with plate-glass collisions numbering more than 97 million birds. Vehicle collisions are estimated to kill 57 million birds annually. The recent increase in towers placed along ridgetops very likely poses an increased threat to migrant birds.

Lighted structures can pose a heightened threat, as birds may become confused, particularly on cloudy evenings. The cloud cover is hypothesized to capture the light and create a lighted area around the structure. Nocturnal migrants, then, are attracted to the light and tend to continue to fly toward it, thus flying in a circle until hitting wires or becoming exhausted. Of the nocturnal migrants, warblers and vireos appear particularly susceptible to tower or structure collisions, with more than 80 percent of tower or building kills being wood warblers. The literature is sprinkled with reports of notable numbers of birds killed in single nights or over a several-day period. For example, at a Tennessee television tower, 104 Gray-cheeked Thrushes were killed May 2, 1964, and 880 Palm Warblers on October 9, 1955. A building in Florida was recorded to kill 847 individuals of 21 species over a two-day period in the spring. In most cases of large kills, the numbers are largest during migration in spring or fall, and the towers or buildings with large kills are placed along migration corridors (e.g., Florida coastline).

Raptors are also regularly recorded to have collisions with power lines, towers, etc. Bald Eagle mortality summaries documented that 215 of

the reported eagle kills from 1966 to 1974 were from accidents. Golden Eagles in the western United States are regularly killed in collisions with power poles and windmill facilities. As diurnal migrants, raptors may be able to avoid some of the hazards that nocturnal songbirds face. However, the wires associated with large towers are often difficult to see and can cause physical injury or even electrocution to large birds. In addition, on days with strong winds, raptors on the Kittatinny flyway may fly below treetop level, particularly species accustomed to flying amid trees such as the Sharp-shinned Hawk and Cooper's Hawk. Electrocution from power lines affects other large flying birds such as herons and cranes as well.

Management of the Kittatinny Corridor should include limiting the number of towers or other structures placed at or near the top of the mountain ridge. If structures are necessary, they should not exceed the height of the surrounding ridgetop vegetation. In addition, use of lighting should be limited and designed to minimize dispersion into the sky. The latest research results on minimizing songbird kills at structures should be consulted, as some lighting can have less of an effect than others. Buildings on the ridgetop should be discouraged, but if necessary, should be designed to minimize kills on the building and window glass.

In summary, to protect the critical flyway for raptors and songbirds along the Kittatinny, conservation agencies and managers must strive to restrict the placement of structures along the ridgetop, and limit development and intensive human uses along slopes to low-density housing, rural businesses, agricultural uses, forestry and other low-impact, low-density uses. Regularly occurring or continuous forest cover along the mountain should be maintained to provide maximum feeding and roosting opportunities for raptor migrants. A matrix of openings with native grasses or grains along the base of a slope, interspersed with shrub thickets, can provide feeding opportunities for a diversity of migrants, from sparrows to Northern Harriers. Outdoor recreation, including hiking, bird-watching, hunting and camping can be encouraged as compatible uses of Kittatinny lands.

Perhaps the best approach to management along the migration corridor is to take a bioregional management perspective, encompassing the entire ridge. Such an approach, although more complex, would provide for migrants using the ridge along its entire extent and thus ensure effective long-term conservation.

The Kittatinny Corridor is one of the most important flyways for birds in the eastern United States. Pennsylvania is fortunate to have this great natural resource in the Kittatinny and the other Appalachian ridges. If we total the more than 80,000 visitors that annually travel to Hawk Mountain Sanctuary in Kempton with the uncounted visitors that visit the other hawk-watching sites on the ridge, the Kittatinny also attracts a considerable number of tourists to its

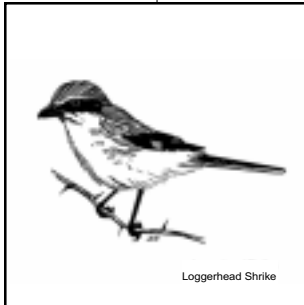
mountaintop vistas to view the migration and to enjoy the surrounding scenic beauty. A recent survey estimated that Pennsylvania ranked fourth in the nation in retail sales related to bird-watching, emphasizing the economic benefit of protecting the Kittatinny Corridor as an Important Bird Area, as well as the ecological benefit.

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