BALD EAGLE MANAGEMENT PLAN

FOR PENNSYLVANIA (2010 – 2019)

Photo Credit: Hal Korber

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May 2011

EXECUTIVE SUMMARY

The recovery of the bald eagle (*Haliaeetus leucocephalus)* in Pennsylvania has been a cause for celebration by a diversity of citizens that enjoy wildlife. It is one of the most recognizable and admired birds of the Commonwealth, the nation, and the world, and as such has its place on the Pennsylvania Game Commission's logo. A fairly short time ago, it was rare and locally distributed in the state. The bald eagle has long been a symbol of not only the nation, but also of the modern threats faced by wildlife. The bald eagle was first listed as a federally endangered species in 1967, and on 2 February 1978, it was listed as endangered or threatened throughout the United States. In the Chesapeake Bay watershed, which includes the eastern half of Pennsylvania, lower productivity resulting from the pesticide DDT and other contaminants was identified as the major limiting factor. Shooting, disturbance, and habitat destruction also contributed to this decline. After the 1972 Environmental Protection Agency ban of DDT the bald eagle populations began to recover throughout their range. Nationwide, the species has increased to the point where the U.S. Fish and Wildlife Service removed the bald eagle from threatened status under the Endangered Species Act in June 2007. The comeback in this region is attributed primarily to the reduction in the use of environmental contaminants.

Prior to the 1960s, most nesting records in Pennsylvania came from the Pymatuning region in Crawford County, the lower Susquehanna River and its West Branch, and some southeastern counties. Hacking and fostering between 1979 and 1989 helped to promote a small breeding population in the state, and since 1992 population growth has been steady from these core areas. The long-range recovery goal has been to attain a population that would warrant the removal of the species from the state's endangered species list. The state's eagle population passed the 100-nest mark in 2006 with 116 nesting pairs and continued growing to 156 active nesting pairs in 2008, the first year greater than 150 nests were documented. Nest success rate regularly exceeds 70% each year. The population also is growing in geographic extent with pairs nesting in at least 48 counties in 2009. Even though eagles ordinarily choose quiet areas with low human usage, this expansion brings bald eagles into more contact and potential conflicts with humans. The development of shoreline habitat may be the greatest limiting factor for bald eagle populations in the state. There is persistent, but infrequent, direct persecution of eagles and other raptors. So, despite the progress, there will continue to be challenges with bald eagle management.

This management plan for the bald eagle was designed for a 10-year period beginning in 2010. The mission of this plan is to increase and maintain bald eagle populations in suitable habitat that contributes to sustaining its population throughout the Commonwealth for the foreseeable future while providing recreational viewing opportunities for the citizens of Pennsylvania. The criteria to consider eagles recovered is a self-perpetuating nesting population of at least 150 pairs with a productivity rate of at least 1.2 eaglets per successful nest and 60% of known nests successful over a 5-year period. This objective is expected to be reached by 2012 if recent population trends continue. Protections and management strategies for this species have been successful and will continue under the authority of the Bald and Golden Eagle Protection Act. The agency will turn to more proactive, educational, and cooperative measures to advance the conservation of the species and protect it as much

as the changing regulatory environment will allow. This charismatic symbol of wildness and high habitat quality can be used to promote conservation of a diversity of life forms that occupy the same environments used by bald eagles that so many Pennsylvanians cherish. With such a popular flagship conservation species, we anticipate widespread voluntary protection and cooperation with the agency's management plan beyond regulations imposed upon these organisms.

SECTION I. MANAGEMENT GOALS, OBJECTIVES, AND STRATEGIES

MISSION STATEMENT: To establish and maintain secure bald eagle populations in Pennsylvania and provide recreational viewing opportunities for the citizens of Pennsylvania

GOAL 1. Sustain a minimum of 150 nesting pairs, including successful pairs in at least 40 counties, with 60% of known nests successful and productivity of 1.2 eaglets fledged per successful nest, based on a 5-year running period.

Objective 1.1: Annually monitor nesting bald eagle populations.

Strategies

1.1.1 Annually involve the public in bald eagle surveys.

1.1.2 Compile an annual inventory of all known breeding territories (nesting pairs) through 2017.

1.1.3 Annually update USFWS post-delisting eagle monitoring database.

Objective 1.2: Annually assess and address factors potentially affecting nesting eagle productivity and populations.

Strategies

1.2.1 Starting in 2011, annually determine principal causes and rates of nest failures.

1.2.2 Annually track nest failures to determine if human interference is affecting nest success and productivity in regions or state-wide. By 2013, develop and implement guidelines to reduce impacts on eagle nest success and productivity.

1.2.3 Determine level of effort needed to obtain a representative sample of annual eagle productivity (young) after status is changed to "Secure".

1.2.4 By 2013, develop and implement guidelines to reduce impacts on eagle nest success and productivity.

Objective 1.3: Delist bald eagles from threatened status to secure, protected status when the average nest success, distribution, and productivity objectives are achieved.

Strategies

1.3.1 Collaborate with and solicit comments regarding delisting from the Ornithological Technical Committee (OTC) of the Pennsylvania Biological Survey.

1.3.2 Prepare official documentation of bald eagle status as secure and advance a proposal for agency staff review, followed by submission of a 58 Pa. Code regulations amendment for consideration to the Board of Commissioners.

1.3.3 Develop a process for reevaluating the status of bald eagle in Pennsylvania after delisting if the population trend reverses and the active nest total reaches 100 active nesting pairs.

GOAL 2. Maintain bald eagle populations outside of the nesting season at the level of 2006-2010 averages for winter and migrating populations.

Objective 2.1: Annually monitor non-breeding bald eagle populations.

Strategies

2.1.1 Annually coordinate statewide mid-winter bald eagle counts with a diversity of partnering individuals and organizations.

2.1.2 By 2012, identify and study eagle winter communal roosts including site characteristics and activity levels.

2.1.3 Develop and implement a monitoring program for larger and regularly used winter roosts.

2.1.4 Monitor eagle migration populations at appropriate hawk watch sites in cooperation with Hawk Mountain Sanctuary, Hawk Migration Association of North America, and the Raptor Population Index.

2.1.5 Publicly acknowledge eagle watch volunteers.

Objective 2.2: Annually assess and address factors potentially affecting wintering eagle populations.

Strategies

2.2.1 Annually assess established winter eagle roosts that support a minimum of 10 eagles.

2.2.2 With conservation partners, monitor the eagle roost sites for disturbance that might cause their abandonment.

2.2.3 By 2013, develop and implement guidelines to reduce impacts on eagle roosts and their use by eagles.

GOAL 3. Protect, enhance and promote bald eagles and their habitat.

Objective 3.1: Prosecute all illegal killings and harassment of eagles**.**

Strategies

3.1.1 Make public the prosecution of illegal killing and harassment of eagles through news releases.

3.1.2 Publicly acknowledge officers who prosecute those who harm eagles and, when appropriate, those who assist the agency to stop these illegal activities.

Objective 3.2: Protect and enhance bald eagle nest locations.

Strategies:

3.2.1. Annually submit all bald eagle nest records to PNDI, PGC Environmental Management, and Pennsylvania U.S.F.W.S. office, incorporating conservation buffers on new locations.

3.2.2. Where necessary, place warning signs around and place predator guards on nest trees to enhance reproductive success, being more proactive on public lands where nests get more exposure.

3.2.3 Review options for management restrictions near eagle nests, including distance buffers, by 2012, and take steps to change restrictions as warranted by review.

3.2.4 Develop landowner conservation agreements to protect or enhance significant nest and roost locations.

3.2.5 Work with land conservancies to protect nests, roost sites, and concentration areas with conservation easements.

3.2.5. Protect all vulnerable bald eagle nests built on human-made structures such as power transmission structures and communications towers by working with the owners of the structures.

Objective 3.3: Promote bald eagle habitat protection.

Strategies:

3.3.1 Educate the public concerning eagles and their habitat needs.

3.3.2 Inform the public about eagle habitat conservation successes.

3.3.3 Publicly acknowledge cooperative landowners and organizations that help protect eagle nests and habitat.

GOAL 4. Improve and enhance public understanding, appreciation and viewing of bald eagles.

Objective 4.1: By 2011, develop and promote materials that educate the public about bald eagle biology and conservation.

Strategies:

4.1.1 Disseminate up-to-date eagle population and status information at the beginning of each nesting season and in July 4 press releases.

4.1.2 Develop guidelines and educational materials (brochures, web pages, and other options) about bald eagle natural history and conservation, eagle nest etiquette, and related subjects annually.

4.1.3 Promote the concept of flagship species conservation using bald eagle in that role with protection of other species associated with same habitat.

Objective 4.2: Enhance eagle viewing opportunities.

Strategies

4.2.1 Promote responsible eagle viewing opportunities.

4.2.2 Cooperate with birding/wildlife trail projects with eagle viewing sites.

4.2.3 Disseminate eagle viewing information through state and regional offices, the PGC website, and other media outlets.

4.2.4 Working with partners, create more eagle viewing opportunities.

ACKNOWLEDGMENTS

Dr. Paul Schwalbe developed the first draft of this document in the 1990s and Dan Brauning revised the draft management and recovery plan in October 2000 under the guidance of Jerry Hassinger. Many sections of those manuscripts remain in this version. Cal DuBrock, Eileen Butchkoski, and Bob Ross reviewed this manuscript at various stages. Executive Director Carl Roe and Bureau of Wildlife Management Director Cal DuBrock reviewed the document, made many valuable suggestions, and supported the process of revising this plan. Agency biologists Roger Coup, John Morgan, and Justin Vreeland and veterinarian Dr. Walt Cottrell reviewed the manuscript and made corrections and suggestions, Special appreciation is due to Glenn Therres, Peter Nye, Matt Sharp, and Brenda Peebles for reviewing earlier versions of manuscript and making valuable improvements. Recovery objectives were proposed by the Ornithological Technical Committee, at the time chaired by Bob Ross. Several members have commented either verbally or in writing about the plan, especially Dr. Todd Katzner, now of West Virginia University. Cathy Haffner contributed graphics and geospatial analysis for this manuscript. B. Watts of the College of William and Mary provided documents and insight concerning bald eagle nest turnover rates and other issues. Several members of the Mid-Atlantic Region's Bald Eagle and Peregrine Falcon committee made suggestions that were incorporated into this plan in some way. This plan also benefitted from reviews from other professional ornithologists and conservationists during the public comment period. These included Dr. Richard J. Clark (York College, retired), Scott Weidensaul (raptor researcher and writer), Dr. Brian Mangan (Kings College and the Susquehanna River Institute), Dr. Fred Brenner (Grove City College), Hawk Mountain Sanctuary (Drs. Keith Bildstein and Laurie Goodrich), Lehigh Gap Nature Center (Dan Kunkle), Dr. David Brandes (Lafayette University), Dr. Jerry Skinner (Keystone College), the Pennsylvania Society for Ornithology, Pennsylvania Falconry and Hawk Trust (Michael Kuringa), the Delaware Valley Ornithological Club, Donald S. Heintzelman (ornithologist and author), the Nature Conservancy (Dr. Scott Bearer), Dr. Ann F. Rhoads (Morris Arboretum), Pennsylvania Audubon (Phil Wallis, Dr. Sarah Sargent, Kim Van Fleet), Quittapahilla Audubon Society, Roaring Run Watershed Association, the North Branch Land Trust (Rick Koval), the Appalachian Mountain Joint Venture (Dr. Brian Smith), the Ornithological Technical Committee of the Pennsylvania Biological Survey (Dr. Margaret Brittingham, Chair), Western Pennsylvania Conservancy (Charles Bier), National Park Service (Al Ambler), the Eagle Institute (Lori McKean), and DCNR (Aura Stauffer). Many hawk watchers, eagle volunteers, birders, hunters, anglers, teachers, college students, photographers, and general citizens made comments and suggestions for the plan.

Since the 1980s, leadership by the Game Commission and the U.S. Fish and Wildlife Service fueled the recovery of bald eagles through protection, funding, and active reintroduction as outlined in this plan. Without these efforts, eagles would not have recovered as they have. Federal delisting of bald eagles in the 1990s and the prospects of recovery in Pennsylvania provide testimony to the successful efforts to protect and reestablish this species contributed by so many at the state and federal levels over the past three decades. Their legacy is the remarkable recovery of this magnificent and charismatic bird species that has received widespread support from conservation organizations and the public at large. The conservation officers, hunters, birders, eagle-watchers, river-watchers, and various raptor enthusiasts have supported the successful eagle recovery in many ways, for which we are extremely grateful.

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SECTION I: LIFE HISTORY

As a symbol of national pride, endangered wildlife, and the wilderness ethic, the bald eagle is one of the most revered and best studied of all North American wildlife species. It is a charter member of the list of "charismatic megafauna" of the country and one of the most recognizable birds in the world. There are well over 2,000 articles published about its biology and management including a published bibliography of publications up to 1979 (Lincer et al. 1979, Buehler 2000). There are two respected reference books on the species that provide a great deal of detail about the life history of the species (Stalmaster 1987, Gerrard and Bortolotti 1988) in addition to bird natural history series (Bent 1961, Buehler 2000) and general raptor references that in some way highlight this species (Johnsgard 1990, Weidensaul 1996, Clark and Wheeler 2001).

The natural history of the bald eagle has bearing on its management. Its diet, nesting behavior, and habitat preferences have defined both its vulnerability and its conservation potential. A review of its natural history is important to understand how the recovery of this species can continue despite its reputation as a sensitive indicator of wildness. Bald eagles have adjusted remarkably to the human-changed landscape of Pennsylvania and have found small islands of habitat even in our urbanized landscapes. It is a success story for both the bird and the programs that have produced one of the most remarkable recovery stories in the history of wildlife conservation.

Taxonomy

The bald eagle (*Haliaeetus leucocephalus*) is one of the largest members of the family Accipitridae, the diurnal raptors. As a member of the genus *Haliaeetus*, it is considered a "sea eagle" or "fish eagle" in the subfamily Haliaeetinae (Johnsgard 1990, Buehler 2000, Lerner and Mindell 2005). There are seven other members of this group of eagles including the very similar white-tailed eagle (*H. albicolla*) of Eurasia, Steller's sea eagle (*H. pelagicus*) of northwestern Asia, and white-bellied fish-eagle (*H. leucogaster*) of Southeast Asia, Indonesia, and Australia (AOU 1998, Ferguson-Lees and Christie 2001). It is not closely related to the other American eagle, the golden eagle (*Aquila chrysaetos*), that is a "booted eagle" in the subfamily Aquilinae, more closely related to Verraux's eagle (*A. verreauxii*) and Imperial eagle (*A. hialaca*).

According to tradition, there are two subspecies of bald eagle that are "tentatively recognized" by ornithologists: the smaller southern subspecies *H. l leucocephalus* Linnaeus, 1766, and the larger northern subspecies, *H. l. alascanus* Townsend, 1897 (Johnsgard 1990, Buehler 2000). The size of bald eagles increases with increasing latitude and is the basis for the designation of the two subspecies in the American Ornithologist's Union Checklist (1957) and subsequent documents, but the geographical limits of these subspecies are not well-defined and recognition of these subspecies has been doubted by some experts (Amadon 1983, Palmer et al. 1988). These subspecies have become more blurred as bald eagles expand their range and fill former range gaps and with the reintroduction of bald eagles using birds from other regions. The division between breeding populations of these subspecies was somewhat arbitrarily set at 40° North, with the larger subspecies found north. So, the Pennsylvania breeding population is part of the *H. l. alascanus* subspecies if these subspecies are accepted, but members of the southern subspecies also visit the state in post-nesting dispersal. It is notable that when bald eagle was

removed from the list of federally endangered species, there was no mention of sub-species (Buehler 2000).

Linneaus originally described the bald eagle in 1766 as *Falco leucocephalus*. His description was based on The Bald Eagle, *Aquila capite alba*, in Mark Cateby's *The Natural History of Carolina, Florida, and the Bahama Islands* (A.O.U. 1957, Buehler 2000). Since it does have feathers on its head, the bald eagle seems misnamed, but the word "bald" actually once meant "shining white" an illusion to its white, but not naked head (Choate 1985). The bald eagle has been given many names over the years including American eagle, American bald eagle, black eagle (young are nearly all-black), fishing eagle, gray eagle, white-headed eagle, white-headed sea-eagle, Washington eagle, and others in foreign languages (Terres 1980, Johnsgard 1990). Some of these names were used in reference to the young eagles (Warren 1890).

Physical Characteristics

With its conspicuous white head and tail, the bald eagle, *Haliaeetus leucocephalus*, is one of the most recognizable raptors in the world and one of the best-known of American birds. Along with the golden eagle, it is the second largest bird of prey in North America (Buehler 2000, Sibley 2000, Kochert et al. 2002); only the California condor (*Gymnogyps californianus*) is larger. Its size varies widely with northern birds generally larger than southern birds (Palmer et al. 1988, Buehler 2000). Its body mass ranges from 3.0 to 6.3 kg (6.6 to 14.1 lbs). (Palmer et al. 1988). Like most raptors, females are larger than the males (about 25% larger in bald eagles), but the sexes are otherwise similar. The total length ranges from 71 to 96 cm. (28 to 38 in) and wingspread from 169 to 244 cm (67 to 96 in). Features are summarized in Table 1.

Bald eagles are well-equipped to fly large distances and forage on a variety of fish, mammals, and birds (Gerrard and Bortolotti 1988, Johnsgard 1990, Buehler 2000). They have broad wings appropriate for both a powerful flight and for soaring. Bald eagles fly with slow, powerful wing beats and soar with wings at right angles from the body in a flat plane – giving them the "flying plank" nickname at hawk watches. Their large, sharp talons are capable of dispatching large prey items and their large beaks are capable of tearing apart carcasses of large mammals that they sometimes scavenge upon. Unlike the golden eagle which is a "booted" eagle, the tarsi of the bald eagle are not feathered.

The adult's body is dark brown with contrasting bright orange-yellow legs and beak (Clark and Wheeler 2001). A sub-adult plumage is acquired during a bird's fourth year that closely approximates the definitive basic adult plumage, but may include a few brown feathers in the head and the tail (McCullough 1989, Buehler 2000, Clark and Wheeler 2001). Bald eagles do not achieve their distinctive white head and tail, contrasting with dark body feathering, until they are 4 or 5 years of age, if not later (Gerrard and Bortolotti 1988, McCollough 1989). From age 5.5 years and older, the head and tail are pure white but some birds will show some dark flecking around their eyes even at 8.5 years (McCullough 1989).

Adult bald eagles are easy to distinguish from other species, but the immature plumages are easily confused with other large raptorial birds, especially the golden eagle. Immature bald eagles also can be confused with other raptors, especially in flight (Dunn et al. 1988). Besides

the golden eagle, species with which the bald eagle is most commonly confused are turkey vulture (*Cathartes aura*), black vulture (*Coragyps atratus*), osprey (*Pandion haliaetus*), red-tailed hawk (*Buteo jamaicensis*), rough-legged hawk (*Buteo lagopus*), and other raptors. It is a common exercise at wildlife education centers and in hawk identification books to show the differences in flight profile, plumage, and behavior between these species. The osprey is much smaller than the bald eagle and flies with crooked wings (more like a gull than a hawk or eagle) rather than with the wings held flat like bald eagle (Dunn et al. 1988, Wheeler and Clark. 1995).

Table 1. Characteristics of different age and plumage classes of bald eagle, following McCollough 1989.

Plumage Class	**Juvenile**	**Basic I**	**Basic II**	**Basic III**	**Basic IV**	**Basic V / Adult**
Age	½ year	1 ½ year	2 ½ year	3 ½ year	4 ½ year	5 years +
Beak and Cere	Blackish gray	Mostly brown-gray	Buffy yellow, dark tip	Mostly yellow	Yellow to orange-yellow	Bright orange-yellow
Iris	Sepia brown	Buffy brown	Light cream	Pale yellow	Pale yellow	Pale silver-yellow
Head Plumage	Dark brown with some white on nape	Brown with tan crown & buffy superciliaries	Brown with whitish superciliary line, smoky-gray crown	White, dark streaks behind eye.	White, some black streaks (osprey-like)	White
Chest	Dark brown	Dark bib-like pattern contrasts with lt. neck	Darker than Basic I.	Black-brown	Black-brown	Black-brown
Belly	Dark brown	Usually white, but variable	Mostly brown.	Mostly brown, some white flecks.	Black-brown	Black-brown
Wing	Dark brown. Serrated trailing edge in flight	Dark brown upperwing coverts	Dark brown with less white mottling.	Dark brown with some white mottling.	Black-brown	Black-brown
Back	Dark brown	Most have mottled V	Sometimes V or triangle, less distinct than Basic I.	Dark with some white flecks.	Black-brown	Black-brown
Tail	Brown to sooty, white on some feather bases	Some white, dark tip, shorter than juvenile	Mostly dark.	White with dark tips and edgings.	White, lacks dark terminal band	All white, occasional dark flecks
Other notes	Nearly all dark with whitish axillars	Also pale variant with extensive pale patches.	"Osprey" face.	Nearly adult, white nape feathers extend partly down neck.	Some fine black streaks on head.	Can have some flecks of brown or gray in head or tail.
Former Terminology Clark and Wheeler (1987)	Immature	White-belly I	White-belly II	Adult transition	Adult	Adult

There is considerable variation in the immature plumages of the two North American eagles according to age, particularly in their third year. Generally, immature bald eagles are chocolate brown with white axillary spots and varying amounts of white in the underwing coverts. This is in contrast to the immature golden eagle, which has white patches at the base of the inner primaries and outer secondaries. The difference in the location of white on the underside of the wing is a major point of differentiation between the immatures of the two species. The tail of the golden eagle at this stage has a white base with a wide, dark brown sub-terminal band, while the tail in the immature bald eagle is mostly darkish to dirty white (Table 1).

In flight, several characteristics distinguish the bald eagle from the golden eagle (Dunn et al. 1988, Clark and Wheeler 2001). The bald eagle soars with its wrists "cocked forward" so its head and neck protrude half the length of the tail or more, while the golden eagle's head protrudes less than half-length of the tail (Clark and Wheeler 2001). The golden eagle's tail protrudes behind the bird about 3 times as much as the head protrudes in front (Dunn et al. 1988). The bald eagle's massive bill also is a good field mark (Dunn et al. 1988). The bald eagle's flight profile is very flat, while the golden has a profile similar to buteo hawks. The golden hackles are a diagnostic field mark for a golden eagle of any age or plumage. Bald eagles begin gliding after an active flight with a downstroke of their wings while golden eagles initiate gliding with an upstroke.

A classification of bald eagle plumages, based on age class, was developed (McCollough 1989) and now is used in standard raptor identification literature (Johnsgard 1990, Clark and Wheeler 2001). There is a great deal of variation in plumage, particularly in the Basic I – IV plumages Molt also is a confounding factor in precisely describing plumages and categorizing eagles by age class.

Habitat Requirements

Nesting Habitat: Most nest sites are found in wooded areas in the vicinity of bodies of water or marshes (Andrew and Mosher 1982). Bald eagles often use super-canopy nest trees that afford easy flight access from the nest to feeding areas and a clear view of the surrounding area (Buehler 2000). Some nests are located in isolated trees located in farmland, suburbs, golf courses, or marshes. Some new nests are in a fairly narrow band of trees along a river or a lakeshore. They reach their greatest densities in timber stands that provide various species of tall dominant trees with stable limbs in an open structure, providing an easy flight pathway through unobstructed air. As a large raptor, they require a substantial food base of medium and large-sized fish near their nest (Johnsgard 1990) and benefit from access to shallow water where fish are easily accessible. The nest typically is placed in a fork, often the highest triple branch crotch, near the crown of a tree, usually 40 to 100 feet (12 to 30 m) above ground. In Pennsylvania, the bald eagles' preferred nesting trees are the eastern white pine (*Pinus strobus*), sycamore (*Platanus occidentalis*), northern red oak (*Quercus rubra*), red maple (*Acer rubrum*), and tulip poplar (*Liriodendron tulipifera*). Although bald eagles nest on cliffs in other parts of their range, there are no modern records of cliff nests for Pennsylvania (Leberman 1992). There are reports of cliff nests along the Lower Susquehanna over a century ago (Stone 1894). Only two nests

found in recent years might be considered cliff nests, but both are supported by a tree and not built on the rock face.

Optimum conditions for nesting success may be assumed to exist when mature timber exceeds 75% of the land area (Peterson 1986) in a wetland complex. Most eagle nests in Pennsylvania were built in view of a large body of water. The majority of eagle nests are less than 1 mile (1.6 km) from the primary food source, but some may be up to 2 miles (3.2 km) from their feeding areas. The usual nest situation is found far from human activity and development; however, some eagles have built nests close to some types of human activity such as residences, highways, airfields, and railroad tracks. An increasing percentage of eagle pairs are nesting in close proximity to human habitations, often in protected "green zones" dictated by land ownership and management. Public water supply reservoirs lend themselves to these conditions because the water company usually keeps the land around the reservoir well-forested, protected from motorized vehicle traffic, and restrict motorized watercraft. Some of these conditions exist in populated areas of the state where waterways are protected from pollution and outdoor recreational activities are promoted near streams and reservoirs.

Like ospreys, bald eagles occasionally will nest on human-made structures (Postupalsky 1978). Aberrant examples include a man-made stick nest placed in an 80-foot pine tree near an active nest on the New Jersey side of the Delaware Bay, and eagle nests on the steel supports of large electric transmission structure and on a 230kV power line transmission tower, both in southeastern Pennsylvania. One pair of eagles nested on a 1.4 x 1.4 m osprey platform placed on a 27 m utility pole along the Delaware River (Ryman 2006). After the nest was built, there was very little territorial aggression between the eagles and supplanted ospreys that nested on a nearby 15 m pole. Eagles also have nested successfully for several years on a transmission structure at the Holtwood Dam. The agency does not attract eagles to these structures.

Nesting territories of bald eagles most often consist of an area close to 2.6 km² (1 mi²) in size in which a pair will build one or more nests. The usual minimum linear distance between active nests located along river or bay shorelines is 8 km (5 miles) (Abbott 1978). However, with the eagle population expanding as it has in recent years, pairs are establishing territories in closer proximity to each other. Pairs are now established within 1 mile (1.6 km) of each other at the Pymatuning Reservoir and along the lower Susquehanna River. Nesting pairs may be saturating the habitat in the upper Delaware watershed (Nye et al. 2006). Active nest sites, defined as sites in which an adult has been observed with eggs or young or in an incubating posture, have been as close as ¼ mile (0.4 km) to each other within the Chesapeake Bay (G. Therres, pers. com.) and within ¾ mile (1.2 km) along the Susquehanna River in Lancaster County (Brauning pers. obs.). According to Byrd et al. (1990), density of nesting territories varies according to the quality of feeding and nesting habitats, and the degree of human disturbance. Possible maximum nesting densities along Pennsylvania's waterways have not been studied or determined. Some eagles' range at least 2.5 miles from the nest tree along the smaller rivers where they are located (D. Gross, pers. obs.). At Bald Eagle State Park, the eagles apparently forage the 8 mile length of Foster Joseph Sayers Lake (S. Reilly, pers. comm.).

Non-breeding Season: Adult bald eagles tend to spend the non-breeding season in the general area of their nest sites if food is available. This is presumed to be the case in Pennsylvania. Ice

cover and water levels are complicating factors for bald eagle distribution in the winter. Individuals that breed in northern interior U.S. areas generally leave their territory in winter for more favorable regions. However, northern coastal birds may remain if conditions permit, often forming large concentrations. This is especially true in Alaska and the northwestern states. In more temperate zones, where the water stays open through the winter months, they tend to stay in the general area of their breeding territories. Non-breeding eagles avoid active nest sites year round (Byrd et al. 1990), and move elsewhere when the suitability of a given location declines. Immature bald eagles sometimes disperse widely; it is well known that individuals from the southeastern U.S. population move northward in spring and summer after the breeding season.

The residential status of Pennsylvania bald eagles has not been studied. Since the Pennsylvania bald eagle population is not marked with bands or other auxiliary markings, there is uncertainty about the resident status of most pairs. From anecdotal accounts of observers, it seems as if many if not most pairs remain in or near their nesting territories throughout the year in the state. This includes streams and reservoirs in northern Pennsylvania. In high elevations where standing water is likely to freeze over and the surface of many streams are partly or wholly covered by ice in the winter, nesting eagles seem to move out to lower elevations where foraging opportunities exist. However, some eagle pairs in the northern part of the state are known or strongly suspected to be year-round residents. The Bald Eagle State Park pair is among the earliest nesting pairs in the state, initiating incubation in February as a result of their permanent residency at Foster Joseph Sayers Lake. The Pine Creek eagles are observed most of the year, but may wander farther away from the core of the nesting territory in winter months.

Many bald eagles migrate through Pennsylvania. Bald eagles tend to soar on thermals, especially early in fall, or use deflection updrafts associated with abrupt topography (Buehler 2000). Migrating bald eagles stop over and forage along rivers and reservoirs, especially where there is shallow water. There is a tendency for immatures to be nomadic for several years while others demonstrate natal fidelity in their second year. They can travel singly or in groups. They often tend to move more at mid-day except when they are using deflection currents (Goodrich and Smith 2008). By contrast, the eastern population of golden eagles follows leading lines and diversion lines in the Appalachian Mountains as part of an overall elliptical or loop migration pattern including a more easterly route in the north-bound flight of late winter and spring (Bildstein 2006, Goodrich and Smith 2008).

The migration population can be divided into two parts: Southern eagles that migrate north in winter after nesting season to spend time in northern part of range including Pennsylvania and northern eagles that migrate each autumn from Canada and northern states through Pennsylvania to the south and return north to their nesting grounds in the winter and spring (Buehler 2000, Goodrich and Smith 2008). Southern eagles generally account for the eagles observed between August and September, continuing into November (Wood 1992 *in* Goodrich and Smith 2008, Buehler 2000). This migration peaks in mid-September in the northeastern states. Many Florida sub-adult bald eagles migrate north through Pennsylvania and other northeastern states each spring and then migrate south in late summer and fall (Mojica et al. 2008). These young eagles stayed 6 – 21 days at stopover locations en route. Northern eagles that migrate south in autumn generally migrate later in the season, accounting for most bald eagles observed in Pennsylvania in November and December. Raptors migrating late in the fall

and early winter tend to use terrain-derived uplifts and migrate close to topographic features that generate that lift, such as ridge tops and escarpment edges (Brandes 2005). Raptors that migrate in such conditions are probably more at risk from collisions with wind turbines and other structures built at such locations.

Bald eagles migrate into Pennsylvania from other states and provinces for the winter. There are concentrations of eagles in the Upper Delaware / Lackawaxan watershed, the Lower Susquehanna River, Raystown Dam, and in the northwestern wetlands, rivers, and reservoirs. These concentrations may include local nesting pairs, wintering birds, and passage migrants. These eagle concentrations attract wildlife watchers to enjoy the sight of several eagles at one place. The public also enjoys watching the behaviors of the eagles including foraging, flying, and interacting with other eagles and various kinds of wildlife.

Roosting Habitat and Behavior: Roosting and roost sites are very important for eagles. They will sit on a perch for hours until disturbed, or until hunger or the sight of prey stimulates them to move. The importance of roosting sites is demonstrated by Byrd et al. (1990) with their comment, "Availability of roost sites with suitable thermal and vegetative characteristics may be an important determinant of bald eagle distribution and abundance, and may also affect eagle ability to use otherwise suitable foraging areas." In winter, their selected roost sites are comparatively more protected than those used in summer. In the Chesapeake Bay region, eagles tend to roost in deciduous trees near foraging areas (USFWS 1990), but roost sites have not been studied in Pennsylvania and may have different attributes. Although several bald eagles will perch in the same roost tree, they tend to perch at least one wingspan apart. The number of eagles and spacing between them may depend on the local food availability. When food is scarce, there is an increase in aggressive encounters between individuals (Hansen 1986).

There has been a tendency for bald eagles to roost in woodlots in agricultural settings of Lancaster County, several miles from any large body of water. This behavior is different than that observed generally in the Chesapeake Bay Region, where they usually roost in larger wooded areas (USFWS 2007). As the population of bald eagles increases, these roosts may become larger and a more significant conservation issue, many occurring in areas where the potential for human contact is fairly high. Eagles also nest along lakeshores and in wooded sections of wetlands.

Food Habits and Feeding Ecology

Bald eagles are very efficient foragers that are very conservative in their energy expenditure. Five distinct methods of food capture used by bald eagles were identified by Stalmaster (1987): hunting in flight, hunting from a perch, wading in water, hunting from the ground (uncommon), and cooperative hunting. Bald eagles generally hunt from perches or on the wing. They are opportunistic foragers and take whatever is available, but generally concentrate on fish (Buehler 2000). Bald eagles also will scavenge on dead fish and mammal carcasses, including large herbivores such as deer and livestock. Eagles notoriously will pirate food from other fish-eating birds such as osprey, mergansers, herons, or other eagles.

Although primarily known as a fish-eating bird (bulk of their diet is fish), bald eagles are quite opportunistic and will scavenge on carcasses, steal items from other predators, and forage on a wide variety of other vertebrates including many birds, mammals, and reptiles, switching to other food sources on a seasonal basis, especially when fish are less accessible (Bent 1961, Ehrlich et al. 1988, Byrd et al. 1990, USFWS 1990, Dzus and Gerrard 1993, Buehler 2000). Bald eagle diet often reflects the fish availability, including both native and exotic species, at the particular body of water where they concentrate their foraging activities. Like other large raptors, scavenging becomes more important in winter when food can be more difficult to find, but carcasses and gut piles can be conspicuous in rural areas especially where there is snow cover. In the northern Chesapeake Bay region, eagles commonly switch to a diet of mammal and waterfowl carrion in March and October. In the lower Chesapeake Bay it has been found that the majority of food items (90.8%) and biomasss (89.8%) were fish, primarily Ictaluridae (catfish) and Clupeidae (herrings and shad) (Markham and Watts 2008). The Chesapeake Bay diet includes at least 12 species of fish, 4 species of mammals, 4 species of reptiles, and 3 species of birds.

With the expansion of bald eagles into new watersheds, many are foraging on fish species stocked in reservoirs and streams for recreation. They also exploit fish when they are more accessible through spawning activity or during low water events. Fish species commonly include gizzard shad (*Dorosoma cepedianum*), yellow perch (*Perca flavescens*), catfish (*Ictaluridae*), common carp (*Cyprinus carpio*), quillback (*Carpiodes cyprinus*), and white suckers (*Catastomus commersoni*) (Byrd et al. 1990, Dzus and Gerrard 1993, Buehler 2000). Water temperature and depth, and ice cover play important roles in fish availability.

Eagles readily forage on dead or moribund fish, birds, and mammals. They will take advantage of fish that are killed or stunned at hydroelectric facilities or where oxygen depletion of shallow areas concentrates fish that are vulnerable to predation. They also will concentrate in the same areas frequented by fishermen, including ice-fishermen, taking advantage of fish discarded on the ice. The remains of ducks (*Anatidae*) and muskrats (*Ondatra zibethicus*) are frequently found at the nest sites. Waterfowl carcasses associated with migratory concentrations and hunting areas are food sources, as are mammal carrion, including gut piles - frequently white-tailed deer (*Odocoileus virginianus*) - used in winter when fish numbers are low. Some have been observed on carcasses of woodchucks (*Marmota monax*), either as prey or scavenged. It is well-known that eagles will forage on deer carcasses, sometimes as a result of road kill, or at game carcass dumps, or an eagle provisioning attempt (providing deer carcasses on ice or at an open location for observation).

A higher percentage of birds and mammals seem to be taken in winter when fish are more difficult to reach and waterfowl are more vulnerable (LeFranc and Cline 1983). At one Washington site, American coot (*Fulica americana*) was the most frequent food item in response to its local abundance (Fielder 1982). There have been no thorough food studies of resident eagles in Pennsylvania.

To quote Dzus and Gerrard (1993): "Food supply should be an integral part of any management plan aimed at protecting or enhancing bald eagle habitat." They found that fish made up 99% of the diet of eagles nesting around Besnard Lake in Saskatchewan. Their study of

Saskatchewan's Besnard and Nemeiben Lakes showed that food abundance determined the densities of bald eagles rather than nest site availability. These two lakes and surrounding habitat were similar in all aspects studied, except for the prey base. Byrd et al. (1990) reported that eagles in the Chesapeake Bay region, which includes the eastern half of Pennsylvania, feed almost exclusively on both live and dead fish when fish are abundant. Shallow water is an important component of live fish availability because eagles typically snatch fish from the water's surface.

Reproductive biology

Bald eagles are not mature until their sixth year, but some individuals will pair off at an earlier age (Buehler 2000). Successful breeding may not occur for two or more years after reaching the adult plumage. Therefore, the life cycle of bald eagles is approximately six years and there are probably many adult-plumaged bald eagles in the state that are not mated or connected to an active nest.

Bald eagles are known for their spectacular courtship, including acrobatic flight displays (Stalmaster 1987). Different displays described by observers include the Cartwheel Display, the Chase Display, and Roller-coaster Flight. The Cartwheel Display is perhaps the best known. In this courtship act, the pair flies to great altitude, lock their talons in flight, and tumble in cartwheels back toward the earth, breaking off their hold at the last moment before colliding with the ground. These flight displays often occur in winter, giving support to the idea that many pairs remain bonded through the year (Harmata 1984 *in* Buehler 2000).

Pair bonds tend to last more than one year but, although bald eagles are generally believed to bond for life, this is poorly studied because of the difficulties in capturing and marking each bird (Buehler 2000). (Pennsylvania's population is largely unmarked.) The persistence of pairs at sites from year to year, sometimes for decades, suggests long-term pair bonds. However, pair bonds might break up after nesting failures (Gerrard et al. 1983).

Bald eagles build among the largest nests of all birds, a massive and often conspicuous structure that is reused and added to each year (Harrison 1975, Baicich and Harrison 1997, Buehler 2000). Nests are a huge pile of interconnecting sticks, rubbish, and cornstalks that support a cup of softer materials such as small twigs, grasses, mosses, weeds, sod, and feathers. Sprigs of greenery are often found in nests and can be delivered to the nest during the incubation or nestling periods (Herrick 1933, personal accounts in Pennsylvania). Typically, these stick nests are 1.5 – 1.8 m in diameter and 3.6 m high and conform to the shape of the tree where they are built, the shape ranging from cylindrical to conical to flat (Stalmaster 1987). Some nests famously have reached huge dimensions, including a site in Vermillion, Ohio, that was 2.7 m. in diameter and 3.6 m high, weighing approximately two metric tones, that was used for 34 years (Herrick 1933). Eagle nests sometime become so large that they topple over from their own weight or break off the tree in which they are built, especially with high winds or under the weight of a heavy rain or snow. The activity of the large eaglets can contribute to nest decay, especially after storm damage.

Bald eagles generally rebuild or refit their old nest each year (Bent 1961). The normal time for this activity in this area is December through February, but they may begin nest repair earlier in the fall or when the nest is in use (Abbott 1978). In Pennsylvania, most egg sets are laid between mid-February and mid-March, with early March as the peak period (Bent 1961, Abbott 1978, Brauning 1992). Some nests in southern Pennsylvania are being incubated in late January and many are being incubated in February. Eggs commonly hatch in April and the young fledge by the end of June or in July.

Although bald eagles have the deserved reputation of territory fidelity and reuse of their nests, there is an annual turn-over of nests used by pairs. Although substantial, eagle nests do not last forever or are abandoned for unknown reasons. Like the eagles, they have a long but limited life expectancy. As an example, the average life expectancy of eagle nests in south Florida (Curnutt and Robertson 1994) and Saskatchewan (Gerrard et al. 1983) is 5 years but eagle nests in Alaska last for 13 years on average (Stalmaster 1987). Annual turnover rates differ in the various areas where this has been studied. Historic Florida nests (1939 – 1946) had an annual turnover rate of 22.4% (Broley 1947). In a high density Florida population, 26% of nests used in the 2006-2007 season were not in place in the next nesting season (Brush and Nesbitt 2007). The average turnover rate in Maine was 28.2% from 1972 – 1978 (Todd 1979). Studies in Alaska reveal turnover rates of 32 to 68% (Hodges 1982, Steidle et al 1997). Recently, in the coastal plain of Virginia nests inventoried each year for a 20 year study (1,463 nests, 1977-2007) were analyzed for turnover rate. The probability of a Virginia nest being used in subsequent years was 0.739 (SE = 0.0055) leading to an annual turnover rate for nests of 0.261, using 1.00 as 100% usage (Watts and Deuerr 2010).

Nest-building generally begins one to three months before egg-laying (Buehler 2000). In some cases, it seems that pairs build or start to build a nest a year previous to egg-laying. Both sexes contribute to nest-building, but the female may place the sticks. Sticks are collected from the ground near the nest tree or broken off from nearby trees. Eagles sometimes use a previously built raptor nest as a base for building their own nest. Sometimes pairs build two nests that they use in alternative years, especially after nest failures (Buehler 2000). The second nest may be in a very different kind of location, an island rather than a hillside or a swamp rather than a forest or hedgerow.

Bald eagles generally have a clutch of one to three eggs with two the most common clutch size. One egg is laid per day, but not always in successive days, with the clutch completed in three to six days (Herrick 1932, Stalmaster 1987). The eggs are large (averaging 130 g) and dull white in color with no markings (Hensel and Troyer 1964, Buehler 2000). On average, eggs are 7.0 to 7.6 cm long and 5.3 to 5.6 cm in breadth (n = 300, Stalmaster 1987). Like body size, egg size increases with increasing latitude (Stalmaster 1987). Incubation begins with the first egg, so the young hatch out over a series of days (asynchronously). Both adults have brood patches, but that of the female is better developed than the male, presumably because she does more brooding. Incubation period is generally 35 days in length, but there is some variation (Herrick 1932, Buehler 2000). Adults are very careful around the eggs, avoiding breakage and exposure to the sun, resorting to walking around the nest cup with clenched feet to avoid puncturing eggs with their talons, and covering eggs when the nest is unattended.

The young pip the eggs without help from the adults, but may take a day to escape the egg's shell. Hatching, like egg-laying, is asynchronous with 1 to 4 days between hatchings. This

leads to differences in size between the nestlings and consequential advantage in competition for food, a source of mortality of young nestlings if food is not readily available. Flight feathers emerge in two to three weeks and body contour feathers emerge with the humeral tract in three to four weeks (Bortolotti 1984, 1989). Eaglets gain a lot of weight daily with a maximum average gain of 102 g per day and 130 g per day by males and females, respectively. They achieve maximum growth in three to four weeks. Competition between nestlings may lead to starvation or fratricide of younger, smaller eaglets.

Nestlings flap their wings across the nest and on adjacent limbs for several weeks before they depart (fledge) in order to develop muscles, practice flight, and improve landing ability (Herrick 1932). About half of the nest departures are unsuccessful so eaglets are often grounded near the nest for weeks before gaining flight ability, making them vulnerable to predators or accidents. Adults feed them, but not always successfully if the eaglets are caught in vegetation outside the nest (Kussman 1977, Fraser 1981). Young leave the nest about 8 to 14 weeks after hatching, depending on many factors (Bortolotti 1986). The adults may encourage fledging by circling the nest with food items. Humans may cause premature and unsuccessful fledging by climbing to the nest (Buehler 2000). The juveniles continue to grow and develop after fledging and are cared for by the adults 4 to 10 weeks after leaving the nest. The fledglings often follow the adults after leaving the nest site, but often stay fairly close to the nest area (less than 230 m) during the post-fledging period (Wood et al 1998).

Current Habitat Conditions and Ecological Requirements

The eagle population in Pennsylvania has been so low during the past century that meaningful information on the ecological requirements is difficult if not impossible to obtain. For this reason, research on eagle populations in nearby regions will be heavily relied upon for our purposes here.

Work on the ecological requirements of bald eagles in areas adjoining Pennsylvania has shown that several factors interact in a complex manner to determine where eagles will be successful. Breeding eagles are fundamentally limited to areas with the following characteristics: sites that (1) are relatively isolated from human activity and development, (2) have suitable nest trees no more than 1.5 km (0.9 mile) from the edge of open water or associated shrub or herbaceous wetland (Andrew and Mosher 1982, Peterson 1986), and (3) have a sufficient prey base to meet the eagles' food requirements (Buehler 1990). Wintering, migrant, and non-breeding eagles in this same region seem to require areas with the following: (1) adequate prey base, (2) diurnal perch habitat and suitable roost site, (3) low levels of human activity and development. As the bald eagle population in the state grows, a developing factor may be a lack of disturbance from other local breeding adults as Buehler (1990) found to be true for eagle populations in the Chesapeake Bay region. These various requirements are expanded upon below.

Judging by the growth of the population and its wide distribution, the habitat conditions for bald eagles have improved greatly in Pennsylvania. Not only has one of the major limiting factors of toxic contaminants been greatly reduced, but there have been significant increases in the quality of riverine habitat in Pennsylvania. When fish populations increase so do eagle foraging opportunities and options for nesting. The amount of undeveloped forested shoreline

habitat may be the greatest limiting factor for bald eagle distribution in the Chesapeake Bay Region and throughout Pennsylvania (Brauning 2002).

SECTION II. HISTORICAL AND CURRENT STATUS OF BALD EAGLES IN PENNSYLVANIA

Historical Status and Distribution Patterns

Historically, bald eagles nested in low densities along streams and natural lakes across the state, particularly along the lower Susquehanna River, the upper Delaware, and Lake Erie (Harlow 1913). The status of the bald eagle in Pennsylvania was spotty and varied depending upon the location in question. Bald eagles disappeared as a nesting species so early in the history of Pennsylvania that little is known of their original numbers and distribution. Also, there were strong prejudices against eagles expressed even by leading citizens and scientists that may have biased worthiness of their study and the written records show this accordingly. Some of the early records were somewhat vague and distribution in the Pennsylvania mountains was not well-reported. Presque Isle and Pymatuning in the northwest, the lower Susquehanna and its West Branch, and parts of the southeastern counties were the source of most nesting records prior to the 1960s.

Bald eagles certainly were well-established in eastern Pennsylvania, especially in the Chesapeake Bay watershed. Beck (1924) wrote that until about 1890 the Susquehanna River was a "kingdom" for the bald eagle, and at least on Mt. Johnson Island in Lancaster County they persisted until 1948 (Poole 1960). Burns (1919) quoted B. H. Warren as stating that around 1839 there were eagle nests in West Chester and near Valley Forge in the southeastern part of the state. A nest was tended by bald eagles in the Philadelphia suburbs at Springton Reservoir in Delaware County in the late 1940s, but it is unknown if it was successful (P. Schwalbe, pers. obs.). Apparently the bald eagle nesting range extended from the Chesapeake Bay up the Susquehanna River and West Branch Susquehanna River into the wildest parts of the state. Todd (1940) quoted John H. Chatham (1919) that bald eagles nested along the West Branch Susquehanna River as far north as the mouth of Sinnemahoning Creek, Clinton County, and on its tributary, Bald Eagle Creek as far upstream as Milesburg in Centre County. Even with recent successes, the bald eagle nesting population has not reached these parts of the West Branch Susquehanna except for some larger tributaries and their reservoirs. The species is nesting in a variety of locations along most major streams in the state where it has not nested in several decades, if not more than a century.

The bald eagle population in the western part of the state was centered in the wetlands of what it now Crawford, Mercer, and Erie counties as well as Lake Erie shoreline. Todd (1940) wrote that at least two pairs of eagles were breeding at Presque Isle in 1938, and quotes J. E. Perry regarding that location that "breeding records prior to 1924 are very scant." However, there was continuous breeding at this site from 1924 through 1956, when the last active nest-tree was cut down (Stull et al. 1985). Pymatuning Reservoir in Crawford County was created in the 1930s and one or more bald eagles have nested there and at Conneaut Marsh every year since (Leberman 1992). Leberman also stated that, beginning in the late 1950s, these Crawford County birds were the only nesting pairs in the state for more than 30 years.

The National Audubon Society's Continental Bald Eagle Project initiated in 1960 demonstrated that eagles were then experiencing reproductive difficulties. Bald eagles were officially declared an endangered species in 1967 in all areas of the United States south of the 40th parallel, under a law that preceded the Endangered Species Act of 1973. Only 417 nesting pairs were known in the lower 48 states at the lowest point of their slump. Shooting, disturbance, and habitat destruction also contributed to this decline (Byrd et al. 1990).

During the mid-20th Century a new problem caused further significant declines, especially in nesting populations: environmental contamination. Broun (1949) states that immature bald eagles averaged 59% of those counted at Hawk Mountain from 1934 to 1939, but only 37% of those counted by the late 1940s were immatures. This certainly indicates unsuccessful nesting during this period, at least in the areas from which those migrating birds originated.

Recent Population Trends Including the Reintroduction Efforts

Bald eagle populations began to recover throughout their range after the 1972 Environmental Protection Agency ban of DDT. Their comeback in the Chesapeake Bay region is attributed primarily to the resulting reduction in the use of environmental contaminants. The recovery of bald eagles in Pennsylvania parallels the recovery in quality of some of the state's most prominent watersheds. Annual aerial surveys of the Chesapeake Bay region began to reveal a gradual recovery of the bald eagle population in the late 1970s. The Chesapeake Bay supported more than 120 eagle territories by 1985 and 230 territories by 1990 (USFWS 1990). By 1993 this number had increased to more than 300 territories; in the spring of 1999 the Chesapeake Bay supported nearly 600 occupied bald eagle territories (Watts 1999). The population is now approaching levels estimated prior to the widespread use of persistent pesticides.

Reintroduction programs contributed to the return of eagles to some of their historic range. A total of 88 bald eagles were hacked at two stations in Pennsylvania between 1983 and 1988 (Kosack 1995). These nestling eagles were obtained from Saskatchewan, Canada, through the Bald Eagle Recovery Program initiated by the Pennsylvania Game Commission. This program was supported by the Richard King Mellon Foundation and the U.S. Fish and Wildlife Service. In addition, seven young eaglets from the Patuxent Wildlife Research Center in Maryland were fostered into active eagle nests between 1979 and 1988. Eagles also were released in New Jersey and New York. Some eagles found in Pennsylvania have bands used in Ohio or New York, so it is understood that these populations are contributing to the Pennsylvania population.

The recovery of eagle populations in Pennsylvania, as across the continent, has been dramatic. Pennsylvania's nesting population experienced a growth rate in excess of 20% per year beginning in the early 1990s (Brauning 1994a; Figure 1). The nesting population nearly doubled between 1997 and 1999, growing from 23 to 43 active nests (Brauning 2000). During this time, pairs established nests in five widely dispersed counties that had not recently supported nests: Chester, Erie, Huntingdon, Northumberland, and Venango. A total of 47 young was produced in

1999, substantially higher than any previous year (Figure 1). This trend continued into the new century.

The bald eagle population recovery includes neighboring states that are contiguous with the Pennsylvania population. The New York nesting population has increased from 4 pairs in the 1980s to 101 breeding pairs in 2006 that produced 172 eaglets (Carroll 1988, Nye et al. 2006). Over half of the New York population is in the southeastern region of the state, including the Delaware River basin it shares with Pennsylvania. New Jersey's nesting population has increased to 55 active nesting pairs that produced at least 82 young (Smith and Clark 2006). Most of these nests are in the southern half of the state. The Ohio population has reached 215 nests in 2009 with a new record of 205 eaglets produced (www.dnr.state.oh.us). Maryland's bald eagle population has been booming for several years with 393 occupied nests when they stopped counting in 2004 (G. Therres, pers. com.). Over 2,000 bald eagles now live in the Chesapeake Bay region. In mountainous West Virginia there are fewer bald eagle pairs than in neighboring states, but its 17 nesting pairs in 2006 constitute an all-time high population in a state that did not have a bald eagle nest until 1981 (Hall 1983, http://www.wvdnr.gov/publications/PDFFiles/WVeaglesWR.pdf). Most West Virginia nests are in the Potomac River drainage. From the various state reports, it is apparent that from banding records that bald eagles hatched and banded in one state are moving successfully to other states. Thus, the successes in each state are building on each other. Several eagles with New York or Ohio bands have been observed in Pennsylvania, including members of nesting pairs.

The core objective of the state plan is to achieve a self-perpetuating nesting population of at least 150 pairs with a productivity rate of at least 1.2 eaglets per successful nest and 60% of known nests successful over a 5 year period before de-listing from state threatened status. This objective should be reached by 2012 if the nearly 15% per year increase in nesting pairs seen in recent years continues. There are many indications that our inventory is incomplete and several nests are not being counted as part of this upward trend. The chief evidence that our inventory is missing some nests are external reports of nests that have been active in years prior to when they are reported to agency. Some members of the public do not know that the PA Game Commission monitors and protects eagle nests and, therefore, do not report new nests to the agency in a timely manner. Other individuals do not report nests out of fear that their use of property would be affected by the nest, but the agency learns of the nest from other sources. As quality habitat fills up, it is anticipated that the population growth will level off and a larger non-nesting adult population will develop (called "floaters"). These "floaters" may occupy spaces between active territories or sub-marginal habitats. They may confuse nesting population inventory efforts. Other population goals have been suggested, including 100 nesting pairs and a 5 year period at that level before removal from the state threatened status. A widespread population with broad-based success is necessary for full recovery of the species. The growth of the eagle population not only in numbers but variety of locations and breadth of geography demonstrates that most of the state can eventually be occupied by a nesting bald eagle population where high quality streams and woodland exists. This includes some urban and suburban areas.

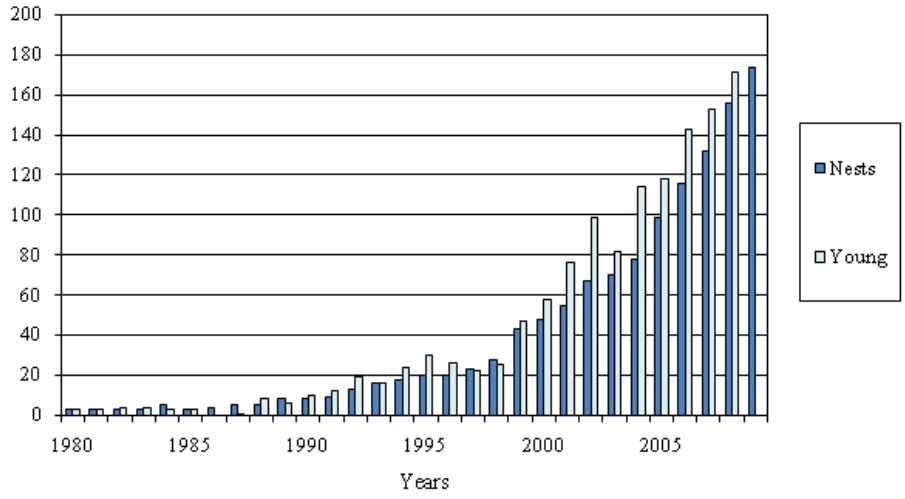

Figure 1. Number of bald eagle nests and young in Pennsylvania, 1980-2009.

The trend in migratory populations of bald eagle also is very positive in recent years. The rates of increase for bald eagles were significant and positive from 1974 to 2004 and from 1990 to 2004 at hawk watches throughout USFWS Region 5 (Farmer 2006). These positive trends were particularly striking at Hawk Mountain Sanctuary (Schuylkill, Berks, and Lehigh counties) and at Waggoner's Gap (Cumberland and Perry counties), both on the Kittatinny Ridge / Blue Mountain. As mentioned previously, the autumn passage migration population of bald eagle is somewhat bifurcated in Pennsylvania with the early-migrating birds being southern birds returning to their southern nesting grounds and the later migrants being northern birds migrating south to avoid iced over bodies of water. Eagles that nest in southern United States wander north after the nesting season and then migrate back south, generally accounting for the eagles observed between August and September (Wood 1992 *in* Goodrich and Smith 2008, Buehler 2000). This includes eagles nesting in the Chesapeake Bay region which contains several hundred pairs.

The bald eagle's federal status was upgraded from endangered to threatened in 1994, two decades after the banning of DDT and the passing of laws to protect both eagles and their nesting trees. The removal of the bald eagle from threatened status of the Endangered Species Act in 2007 was justified by its remarkable comeback on a national level.

Population Dynamics

The population of the bald eagle has been growing dramatically in eastern United States including the Mid-Atlantic Region. The Pennsylvania breeding population has been growing at approximately 15% per year since the early 1980s. This species has great dispersal ability and individuals are known to travel great distances. The populations of several states are probably contributing to Pennsylvania's population. Eagles that were banded in Ohio and New York are nesting in the state. Bald eagles equipped with radio transmitters in New York have been followed into Pennsylvania.

Current Distribution and Population Status

Despite the growth of the state population, Pennsylvania is not as important to the overall population of bald eagle as are other states and provinces. Yet the distribution of eagle territories in this state reflects the national picture. The bald eagle once was widely distributed in aquatic habitats of North America and now is reclaiming much of its former range. Bald eagles now are locally common during the breeding season in Florida, Chesapeake Bay, coastal Maine and the Maritime Provinces; the Great Lakes; western Ontario through British Columbia; most of Alaska; Washington south to northern California; and in the greater Yellowstone area (Buehler 2000, Clark and Wheeler 2001). Small breeding populations also exist along the Gulf Coast of Texas and Louisiana, in Arizona and New Mexico, and along the Mississippi River. These populations have been building in recent years with expansion into areas where eagles did not occur in several decades. In winter, most individuals leave northern inland breeding areas and large concentrations form in the Chilkat River in Alaska, in the Klamath basin in Oregon, and along the Mississippi River. There also is a limited population in Baja California, south Sonora, and Chihuahua of Mexico (Russell and Monson 1998) (Figure 2). The nesting population is expanding at such a rapid rate that many published maps, including the NatureServe map (Figure 2), somewhat under-represent bald eagle nesting distribution in Pennsylvania and adjacent states. The NatureServe map (Figure 2) and other maps (Buehler 2000) should show more or most of Pennsylvania, New York, and the Mid-Atlantic states with a permanent resident bald eagle population. Each nesting population map of the state is out of date within a year of its publication.

Pennsylvania's population continued to grow in 2008 to 156 active nesting pairs, the first year in which greater than 150 nests were documented. As of 2009, eagle nests were found in 48 counties, and totaled 174 active nests which produced 244 young (Fig. 3, Table 2; Gross 2009). Since 1980, Pennsylvania bald eagle nests have produced at least 1,100 eaglets (an underestimate because the fate of several nests are unknown and evidence suggests that many nests are productive). This productivity is fueling the spread of eagles throughout the Commonwealth.

Bald eagle nest territories are not only increasing in number, but also in geographical range across the Commonwealth. There are concentrations of nesting territories in the following areas, with satellites outside of these source areas: 1. Northwest glaciated wetlands, 2. Lower Susquehanna / Chesapeake Bay, 3. Pine Creek drainage, 4. Upper Delaware River / Pocono Mountain region. Bald eagles now have claimed most of the main stem and North Branch of the Susquehanna River. They also have spread into watersheds of the Southeastern counties that are either tributaries of the Susquehanna or Delaware rivers. Although there is a population in the Pine Creek valley, the West Branch Susquehanna River is a gap in bald eagle nesting distribution, perhaps as an artifact of poor water quality and subsequent fish availability. Reservoirs are becoming increasingly important as nesting areas for eagles. Leading the inventory is Lake Raystown, Huntingdon County, and Hammond / Tioga Lakes, Tioga County. The counties with the most nests in 2009 were Crawford (17), Pike (14), Lancaster (12), and York (12), the traditional centers of bald eagle nesting activity in the state (Leberman 1992, Brauning 2002, Gross 2009). Eagles are expanding from these centers into other parts of the state with acceptable habitat often in step-wise fashion.

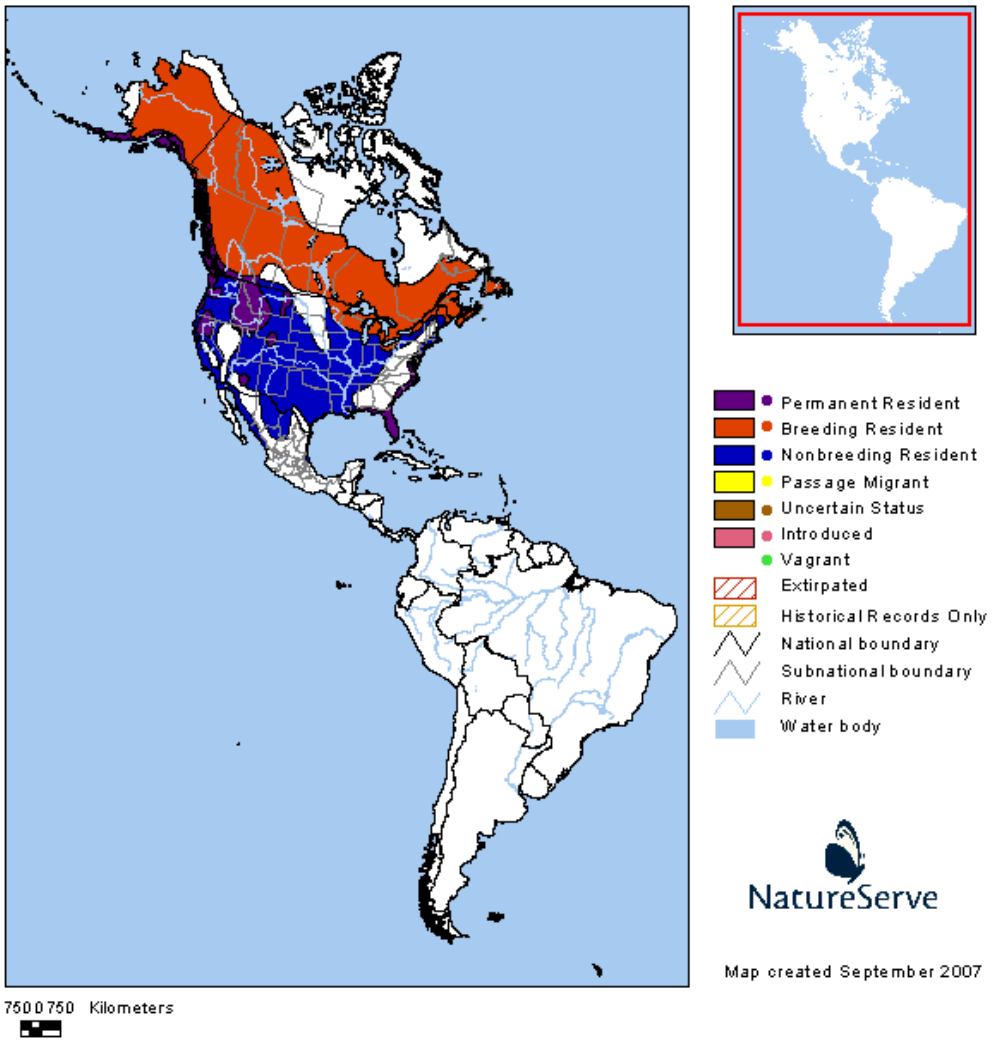

Figure 2 North American Distribution of Bald Eagles.

Although the extent of geographical coverage is becoming increasingly complete, there is a tendency for eagle pairs to fill in good habitats near already established pairs, broadening a local cluster of eagle territories. From an analysis of band recovery data from five states (Alaska, Arizona, Florida, Minnesota, Virginia; n = 50), the median natal dispersal distance for bald eagles has been estimated to be 43 miles (69.2 km) (USFWS 2008). New nesting territories usually are near concentrations of active nests, sometimes forming a string along available aquatic resources (see Figure 3). It may take some leaps for eagles to establish populations in isolated reservoirs or riparian habitat far removed from established populations.

The expansion continues to move eagles into closer contact with human activity and increasing the potential for eagle–human conflict (Brauning 2002). More pairs are occupying suburban counties or nesting close to human habitations at the edge of towns. Some pairs regularly fly over major highways to visit their nests and to bring food to their eaglets. However, many regular human activities are tolerated near nests as long as the activity is not perceived by

the eagles as a threat to them or their nest. Also, the eagles tend to pick locations even in a human-dominated landscape with tree canopy cover and little human activity, so-called "green zones." It has been observed that some pairs have tolerated human activities including earth-moving and road-building within a few hundred feet of their nest. This growing tolerance is one of the factors contributing to the growth in eagle nesting population. Coexistence often is possible because of the popular support of eagles by the general public and their recognition as a national symbol and source of pride of anyone supporting either the wilderness ethic or patriotism.

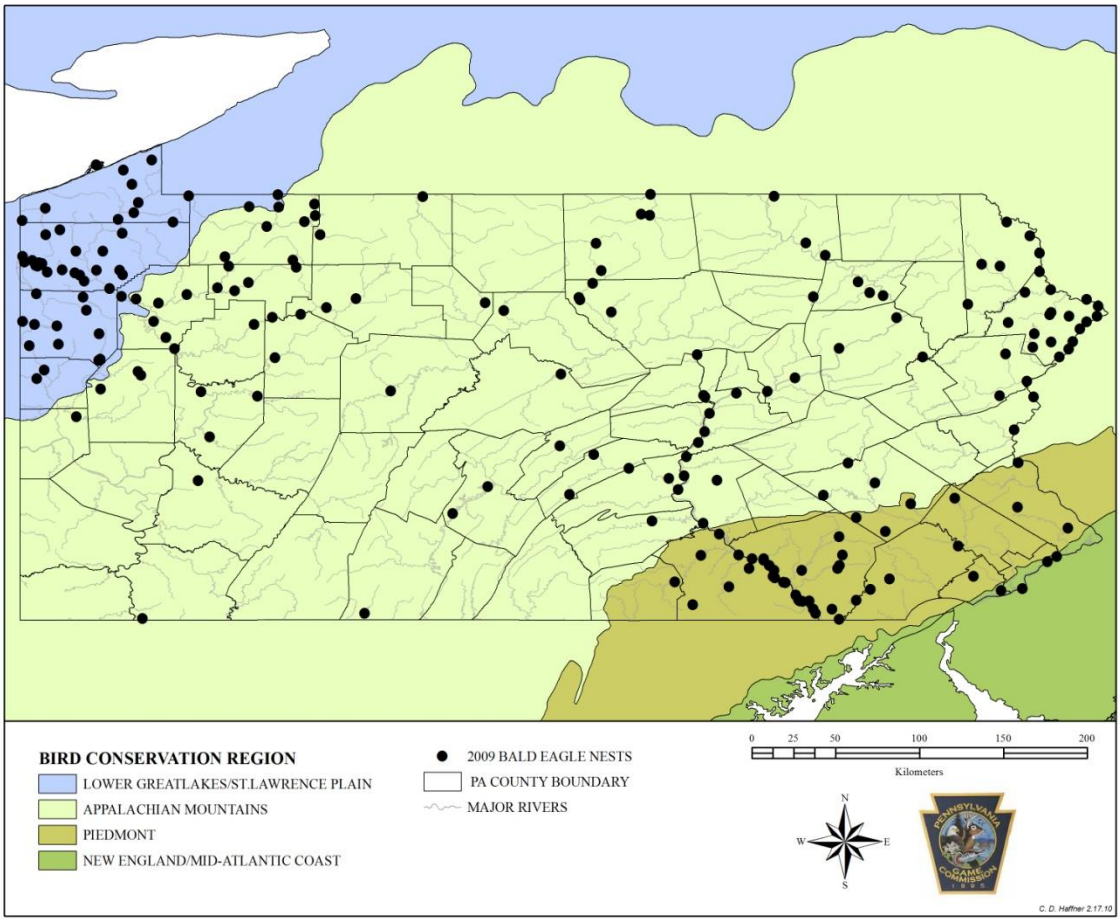

Figure 3. Distribution of nesting territories of bald eagle in Pennsylvania, 2009.

There is potential for continued growth of the nesting and wintering bald eagle population. The increase in water quality of many major streams in the state open many areas for recolonization that have not been occupied by nesting bald eagles for several decades. Over 44 state parks and state forests contain lakes or are situated on the edge of lakes, and more than 10 are located on one of the large rivers or larger streams in the state. Some of these parks already are occupied by nesting eagle pairs. In addition to these, many Pennsylvania Fish and Boat Commission lakes, Army Corps of Engineer reservoirs, municipal and private lakes, and

reservoirs provide potential nesting habitat. As far as is known, areas with <8 ha (20 ac) of open water surface are not suitable bald eagle habitat (Peterson 1986). Pennsylvania bald eagles are known to forage at multiple bodies of water near their nest and do not necessarily build their nest at the largest one. Some bodies of waters may have too much human disturbance for eagle occupancy, but all lakes exceeding 8 ha (20 ac) and major rivers are potential for eagle breeding territories. Although bald eagles have spread through the Chesapeake Bay (Susquehanna River) and Delaware River drainages, many miles of streams in the Ohio River drainage, particularly in the southwest region, are unoccupied by nesting eagles. Also, there are many larger tributaries of the Susquehanna and Delaware Rivers that are not fully occupied by bald eagles. These gaps in occupation may be the result of limited natal dispersal, stream or site quality issues, or lack of good coverage.

It also is appropriate to evaluate characteristics of active nest sites, as has been done previously. Basic habitat and site characteristics of active eagle nests should be evaluated to better describe sites currently being selected by eagles for nesting. A habitat survey form (developed by the Wildlife Diversity Section) was used in 1996 and 2000 for many active sites. The survey includes both site features (e.g., tree species, condition, and size) and landscape features (percent of area forested). These features will help identify potential habitat and fine-tune a model for eagle nesting habitat. This task may be completed in several stages and should be completed for each newly discovered nest site.

Winter Populations and Distribution

Each year, Pennsylvania participates in the national mid-winter bald eagle survey. The national survey involves many states, so the coordinated effort can track trends in winter abundance and distribution of the national symbol. The national mid-winter eagle survey was coordinated for many years by the U.S. Geological Survey Snake River Field Station (SRFS), but is now coordinated by the U.S. Army Corps of Engineers (USACE). This is not the first time that there has been a change. Nationwide counts of eagles were coordinated by the National Wildlife Federation from 1979 until 1992, when the Raptor Research and Technical Assistance Center (now SRFS) assumed responsibility for overseeing the count.

Wintering eagles typically were found associated with nesting territories. However, this does not explain the large concentration on the northern half of the Delaware River, where counts have soared to over 160 eagles (Brauning 2000). The Upper Delaware River hosts one of the largest concentrations of bald eagles in the Northeast during the winter (Nye et al. 2006). The Upper Delaware Scenic River has been designated as Pennsylvania Important Bird Area #60 because of its importance to wintering bald eagles (Crossley 1999).

Table 2. Number of bald eagle nests and young in Pennsylvania, by county, in 2009. Counties with eagle nests recorded for the first time in 2009 are marked with an "*".

County	Active nests	Nests with known results	Successful nests	Young fledged	Avg. young / active nest
Adams	1	1	1	1	1.0
Armstrong	2	2	2	4	2.0
Beaver*	1	0	0	0	0.0
Bedford*	1	0	0	0	0.0
Berks	5	5	5	8	1.6
Bradford	3	3	3	6	2.0
Bucks	4	4	4	11	2.8
Butler	3	3	3	5	1.7
Cameron	1	0	0	0	0.0
Carbon	1	1	1	1	1.0
Centre	1	1	1	3	3.0
Chester	3	2	1	2	1.0
Clarion	1	1	1	1	1.0
Clinton*	1	1	1	2	2.0
Columbia	1	1	1	2	2.0
Crawford	17	13	10	20	1.5
Cumberland	1	1	1	2	2.0
Dauphin	4	2	2	3	1.5
Delaware	1	1	1	2	2.0
Elk	3	2	0	0	0.0
Erie	8	8	5	9	1.1
Fayette	1	1	1	2	2.0
Forest	5	6	5	6	1.0
Huntingdon	2	2	2	5	2.5
Jefferson	1	1	1	1	1.0
Juniata	3	3	3	6	2.0
Lancaster	12	8	8	13	1.6
Luzerne	2	1	1	3	3.0
Lycoming	3	3	1	3	1.0
McKean	1	1	0	0	0.0
Mercer	11	9	9	16	1.8
Mifflin*	1	1	1	1	1.0
Monroe	2	2	2	4	2.0
Montgomery	1	1	1	1	1.0
Montour	1	0	0	0	0.0
Northampton	1	1	1	4	4.0
Northumberland	7	6	5	14	2.3
Perry	1	1	1	2	2.0
Philadelphia	1	1	1	2	2.0
Pike	14	12	10	24	2.0
Sullivan	1	1	1	1	1.0
Tioga	5	5	5	10	2.0
Venango	6	6	4	6	1.0
Warren	5	6	4	7	1.2
Wayne	8	5	5	8	1.6
Westmoreland	1	1	1	2	2.0
Wyoming	3	3	3	4	1.3
York	12	11	11	18	1.6
Total	174	150	130	245	1.6

In the 2008 mid-winter bald eagle survey, cooperators recorded 184 eagles in over 130 hours of survey effort (Table 3). There are wide year-to-year variations in observed numbers, perhaps an artifact of weather conditions, water conditions, and eagle dispersal to alternative sites during ice and high water events. The highest tallies were registered in the Lower Susquehanna drainage including Dauphin, Lancaster, and York counties. Larger bodies of still water are attractive to eagles in winter, including Pymatuning Lake (Crawford Co.), Raystown Dam (Huntingdon Co.), Hammond Lake (Tioga Co.), and Kinzua Dam (Warren Co.). Some eagles seen were observed as pairs, apparently already on nesting territories. Other eagle hot-spots included the junction of tributaries with larger streams such as the outflow of Tionesta Creek to the Allegheny River (Forest Co.).

Some locations are so notorious that they attract wildlife watchers to see concentrations of eagles. The Upper Delaware River and Lackawaxan River (Lackawanna, Wayne, and Pike counties) corridor holds fairly high concentrations of bald eagles, enough to attract many tourists to the region from a number of states. The Upper Delaware River has a large concentration of wintering eagles with 93 observed between Port Jervis and Hancock, New York in the January 2006 mid-winter survey (Nye et al. 2006). This section of the river often tops 100 eagles during winter surveys. The lower Susquehanna River, including fields in Lancaster County, is another concentration area. Concentration areas are somewhat like the nesting concentration areas, but bald eagles use fewer lakes and reservoirs in northern counties because they are frozen over. When there are high water and ice conditions on rivers, eagles may concentrate at reservoirs such as Lake Raystown, Huntingdon County, which is emerging as an important eagle habitat in all seasons. New winter concentration areas are emerging in the southern counties where open water is less likely to freeze over. These include reservoirs near the Delaware River and Philadelphia . Temporary food bonanzas like carcasses also draw eagles away from water bodies where they forage on fish.

Nationwide, the USFWS bald eagle program evaluated midwinter count data from 1986-2005 to assess count trends (Steenhof et al. 2002). This analysis was based on 178,896 observations of eagles during 8,674 surveys of 746 routes in 43 states including Pennsylvania. Regional and route-level trends were found using a hierarchical mixed model. Survey-wide, the winter eagle counts increased an estimated 17% per year from 1986 - 2005. Twice as many routes showed positive trends rather than negative trends (63% vs. 37%) over 20 years. In the Northeast, the estimates of counts increased approximately 6% per year. Generally, there were more positive trends in the northern (76%) part of the range than in the south (south of 40 degrees latitude, 50%). The winter population of bald eagles is doing well in Pennsylvania but may be somewhat limited by the resident breeding population that are not tolerating migrants in their territories.

Table 3. Pennsylvania results of 2008 mid-winter bald eagle survey.

County	Survey Effort (minutes)	Number of Immature/Unknowns	Number of Adults	Total Eagles
Allegheny	15	0	0	0
Armstrong	505	1	3	4
Bradford	473	0	4	4
Bucks	15	0	2	2
Chester	85	0	4	4
Clarion	290	3	1	4
Clearfield	60	0	0	0
Columbia	225	0	2	2
Crawford	600	8	16	24
Dauphin	120	1	1	2
Elk	145	1	0	1
Erie	60	0	0	0
Fayette	310	2	0	2
Forest	190	8	2	10
Huntingdon	202	6	7	13
Indiana	120	0	0	0
Lancaster	360	14	13	27
Luzerne	350	0	3	3
Lycoming	360	5	9	14
Mercer	170	5	4	9
Montour	240	0	4	4
Northumberl'd	97	0	0	0
Perry	290	5	3	8
Pike	70	1	1	2
Snyder	90	0	1	1
Susquehanna	180	0	0	0
Tioga	780	3	6	9
Venango	105	1	1	2
Warren	120	12	4	16
Wayne	45	5	9	14
Westmoreland	145	1	1	2
York	60	1	0	1
Total	6,877	83	101	184

Threats and Limiting Factors

Although the bald eagle has made an amazing comeback in Pennsylvania and throughout most of the United States, it still remains vulnerable to several limiting factors and serves as a symbol of American wilderness because of its reputation as intolerant of human activities. Many people still regard eagles as "vermin" that take game from them, so they remain a threat to eagles and their habitat because of this attitude. It was only a century ago that publications reported that bald eagles carried off infants (Warren 1890). As one of the animals on the top of the food chain,

eagles serve as bio-indicators of ecosystem health and bio-accumulators of environmental contaminants. Human infringement on eagle habitat remains as perhaps the greatest threat to eagles. Human development that replaces riparian forest and swamp where eagles thrive with roads, housing, shopping malls, and industry can be permanent and irreversible. De-listing bald eagle from Endangered Species Act protections is a grand experiment. Success may depend on understanding the extent to which the following limiting factors can prevent future success of recovery.

The previous decline of the bald eagle in Pennsylvania and the country as a whole can be attributed to several factors. During the 19th Century, nesting populations of bald eagles were reduced drastically in many states including Pennsylvania. The loss of habitat seems to have been a primary factor in these early declines, but mortality from shooting and trapping also was important.

Direct persecution of eagles has been a very serious limiting factor for this species in Pennsylvania for at least two centuries. Despite its status as a national symbol, the bald eagle has been one of the most persecuted birds in the country (Beans 1996 in Bildstein 2008). Early publications accused bald eagles of preying upon game and farm animals as well as infants (Wilson 1808 – 1814, Audubon 1840, Wright 1895). Some of these stories were quite fantastic and seized the imagination of the public, prejudicing many against eagles to the point that eagles were routinely shot on sight. Even respected ornithologists and naturalists voiced their negative assessments of the moral character and value of eagles. Pennsylvania's respected ornithologists of that era, Witmer Stone and George Sutton, voiced their own concerns about eagles and public acceptance of eagles (Sutton 1929, Stone 1937). For many decades, it was public opinion that "the only good hawk was a dead hawk" especially in the hunting and farming communities. And eagles were and are considered to be large hawks or "buzzards" by many. Of the 800 nestling bald eagles banded in Central Florida in the late 1930's and early 1940's, more than half of the 48 recovered eagles had been shot or otherwise killed by people (Broley 1952). These problems continued and even accelerated in some areas during the 20th Century. Pennsylvania is a state in which shooting did continue to be a problem. In 1958, Ray Sickles, the refuge "keeper" (Poole 1960s) at Pymatuning stated that, "Apparently two new birds took over the nest from which the adults had been shot last year." This was in reference to two birds found dead at their nest.

U.S. Fish and Wildlife Service investigations showed that shooting and trauma were the leading cause of death through the mid-1970s (Grier et al. 1983), with poisoning and others factors making up most of the losses. Studies from 1975 to 1983 placed the responsibility for 39% of all bald eagle mortality on shooting and trauma.

By 1990, shoreline development was perceived as the greatest limiting factor to bald eagle population growth (U.S. Fish and Wildlife 1990). Waterfronts have enormous attraction for human recreation and residency. Pennsylvania's network of highways, canals, and railways have followed streams, particularly the larger rivers, putting human use of the riparian area in direct conflict with eagles from the very first days of colonization and development. Forested habitat is regularly destroyed to make way for housing, airports, shopping malls, and even maritime recreational development. The human activities associated with shoreline development increase pressure on bald eagles by limiting their access to foraging sites. Eagles can be fairly tolerant of some housing and low impact human recreation, but motorboat, jet-ski, and off-road vehicle

traffic flush eagles from perches and foraging areas. Indeed, boat landing areas are fairly good predictors of areas of shoreline that the eagles will regularly avoid that otherwise have acceptable wooded habitat and shallow waters for nesting and foraging. Foot traffic along paths and grades near river shores also can be a source of human interference to nesting eagles especially as this traffic increases in the warmer weather or as a result of curiosity about the eagles. Wind energy development along ridges and escarpments near rivers could pose hazards to migrating and foraging eagles. Wind energy development on lakeshores might be particularly dangerous for eagles that migrate, forage, and roost in this environment. Visibility is not always very good in these environments so eagles may not always have opportunities to see a dangerous moving object like a turbine's rotor blade. Poor weather conditions increase the risk for eagles.

Road development, either in an urban or rural landscape, may be one of the most limiting factors for eagle nesting populations. Only comprehensive planning may be the solution to allow the open spaces required for bald eagles and other habitat-limited species.

Energy development, particularly of wind energy and natural gas, may be an increasing factor in fragmenting forests including riparian forests where eagles tend to nest (Johnson 2010). Marcellus shale development may be a particular threat to the quality of streams and the size and extent of forests that now support bald eagles and the foraging habitat they require. The development of Marcellus shale extraction well pads and the accompanying infrastructure of roads and gas lines will have extensive direct and indirect effects on the forests and streams of Pennsylvania where many eagles nest, migrate, or spend their winters. Since eagles use extensive shoreline for foraging, and also migrate and feed extensively along the wooded shores of streams, they are particularly vulnerable to the kind of forest fragmentation and pollution that may result from extensive natural gas development.

The area of Marcellus Shale gas formation covers much of the Southwest, Northwest, North-central, and Northeast Regions where many eagles nest and where there are many hundreds of miles of quality streams that support eagles. It may also affect the ability of eagles to continue to colonize new areas not yet occupied, but having good eagle habitat ripe for use by this species. Continued monitoring of nests, roosting areas, and documentation of critical eagle habitat in PNDI will be critical to minimize the negative effects of further energy development in the wilds of Pennsylvania. Comprehensive planning may be necessary to conserve large enough tracts of forest and shoreline to allow eagle and other species to persist widely in the state as we now enjoy.

Land birds in North America are managed through the Partners in Flight program that utilizes Bird Conservation Regions (BCR) as a geographical unit (Pashley et al. 2000, Rich et al. 2004). The federal de-listing monitoring plan for the bald eagle uses BCR as the sampling unit for eagle nest monitoring (USFWS Bald Eagle Monitoring Team 2007). Each of these regions is based on physiographic features and has its own attributes that may help explain the pattern of distribution and success of eagles in Pennsylvania. Some interesting patterns emerge if eagle nests are grouped in this fashion (Table 4). For instance, the percent of successful eagle nests is lower in BCR 13 (equivalent to the northwestern wetlands and Lake Erie region) than in the rest of the state except for the narrow belt of Pennsylvania that lies in the Atlantic coastal lowlands, which is an urban landscape in this state. This pattern deserves further investigation, but

knowledge of the nest failure causes points to a pattern of weather-related nest failures including nest tree collapse in this region (Lake-effect snow). Even in the heavily populated Piedmont region the eagle nest success approached 70% in 2008 (and exceeded it in 2007) and some of these failures are known to be caused by severe weather events or accumulation of weather's deteriorating effect on nest support structure and stability. The BCR with the largest number of eagle nests and best nest success is the Appalachian Mountains where many eagle nests are well-hidden along large streams, on islands, and on mountainsides. Eagle densities now have reached levels where there is competition for nest sites and some nestling mortality from eagle-to-eagle conflicts in the northwestern counties (BCR 13 and 28). Some signs of population saturation are being observed in the Upper Delaware River and the Northwest. Similar results might be found in other regions as densities increase.

Table 4. The distribution and success of bald eagles organized by Bird Conservation Regions in 2009.

BCR*	Active Nests	# w/ Known Results	Successful nests	Percent Successful	Young fledged	Average young/known active nest
13	38	33	26	78.8	48	1.5
28	99	86	75	87.2	142	1.7
29	35	29	28	96.6	48	1.7
30	2	2	2	100.0	4	2.0
Total	174	150	131	90.6	242	1.6

* BCRs: 13. Lower Great Lakes / St. Lawrence Plain; 28. Appalachian Mountains; 29. Piedmont; 30. New England / Mid-Atlantic Coast.

Sources of Mortality

The U.S. Fish and Wildlife Service had been conducting necropsies and chemical analyses to determine the cause of death of moribund or dead eagles sent to them for several decades prior to 1983 (Grier et al. 1983). These investigations showed that through the mid-1970s shooting and trauma were the leading causes of death, with poisoning, electrocution, disease, and trapping injuries making up most of the balance. Bald eagle mortality data from 1975 to 1983, obtained from 754 individuals, produced the following results: trauma, 21%; shot, 17.6%; too decomposed for diagnosis, 12.3%; emaciation, 9.7%; electrocution, 9.3%; poisoned, 8.4%; infectious diseases, 8.0%; undetermined, 5.7%; trapped, 5.2%; and all others 2.8%.

Despite the many regulations, direct persecution of raptors including bald and golden eagles persists in Pennsylvania and other states. Cited individuals sometimes state that the eagle they shot was only a "buzzard," apparently mistaking an immature-plumaged eagle with the turkey vulture which is a protected species. There is a long history of prejudice against raptors which provides a cultural setting in which eagle-shooting is accepted by some members of the public despite its illegality (Bildstein 2008). The widespread shooting of eagles was probably a significant factor in their absence in many parts of the state where good habitat was present.

Competitors, predation, parasites, weather and other inter- and intra-specific interactions are some of the factors, but there is no good evidence that any of these are limiting factors for the eagle (Byrd et al. 1990). Pennsylvania nests suffer from storm damage, an important source of nesting failure and nestling mortality. Heavy winds that damage or topple nests invariably cause nestling deaths either immediately or eventually through exposure. Eaglets that fall from nests are vulnerable to predators or accidents. A few nests have suffered from conflicts between eagles where the eaglets were harmed by eagles invading a territory. Nests can be preyed upon by a variety of predators including other raptors (hawks and owls), corvids (crows and ravens), gulls, and mammals (Buehler 2000). Nests located where human activities attract more of these predators and cause eagles to flush from nests may be particularly vulnerable to predation.

The agency keeps track of nesting success and attempts to find reason for nest failures. By studying nest success and failure patterns, perhaps sources of nest failures can be identified and addressed.

Disease

Eagles may not be as affected by diseases as by other factors since only 2% of 1,428 eagles that were examined over 20 years died directly from disease (Wood et al. 1990). However, there is much not understood about the diseases of raptors because the afflicted birds that die are rarely recovered and necropsied (Buehler 2000). Some of the diseases leading to mortality in the period 1975-77 were peritonitis, pneumonia, enteritis, septicemia, avian cholera, aspergillosis, hepatic necrosis, and myocardial infarction (Kaiser et al. 1980). Birds affected by disease may actually die from other factors because they are in a weakened, vulnerable condition.

In recent years, more avian diseases have been documented as affecting bald eagles. Avian Vacuolar Myelinopathy (AVM) is a recently discovered neurological disease causing mortality in bald eagles and other water birds, especially American coots, in southern U.S (www.nwhc.usgs.gov/disease_information). AVM has caused the death of a least 80 bald eagles and possibly thousands of coots since it was discovered in 1994 at DeGray Lake, Arkansas. AVM also has also been confirmed as the cause of death in other bird species including some waterfowl species, killdeer (*Charadrius vociferous*), and great horned owl (*Bubo virginianus*). Outbreaks of the disease typically occur in the winter months when flocks of water birds concentrate in certain areas. These outbreaks seem to be short in duration. Birds affected by AVM have uncoordinated flight, often crash-landing into solid objects. When on land, affected birds seem unsteady, walking with outstretched wings and wobbling, and when in water, they sometimes swim upside down or with a trailing appendage. Natural or man-made toxins are suspected as the most likely cause of AVM and the affects are probably dose-dependent.

Since 1999, West Nile Virus (WNV) has been detected in over 284 wild and captive bird species including the bald eagle and many other raptor species. This list is based on reports from public health, wildlife, and veterinary diagnostic laboratories across the United States. The University of Minnesota Raptor Center has confirmed WNV caused the death of 4 adult male bald eagles from Minnesota and Wisconsin. Infected eagles exhibit neurological signs including

head tremors, blindness, and seizures. The affects of this mosquito-borne disease on populations of bald eagles and other wild birds is not well-understood.

Avian cholera is known to be transmitted from waterfowl that have died from the disease to scavengers that feed on them, such as gulls (Byrd et al. 1990, Rosen 1971). Byrd et al. (1990) reported no known cases of bald eagles contracting this disease in the Chesapeake Bay region. Because bald eagles often co-occur along rivers and lakes where there are concentrations of waterfowl, and prey on both waterfowl and gulls, they may be particularly vulnerable to this and other waterfowl-borne diseases. Other natural environmental factors may affect the reproduction and mortality of young and adult bald eagles.

Environmental Contaminants

Environmental contaminants and pollutants have an impact on bald eagle populations. Death by acute poisoning as a direct toxic effect results from the organochlorine insecticides dieldrin and endrin, as well as from the heavy metals lead and mercury. It is also well known today that DDE, a metabolite or breakdown product of DDT, contributes to reproductive failure due to eggshell thinning. This is true in many other bird species as well as bald eagles. Because birds at the top of the food chain feed heavily on other birds or fish, they are especially subject to eggshell thinning.

Environmental contaminants and pollutants have a two-pronged impact on bald eagle populations. First, direct toxic effects (i.e. death by acute poisonings) often resulted from the organochlorine insecticides dieldrin and endrin. Heavy applications of DDT have also been implicated in massive kills of birds, and of other non-target fish and wildlife. However, the most grave contaminants problem is due to DDE. DDE is operative in the second part of this two-pronged assault i.e. reproductive failure brought about by eggshell thinning. Today it is well known that by the late 1960s pesticide research had proven experimentally that chronic exposure, even to low levels of DDT, inhibits reproduction in many bird species (Grier et al. 1983).

Reproductive failure is brought about mainly through the thinning of eggshells, which in turn results in hatching failure. Eggshell thinning has been measured from eagle eggs obtained from nearby states that are a part of the Chesapeake Bay Region Bald Eagle Recovery Area, which includes Pennsylvania (Byrd et al. 1990). DDE interferes with calcium metabolism through physiological mechanisms (Wiemeyer and Porter 1970, Lincer 1975, Mendenhall et al. 1983). Adult bald eagles living even for only part of the year in areas with high background levels of DDT absorb amounts sufficient to cause the loss of annual production of offspring through eggshell thinning.

Lead is a hazard for a wide variety of wildlife, especially bird species that scavenge or prey upon hunted species (Hunt et al. 2006, Lahner and Franson 2009). Low doses cause a variety of health problems such as tremors, emaciation, lethargy, poor balance, impaired vision, and other symptoms. Higher doses are lethal. There may be large numbers of eagles poisoned by lead, more than are reported (Neumann 2009). Like other raptors, bald eagles can ingest lead from a variety of sources including lead pellets in animal carcasses that causes lead poisoning (Pattee and Hennes 1983). Prior to the 1991 U.S. Fish and Wildlife Service ban on the use of lead shot for waterfowl hunting, it was a widespread problem with 338 bald and golden eagles

from a total of 34 states reported to the National Wildlife Health Center (Franson et al. 2002). In one published report, elevated lead concentrations were found in the livers of several bald and golden eagles in Idaho (Craig et al. 1990). This is significant because golden eagles do not regularly consume fish or waterfowl, so lead shot is not the likely source for these mortalities; in Pennsylvania lead pellets are only rarely encountered in eagles with fatal lead poisoning (Cottrell, pers. comm.). Lead poisoning has been a particularly problematic health issue in the Midwest where it was the primary reason for 22% of the bald eagles admissions (138 out of 634 total admissions) to the Raptor Center at University of Minnesota from 1980 to 1995 (Kramer and Redig 1997). There is an increasing body of evidence collected by wildlife biologists and rehabilitators that many eagles have abnormal and unhealthy levels of lead and many eagles die each year from lead poisoning (Craig et al. 1990, Hunt et al. 2006, Newmann 2009, see www.soarraptors.org for more information). Since eagles can travel large distances and the symptoms of lead poisoning may be delayed following ingestion (Hoffman et al. 1981), the source of any lead contamination in any eagle is difficult to ascertain, especially if the migratory status and history of the bird is unknown. Lead also has been implicated as an important source of mortality and sickness for charismatic non-game birds such as the endangered California condor (*Gymnopys californicus*, Snyder and Snyder 2000), the common loon (*Gavia immer*, McIntyre and Barr 1997), and other species (Lahner and Franson 2009) although these species have other contamination problems. This cause of mortality is increasing and deserves monitoring since so many eagles scavenge on carcasses of waterfowl and large animals that may be contaminated by lead ammunition. Other sources of lead exposure should also be investigated. To summarize, the three likely sources of lead to eagles are: lead shot found in waterfowl or other prey or scavenged items, fishing weights (sinkers), and lead ammunition in scavenged larger game animals and gut piles. Lead found in the environment from any of these factors may find a way into the food chain of an opportunistic raptor like the bald eagle. These risks seem higher for migrating eagles than for residents.

Habitat Loss and Human Disturbance

Habitat loss and human disturbance, which are responsible for decreases in the populations of many species of special concern, seem to be major factors in the decrease of bald eagle populations over wide parts of their range. This is true in several nearby states, including Maryland, New Jersey, Delaware and Virginia (Byrd et al. 1990); and New York (Carroll 1988). Much of the habitat loss in the states bordering the Chesapeake and Delaware Bays has been the result of development along their shorelines and tributaries. Highways, shopping malls, housing, public utilities, airports and parks are all disturbances that destroy bald eagle habitat. Development is especially critical in these areas since most bald eagle habitat found there is on private land. Cline (1986) found that in the Chesapeake Bay area only 15.5% of the eagle nests were on public land. In Pennsylvania, new reservoirs have created new habitat in parts of the state that historically did not have open water.

Perhaps the most serious negative factor, and the most difficult to halt and reverse, has been the loss of habitat. The suitability of both wintering and breeding areas has no doubt been adversely affected through the destruction of wild areas as a result of increased human activity and land development. While such activities may not be important in a singular given location,

"the cumulative effect of many small, seemingly inconsequential actions on eagles may be significant." (Grier et al. 1983).

The behavior of eagles, as is true of other wildlife, varies in response to human activity. This disturbance is difficult to evaluate. Eagles are large birds, less maneuverable than smaller raptors, and less able to escape sudden dangers. Because of this, they are traditionally intolerant of human activity. While some individuals will be more tolerant than others, most are easily disturbed (Grier et al. 1983). As with other birds, they are particularly vulnerable to nesting failure during incubation and when young are small. Such disturbance is believed to be a cause of reproductive failure as well as having a negative affect on the suitability of wintering areas. Eagle population reductions from these factors (habitat destruction, shooting, trapping, and other human activities) can be identified and reversed through sound management practices.

Increased human activity is a common and expected result of most types of habitat destruction, including shoreline development. Eagles often avoid areas where boating, fishing, camping, and other recreational activities take place even when these areas have not been developed (Byrd et al. 1990). Studies have shown that eagles select nest sites away from areas that have been developed and in areas that are less than 1.5 km (0.9 mile) from open water (Andrew and Moser 1982). This means shoreline development along the rivers, streams and reservoirs of Pennsylvania could be very detrimental to the success of eagles in the state. Both habitat loss and human disturbance of the types enumerated above should be kept to a minimum in these areas if we are serious about their management.

All of the above suggest that human activity would have a negative impact on eagles with or without its resultant disturbance of habitat and the building of structures of various types. This negative impact would be operative not only near the eagles' nesting territories, but also in their selection of roosting sites and foraging areas, both when humans are present and when they are absent. Thus, for successful eagle management, areas that are free from human disturbance and development are required. Eagles have become increasing adept at finding quiet corners of the human landscape to build nests and forage successfully. Several pairs also are tolerant of human activities near their nests including homes, cabins, walking paths, and vehicular traffic along roads. The PGC will continue to monitor the success and failure of nesting eagles and look for patterns in nest failure and abandonment as it relates to human disturbance and other factors.

Land Management Issues

Land clearing for agriculture and by logging also may impact eagles. Threats against eagles brought about by logging practices include 1) nest destruction at any time or disturbance, especially after the onset of incubation, 2) the loss of forest age classes that can be used by bald eagles for nesting (this of course becomes more critical as less and less habitat is available for nesting), and 3) forestry practices that leave seed trees that are less acceptable as nesting trees (Byrd et al. 1990).

Logging has frequently been reported as a cause of abandonment or loss of eagle nesting sites (Broley 1947, 1950; Barnes 1951; Howell 1962). However, the establishment of buffer zones around nest trees can reduce the impact of logging on bald eagles. Nest trees can also be

preserved by leaving seed trees, especially if the nest tree is left as a seed tree. While a nest tree is likely to be abandoned during a timber harvest, seed trees may be utilized as nest trees after the harvest has taken place. The developing dense second-growth forest will discourage human disturbance of the eagle nest.

Management Conflicts

There may be possible conflicts with the management of other forms of wildlife. An effort to restore fish stocks in the state could affect the populations of fish species eaten by eagles and result in either an increase or depletion of these species. Any such management programs should be preceded by careful research and study to determine if there would be a positive, negative, or null effect on fish species that are a part of the food base for the bald eagle. Ospreys often conflict with bald eagles, fighting over prey items and potential nest sites (Buehler 2000, Poole et al. 2002). Some conflicts can be prevented by avoiding constructing osprey platforms near active eagle nests. Although a few eagles build nests on human-made structures, ospreys are much more likely to do so (Poole et al. 2002).

Waterfowl hunting, especially for Canada geese, has potential for conflict with eagle occupation of foraging habitat. Resident goose populations have reached pest levels in many parts of the state and their control is important for environmental quality because of the damage caused by large goose populations. In winter, bald eagles concentrate along rivers and at reservoirs with high availability of fish and waterfowl. Shallow waters allow better foraging potential for bald eagles. Some of the same traits also attract geese and waterfowl hunters, so there will be an overlap in activity and potential for conflict. Allowing a variety of roost trees for use by eagles may allow eagles to continue to persist in areas where winter waterfowl hunting is popular. This is an example of how habitat protection for use of both game and non-game species coincide and compliment each other.

There also is the potential for aquaculture to conflict with bald eagle protection.

Recreational Conflicts

There is substantial growth in various outdoor recreational activities that might conflict with bald eagle management. This is particularly true of motorized outdoor recreation whether enjoyed on land or on water. All Terrain Vehicles (ATV) have the potential to flush eagles from nest, especially if introduced into an area where eagles are not familiar with these vehicles. In some cases, eagles can habituate to the regular traffic of motorized vehicles as long as they are not perceived to be a threat to the eagles or their nests (driving directly toward the birds or nest at close distance). Motorboats and jet-skis also can interfere with eagle nesting and cause eagles to flush from nests, perches, or roosts. For these reasons, both kinds of motorized transportation are restricted near nests (USFWS 2007). Eagles often avoid large sections of shoreline of waterways and wetlands near boat launches and other water recreation access (USFWS 2007). Wildlife photography is another recreational activity that has potential for disturbance of eagles. Over-enthusiastic photographers, especially those who do not recognize the signs of stressed animals, could stress eagles at nest or roost sites and cause abandonment or harm to the birds.

Hunting and fishing interests have the potential to create conflicts with eagles and with eagle-watching as a recreational activity. In particular, winter waterfowl hunting may cause some eagles to flush from waterside foraging areas, loafing areas, and roost sites. Repeated flushing of eagles may cause eagles to waste valuable energy during a cold time of year or abandon critical foraging areas. There also may be the perception of harassment when the hunters are merely pursuing their quarry. The presence of hunters may also conflict directly or indirectly with eagle-viewing activities, especially where and when there are concentrations of eagles and people in an area. One of most important effects of human activity on bald eagles is the increase in nest abandonment and failure due to interference. We will review causation of eagle nest failures in the state to determine the extent and nature of this and other factors in the state. We also will use Pennsylvania eagle nest data already collected to ascertain causes of nest failure and determine, if possible, the role and extent of human activities in these failures and abandonments. We will conduct a study of eagle nest impacts from human activities in the state, including tolerances of eagle pairs to human activities near nests and communal roost sites. We also will determine if the recommended buffer of 1000 ft (305 meters) is appropriate for the Pennsylvania population in all parts of the state and in all circumstances. It may be necessary to test various proposed distance buffers to ascertain the most appropriate distance buffers for Pennsylvania eagle nests and communal roost sites. The agency will consider results from the review of nest failures and abandonment as well as direct studies of eagle tolerances of human activities. We also will review options for management restrictions near eagle nests, including distance buffers, involving members of the scientific and conservation communities in this review. As a result of these findings, we may develop a plan to reduce eagle/human conflicts where such conflicts occur. This plan would attempt to remedy situations where eagles are nesting very close to human populations and activity centers with activities that might prove detrimental or unacceptable to eagles. It also would involve people and organizations to minimize negative effects on the eagles with voluntary protections from members of the community. The process would involve a variety of stakeholders including community members, landowners, and local conservation organizations, PGC regional office personnel, other government agencies (where appropriate), and law enforcement staff. Educational materials and programs may need to be developed to educate the public on the natural history of bald eagles, their role in ecosystems, and their sensitivities to human activities. Potential strategies for reducing conflicts will be explored.

Conflicts with Other Wildlife Species

Bald eagles are predatory birds that interact with other species of wildlife by preying on several species of fishes, birds, mammals, and reptiles and competing for resources with several other species, particularly other fish-eating birds. Conflicts between these species are inevitable. Bald eagles will prey upon waterfowl, especially when fish are not easily available.

It is well-known that bald eagles compete with food and other resources with other raptorial birds, especially osprey (Buehler 2000, Poole et al. 2002). Bald eagles pirate fish from ospreys and fish-eating ducks like mergansers. At carcasses, bald eagles conflict with golden eagles, black vultures, turkey vultures, ravens, gulls and various mammals (foxes, coyotes, bobcats). Bald eagles often are dominant over other bird species; the eagle species often displace each other at winter feeding sites. Bald eagles will use osprey platforms for nesting, as

documented in Pennsylvania (Ryman 2006). In many cases, the eagles dominate the ospreys easily and conflict is avoided due to abandonment by the ospreys or their adoption of another nest site. In some cases, osprey can replace bald eagles in a territory because they are more tolerant of conditions nearby, including human activities. Ospreys are much more likely to nest on human-made structures (Buehler 2000, Poole et al. 2002). Bald eagles may be attracted to areas in the winter that are less attractive in spring or summer when human activities are greater in waterfront areas. And, they tend to congregate at roost or foraging sites in the non-nesting season.

Bald eagle nests are vulnerable to predation despite the ability of the adults to defend the nest and themselves. When not attended, the nests are subject to predation by corvids (crows and ravens), gulls, and other raptors (Buehler 2000). Red-tailed hawks and common ravens are often found in areas where eagles are nesting near mountains. Eaglets that fledge prematurely are vulnerable to predation by a variety of mammals including foxes, coyotes, black bears, and bobcats. Therefore, areas that are heavily trafficked by humans may be more likely to experience eagle nest failures due to opportunistic predation of nests.

We intend to better understand and solve conflicts between bald eagles and other wildlife species by a variety of means. We will interview any observers of eagle/wildlife conflicts to better understand the extent of the issue in the state. In this process, the agency will compile a list of species for which there are conflicts and how these conflicts occurred.

The PGC will endeavor to find resolution, if any, in avoiding conflicts and resolving those conflicts of importance to either species. We will work with agency staff, cooperators, and raptor experts to avoid conflicts and resolve the conflicts that occur. We also will develop guidelines to reduce conflicts between managed species when and where such conflicts have significant impact to those species. After reviewing those conflicts that have been observed to exist, guidelines will be written as needed for resolving conflicts. The staffs of the regional offices and the Bureau of Information and Education should be involved with this process.

SECTION III: RECREATION, ECONOMIC SIGNIFICANCE, AND PUBLIC INTEREST

Non-consumptive Wildlife Watching

Wildlife watching has grown as an outdoor recreational activity and economic force in Pennsylvania as it has throughout the United States (U.S. Dept. of the Interior, Fish and Wildlife Service and U. S. Dept. of Commerce, U.S. Census Dept. 2001). In the 2001 Pennsylvania summary, it was found that there were 3,522,000 resident participants in wildlife watching whose expenditures totaled over $1.2 billion dollars. This survey did not break down raptor-watching or eagle-watching, but it is known that many residents and tourists from out-of-state travel to see eagles and other raptors, spending money in the local economy for food, beverages, hotels, and other travel-related expenses. Among the targets are the Upper Delaware Scenic River area, the Lower Susquehanna River, Hawk Mountain Sanctuary and other famous hawk-watch sites on ridges and escarpments, and the lakes and wetlands of the state, including our game lands, where bald eagles and ospreys are easily viewed. In addition, eagle-watchers equip themselves with high-priced optical equipment, boats, and clothing appropriate for harsh weather that is associated with eagle-watching. Many of those expenditures are made in this state, which has successful retail outlets for such equipment.

The general public has great interest in and holds high esteem for the bald eagle. It is an instantly recognizable symbol of patriotism and wildness that has very wide appeal to a cross-section of Americans. On June 20, 1782, our forefathers adopted the bald eagle, or the "American eagle" as it was then called, as our national emblem. As Bent (1961) states, "Eagles have always been looked upon as emblems of power and valor, so our national bird may still be admired by those who are not familiar with its habits. Its soaring flight, with its pure-white head and tail glistening in the sunlight, is really inspiring; and it adds grandeur to the scene as it sits in a dignified pose on some dead tree, its white head clearly visible against the dark green of the forest background." Even such a hard, "dyed in the wool" scientist as A. C. Bent was led to wax poetic about the bald eagle.

Not only do birders and wildlife enthusiasts go out of their way to see and enjoy bald eagles, but photographers, fishermen, hunters, students, and the public in general become excited over the prospects of seeing an eagle and relating their experience of such observations to others. People who are not very interested in other non-game birds are excited by the chance to see a bald eagle. This is well-understood by the advertising industry. One does not have to view television very long in order to see the bald eagles used in commercials by various companies. Billboards along highways display this bird, as does the packaging for many products on the shelves of our stores. The recreational interest in and activity for this bird are very high. The digital age has made possible the enjoyment of eagles by a wider portion of public.

This great interest in bald eagles moved from individuals to organizations in the 1960s. Concern among federal and state agencies increased dramatically as habitat loss and declines in reproduction became known (Grier et al. 1983). In 1963, the U.S. Forest Service was the first agency to develop a specific management plan for the protection of bald eagles, by establishing buffer zones at all known nest sites on National Forest lands in the Great Lakes Region. During

this period, the U.S. Fish and Wildlife Service, as well as state agencies, began showing interest in the species. The National Wildlife Federation established a Raptor Information Center during the 1976 bicentennial with a special emphasis on the bald eagle. Organizations such as The Nature Conservancy, the Eagle Valley Environmentalists, and the National Wildlife Federation have acquired major habitats, such as wintering areas, and have been very effective in the protection of these areas.

Today many groups in this state have a great interest in the welfare of the bald eagle. In addition to state agencies such as the Pennsylvania Game Commission and the Pennsylvania Department of Conservation and Natural Resources (DCNR), there are thousands of wildlife enthusiasts, members of over 28 bird clubs, Audubon Pennsylvania and its many chapters, the Pennsylvania Society for Ornithology, the Ornithological Technical Committee of the Pennsylvania Biological Survey, the Pennsylvania Ornithological Records Committee, and *Pennsylvania Birds*. The Richard King Mellon Foundation and the U. S. Fish and Wildlife Service committed resources to the reintroduction of the species in Pennsylvania. Bald eagles also enjoy a great deal of support from hunting and fishing organizations that equate the eagle with habitat quality, wildness, and freedom.

The Pennsylvania Game Commission disseminates information on eagle status and distribution to the public via news media, its own web page, and other outlets. In addition, viewing opportunities have been enhanced at select sites where eagle concentrations may provide reliable sightings. Wildlife watchers go to Pennsylvania game lands to view eagles and other raptors. Eagles are easily viewed at several game lands. This is especially true of Game Commission wildlife management areas at Middle Creek and Pymatuning. DCNR Bureau of State Parks has installed informational kiosks at viewpoints of bald eagle nests at its parks. These kiosks not only inform the public about the natural history of bald eagles, but also conservation issues surrounding the eagle and its habitat.

The Pennsylvania Game Commission will work to improve eagle viewing opportunities in the state. This will be achieved on its own properties and also in cooperation with partners with a common interest in enhancing wildlife viewing opportunities, educating the public about wildlife, and improving wildlife habitat in the state.

Raptor and Eagle Watching

Raptor and eagle watching have increased as outdoor recreational experiences in their own right. Casual observers flock to Hawk Mountain Sanctuary Association (HMS) in Berks County each year to enjoy the "river of raptors" there. Pennsylvania has long been recognized as an important destination for migrating raptors and for hawk-watching. Several standard references on hawk migration not only highlight the state but were written by its citizens (Brett and Nagy 1973, Heintzelman 1979, Zalles and Bildstein 2000). Places like Hawk Mountain, Bake Oven Knob, Waggoner's Gap, Bald Eagle Mountain, and the Allegheny Front now have worldwide recognition because of these publications and the on-line access to Hawk Migration Association of North America data at hawkcount.org (Moulton and Weber 2002). It has been estimated that visitors to Hawk Mountain bring in an estimated 1.5 million dollars into the community economy from various activities associated with their visit to Berks County (Kerlinger and Brett 1995). That figure was based on 53,853 visitors per year and the economics

of the early 1990s. If this rate was extrapolated to the more current estimate of 70,000 visitors per year, the economic impact is closer to 2.5 to 3.7 million dollars per year. Local businesses surveyed estimated that they derive 10 – 25% of their revenue from HMS visitors. In addition, there are more hawk watch sites throughout the state that attract raptor-watchers to rural, mountainous counties. The most popular bird at Hawk Mountain Sanctuary remains the bald eagle despite its population increases.

There has been a steady growth in eco-tourism in the state involving bird-watching and especially eagle- and raptor-watching. Several eagle pairs apparently are permanent residents and can be observed more easily in winter than after leaf-out in spring when the nest is active. Some of these nesting pairs are easily observed at game lands, state parks, and river view points. Eagle concentration areas discussed earlier also attract many human visitors. The National Park Service's Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area websites highlight bald eagle watch locations, protections, eagle watching etiquette, and ecological associates of eagles. The Upper Delaware River hosts an EagleFest each winter that attracts hundreds of tourists. A variety of educational and tour companies, including ElderHostel, include eagle watching as a featured activity. Birding trails also are beginning to attract tourists to wilder areas where people can observe eagles. Viewers' guides to wildlife areas often feature bald eagles as a highlight (Korber and Korber 1994). Both the Susquehanna River Birding and Wildlife Trail and the Eastern Pennsylvania Birding and Wildlife Guide feature several locations where eagles can be observed (Audubon Pennsylvania 2004, Brock et al. 2009). The PA Game Commission is involved with an eagle festival at Pymatuning that attracts many participants.

The charismatic bald eagle functions as a "flagship" species for riparian forests and wetlands where it can be seen by visitors that also support populations of other, less well-known wildlife species of conservation concern, not unlike other charismatic species. Flagship species are those that can serve as ambassadors of conservation causes because of their charisma and popularity for habitats that contain many other species of concern but are not as well-known by the public. Since bald eagles need high quality watersheds, forest cover, and large areas for nesting, they serve well as flagship or umbrella species for a large set of species. More birding and wildlife trails are being planned, a reflection of the growing trend in this recreational activity. Many wildlife trail locations feature access to water for viewing waterfowl, wading birds, and eagles. The bald eagle is a particularly good flagship species for riparian forests because of its preference for very large trees for nesting support. Not only to these large trees furnish homes and foraging areas for arboreal wildlife, but some tree species provide mast for a variety of other wildlife species. Eagles also require fairly large stretches of shoreline with perches for foraging. These trees in turn provide shade along streams and assist with erosion prevention. The bald eagle ties together many conservation issues in such a landscape.

SECTION IV. BALD EAGLE MANAGEMENT OPTIONS

Legal Protection, Regulatory Authority and Responsibility

The U.S. Fish and Wildlife Service announced the removal of the bald eagle from the List of Endangered and Threatened Wildlife on 28 June 2007. It had previously been upgraded from endangered to threatened in 46 states including Pennsylvania in 1995 (U.S. Fish and Wildlife Service Monitoring Team 2007). The declassification of bald eagle is seen as a colossal success story of conservation in North America using the Endangered Species Act of 1973 (ESA), while others perceive the possible dangers to the bald eagle recovery once ESA protections were removed. The USFWS pledges to continue to work with states to protect bald eagles through other regulations, including a monitoring plan for 5 years after de-listing. Bald eagles will continue to be protected by the Bald and Golden Eagle Protection Act (the Eagle Act) and the Migratory Bird Treaty Act (MBTA). Bald eagles still are fairly sensitive to human interference at nests and roosts and at risk from persecution where the MBTA is not effectively enforced.

The bald eagle was listed as endangered in the contiguous United States in 1978 with the exception of five states (Minnesota, Wisconsin, Michigan, Oregon and Washington) where it was listed as threatened. This was done under the authority of the ESA. Five regional teams were appointed by the director of the USFWS to oversee recovery efforts. The federal status of the bald eagle was changed from endangered to threatened across most of its range during the summer of 1995, following a 1994 proposal by the USFWS (1994).

Despite widespread prejudices against eagles and other raptors, there was increased support for eagle conservation in the early twentieth century that resulted in protections given this species. Some ornithologists were educating the public that “the more common Bald Eagle feeds mainly on fish” and are not to be “reckoned with among the enemies of birds” (Forbush 1907). Others came to the defense of eagles (Sutton 1929). The rarity of eagles and consequential greater appreciation and concern for them resulted in the introduction of the Bald Eagle Protection Act in 1930 and enactment in the patriotic period of 1940 (Bean 1983 in Bildstein 2008). The Bald and Golden Eagle Protection Act (1940, amended in 1962) and the amended (1972) Migratory Bird Treaty Act provide for national protection of bald eagles. Both laws prohibit “taking” of bald eagles, their nests or eggs, defined as killing, selling, or otherwise harming. The Eagle Act has protected bald eagles where it was not protected by the Endangered Species Act, most notably in Alaska. The Eagle Act prohibits “the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export or import, of any bald or golden eagle, alive or dead including any part, nest, or egg, unless allowed by permit (16 U.S.C. 688(a); 50 CFR 22.3).” The Eagle Act provides substantial protection for eagles, including significant disincentives.

Violations of either the Eagle Act or the MBTA can result in significant penalties. For a violation of the Eagle Act, a conviction can result in civil and criminal penalties that include fines of $100,000 and imprisonment for one year (or both) for the first offence. Additional offences can result in yet larger penalties. The second violation is a felony. Penalties of the MBTA also can be substantial. The maximum penalties under the MBTA start with 6 months

imprisonment or $5000 for a misdemeanor conviction and ranges to a maximum of 2 years imprisonment and $250,000 fine for a felony conviction. Penalties for the Eagle Act and MBTA are doubled for organizations.

In 2007, modifications were made to the Eagle Act that established a regulatory definition of "disturb." The final definition of "disturb" includes "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior." (50 CFR Parts 13 and 22). The term "injury" also was better defined in a 2007 ruling. "Injury means a wound or other physical harm, including a loss of biological fitness significant enough to pose a discernible risk to an eagle's survival or productivity." This definition does not broaden protections provided by the Eagle Act but did clarify the meaning of the protections that existed already. It also provides some protection to eagles at feeding and roost sites where they may be particularly vulnerable to disturbance.

The bald eagle also is protected by the Lacey Act, passed in 1900. The Lacey Act primarily protects eagles in the context of commerce and trade. It makes it a federal offense to take, possess, transport, sell, import, or export their nests, eggs, and parts. It also prohibits false records, labels, or identification of wildlife shipped. The penalties for the Lacey Act also are substantial.

Pennsylvania listed the bald eagle as endangered until the fall of 2004 when it was changed to threatened status. This change was made on the advice of the Ornithological Technical Committee of the Pennsylvania Biological Survey. This change was made because the bald eagle's nesting population had exceeded the management goal of 80 nesting pairs with a productivity rate of 1.2 eaglets per successful nest and over 60% of the known pairs nesting successfully (0.7 young per occupied nest) (Brauning and Hassinger 2000). The bald eagle nesting population had also become rather widely dispersed across the state with nests in 27 counties (40% of the total counties), making it less vulnerable to local environmental or human-made problems (Gross 2005). However, interest by the public to protect eagles remains high and may be increasing because people have the opportunity to personally experience eagles.

The Eagle Act authorizes the Secretary of the Interior to permit "take" of eagles "necessary for the protection of…other interests in any particular locality." (USFWS 2008). There also may be instances where the take of eagle nests is necessary to protect public safety and welfare. A possible example of the latter might be the necessary maintenance of a flood-control dam with an active eagle nest nearby that would be disturbed by the activities for a nesting season, resulting in "take" of that year's production or the needed removal of a nest from such a structure for it to function properly. Information taken from the actual location and circumstances would be critical in any authorization of loss or reduction of one or more years' productivity of a nesting pair of eagles.

Monitoring Programs

Ever since the PGC initiated its reintroduction program, it also has conducted monitoring of the nesting and wintering bald eagle populations in Pennsylvania. It is critical to monitor bird populations to assess the effects of management and protections conferred as well as the overall health of the species. It is important to track the nesting population of the bald eagle in order to "maintaining continued species recovery." (USFWS Eagle Monitoring Team 2007). Emphasis is placed on nesting populations, but the wintering and migrating populations are also monitored. In order to participate in the federal post-delisting monitoring scheme, the state needs to continue nest monitoring for 20 years after de-listing. The federal program also emphasizes occupancy of active nesting territories (that is whether or not a nest is occupied). Success also is an important parameter for assessing bald eagle population health because repeated nest failures in areas could be the result of human disturbances or undetected contaminants indicated only by collecting occupancy data on a long-lived bird that shows strong fidelity to nest sites.

For the sake of better communication, a set of terms have been developed for eagle monitoring efforts. The following definitions were presented in the draft federal monitoring plan (USFWS Eagle Monitoring Team 2007) and were derived from Postapulsky (1974), Fraser (1978), Steenhof and Kochert (1982), Steenhof (1987), and Watts and Duerr (in press).

Active Nest (Breeding): A nest where eggs have been laid. Activity patterns are diagnostic of breeding eagles (or those with an "active" nest). This category excludes non-nesting territorial pairs or eagles that may go through the early motions of nest building and mating, but without laying eggs. From egg-laying to hatching, incubation typically lasts 35 days (Stalmaster 1987).

Alternate Nest: One of several nest structures within a breeding area of one pair of eagles. Alternate nests may be found on adjacent trees, snags, man-made towers, or on the same or adjacent cliffs (although no cliff nests have been found in PA in recent history). Depending on the size of the breeding territory, some alternate nests can be a few miles away from the primary nest.

Bald eagle habitat: For this study, bald eagle habitat will be defined as supercanopy or sturdy-structured trees within one mile of water bodies greater than 35 acres (14.2 ha) and rivers greater than 100 meters (328 feet) in width, but some eagles nest along smaller streams than this limit.

Breeding Area (Nesting/Breeding Territory/Site): An area that contains or was previously known to contain one or more nests within the territorial range of a mated pair of eagles.

Nest: A structure, composed largely of sticks, built by bald eagles for breeding.

Nest Turnover – The failure of eagles to reuse a nest from one year to the next.(Watts and Deurr 2010).

Occupied Nest: Any nest where at least one of the following activity patterns was observed during the breeding season:

- a recently repaired nest with fresh sticks or fresh boughs on top;
- one adult sitting low in the nest, apparently incubating;
- one or two adults present on or near the nest;
- one adult and one bird in immature plumage at or near a nest, if mating behavior (display flights, nest repair, coition) was observed;
- eggs were laid (detection of eggs or eggshell fragments);
- any field sign that indicate eggs were laid or nestlings hatched;
- young were raised.

Unoccupied Breeding Area/Territory/Nest: A nest or group of alternate nests at which none of the activity patterns diagnostic of an occupied nest were observed in a given breeding season. Breeding areas must be previously determined to be occupied before they can be recognized and classified as unoccupied.

Nesting Population: The current breeding season monitoring involves ground-based determination of the number of young produced from all known active nests. Established nesting areas are monitored by agency personnel, cooperating government agencies and organizations, and volunteers. New active nests have been identified from reports given to agency personnel by the general public, especially birders and eagle enthusiasts. It has been assumed that nearly all active nests in the state are identified within a year of their establishment, but in some cases we know that nests were active for as much 6 years before the agency was aware of a nest. A standardized nest-monitoring form has been in use since 1998, but is not necessary for participation in the program or successful monitoring. In addition to the active nesting pairs, several pairs or summering individuals are reported each year by the public or found by agency staff or cooperators. In many cases, these eagles are either establishing territories or are nesting at an unseen location. In many cases, pairs are discovered nesting in an area in where they were observed regularly in previous years.

Monitoring activities are coordinated by the Bureau of Wildlife Management's Diversity Division through the regional offices with the regional wildlife supervisor organizing monitoring efforts within that region. Statewide monitoring of productivity at all known eagle nests and searches for new pairs are conducted annually, a "complete census" approach. The general public and especially the large wildlife-watching component of the public, have a great interest in bald eagles. Even many people who would not consider themselves "bird-watchers" or "birders" are interested in eagles and motivated to study and monitor them. Several nests are monitored by non-agency government employees or volunteers, especially those nests on lands owned or managed by other government agencies. Since eagles will use alternative nests and can move to more obscure locations from the first observed nest, it is critical to maintain a year-to-year continuity with a nesting territorial pair. With the increasing size of the eagle population, monitoring nests is a growing challenge for the PGC staff to do alone. The following data are collected for each nest each year:

- The presence of a pair is confirmed at the nest site and the date of that confirmation.
- The initiation of incubation.
- The timing of eggs hatching or earliest confirmation of eaglets

- The number of eaglets observed in the nest
- The timing of fledging and the number of successful fledges.

Each new nest is documented. For each new nest, the documentation of the nest site is important to fulfill obligations to report nests to the Pennsylvania Natural Heritage Program (PNHP), the PGC Environmental Planning database, PGC Wildlife Diversity database, and the USFWS database of eagle nests. This is a high-priority task for PGC to fulfill in order to ensure full protection of each nest site. The information needed for the environmental review includes the following, as outlined on the data form called "Easy Element Occurrence" form, used for PNHP records:

- Date of nest discovery and observation dates
- Name and contact information of surveyor
- Driving directions to the nest
- Coordinates (latitude / longitude) of the nest
- Information about the pair's behavior helpful to conservation (incubation date, feeding range, sensitivity to disturbance)
- Nest's supporting structure and habitat around the nest
- Landowner information
- Threats to the site

The task of monitoring known nests has grown dramatically with the expanding eagle population. In the future, a higher percentage of active nests may need to be monitored by volunteers or cooperators if the agency desires eagle nest occupancy and productivity information. Nest occupancy (activity) is much easier to monitor than nest productivity. It also is the most critical information about the eagle nesting population (USFWS Bald Eagle Monitoring Team 2007). We believe that it will be necessary to adjust the current "complete census" of bald eagle nesting territories to a stratified sub-sample based on Bird Conservation Regions with input from USFWS and other authorities and partners, especially for nest success and productivity measures. Tracking nest occupancy is important to maintain information about nest sites which are protected from disturbance by the Eagle Act. Maintaining the eagle nest list (the "list frame") through the Pennsylvania Natural Diversity Inventory is important to avoid take of nests and to continue to cooperate with the U.S. Fish and Wildlife bald eagle monitoring plan (USFWS Bald Eagle Monitoring Team 2007). The list frame is "the current summary of all known occupied bald eagle nests for the contiguous 48 states" that is maintained by the states (USFWS Bald Eagle Monitoring Team 2007). It also is important to check on nests each year and not assume activity because there is a natural nest turnover rate and consequent list-frame decay (Watts and Duerr 2010).

As the population grows it may become difficult to monitor all nests, but a subset of nests could be monitored in order to understand the health of the population. A sub-sample of nests using a stratified sampling scheme would be used to assess trends, especially in nest success and productivity. USFWS staff will be consulted in this project. In the first five years after removal from the Endangered Species Act, a minimum of 50% of the known bald eagle nests will be monitored for occupancy and productivity using a combination of PGC staff, personnel from cooperating government agencies, and volunteer nest watchers. There will be more reliance on volunteer monitoring in the future and more efforts will be placed in recruiting and maintaining a

core of volunteer nest watchers to supplement and complement the work of agency personnel. A random set of nesting territories will be selected in each Bird Conservation Region (BCR) for the official agency monitoring program, but data of acceptable quality received from cooperating parties will be accepted and recorded on any and all nests. The federal post-delisting monitoring plan's sampling scheme is based on BCRs (Sauer et al. 2003). Management priorities and population monitoring of other land birds found in the same habitat are based on BCRs (USFWS 2002, Pashley et al. 2000, Rich et al. 2004).

Due to the great public interest, conservation interest, and charisma of the bald eagle, several nests are relatively easy to monitor. Either PGC staff or cooperating government agency staff often receive information from qualified volunteer observers dedicated to bald eagles. The non-targeted eagle nest data can be used for a variety of purposes including public information. Other nests will be more of a challenge due to their remote location or camouflage by leaves, but are still important because they are part of the eagle population and representative of that population, which needs to be monitored in a non-biased manner. Full surveys will be attempted to obtain "nest site occupation" of sites, while sub-sampling is more appropriate for determining the success and productivity of nests each year. Year-to-year continuity is important to ensure that observers can keep track of nests which can change each year due to changes in the supporting structure or use of alternative nests. Sampling each nest on a five-year basis is not realistic on a practical basis because of the changes in nest sites by eagles.

Mid-winter Bald Eagle Survey: The PGC coordinates the mid-winter bald eagle survey in cooperation with the national survey coordinated in partnership by the U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (USACE). For many years, the USGS coordinated the national survey, but this responsibility was transferred to USACE when Karen Steenhof, long-time coordinator, retired. In Pennsylvania, two kinds of routes are conducted: standardized routes for national monitoring and state routes that are reported only in the PGC annual report and associated publications. The state winter eagle routes are also fairly standardized and generate data on eagle populations and distribution that otherwise would be lost.

The annual mid-winter bald eagle survey is conducted during a selected period in early January each year with 2 target dates within that period. This strategy is adopted to avoid double-counting eagles that might move between different bodies of water. Routes can be classified as either continuous, fixed point, or both. They also can be associated with an eagle roost site or not.

The number of miles surveyed, time spent, and number of observers are recorded as a measure of effort. The instructions state that "counts should be conducted on one of the two target dates along non-overlapping, clearly defined, standard survey routes that have been surveyed consistently in previous years. Routes that have been surveyed consistently for at least 4-years and where at least 4 eagles have been seen in at least 1 year should be a priority" for each survey year. It is important that the same survey method of transportation be used for each sample area each year. USGS analyses have shown that data and, therefore, trend estimates are biased when observers switch methods of transportation (air, vehicle, boat), even when they

survey the same area from one year to the next. There also is a consistency in coverage on routes on a year-to-year basis.

Instructions and forms are provided by USGS and USACE through websites and communications with state coordinators. Cooperators and volunteers can download preprinted forms for existing standard survey routes from the USACE website. Publications have traced the recovery of bald eagles with these data (Steenhoff et al. 2002) that are available on-line at the websites mentioned.

There are additional benefits to the mid-winter bald eagle survey. Observers find that many nesting pairs are present in their territories during the winter survey period. The winter survey brings information and opportunities for protecting and monitoring eagle nests. Since pairs will build an alternative nest, sometimes far from the original one, observations made in the winter can be valuable in locating a new nest of an established pair. Observers have located courting or early nesting by eagle pairs while doing surveys. They also learn of roosting areas, which probably will increase as the eagle population increases. These important pieces of information are often shared with the PGC as a consequence of the winter survey and its communications.

We recommend that the PGC continue to recruit agencies, organizations, and individuals to participate in the bald eagle monitoring programs. There is cooperation between DCNR and PGC in monitoring of nests in state parks and state forests. There also is educational value in monitoring nests that are easily observed at state parks, forest lands, and game lands where there is potential conflict between humans and eagles and where opportunities to educate the public about eagles and their habitat exist. Individuals also assist with monitoring efforts throughout the state, especially where a nest is not easily accessible or where there is a concentration of nests. Audubon chapters and bird clubs conduct some surveys. In many cases, the eagle wintering areas are in an Important Bird Area, where there is a sponsoring organization with an abiding interest in protecting and monitoring that site (Crossley 1999, http://pa.audubon.org/iba/). Watershed protection organizations and county conservation districts are involved with some eagle monitoring and have potential for increased participation because eagles are associated with improved water quality. Through the network of birding and raptor enthusiasts and conservationists, more volunteers will be used to monitor nests. We also recommend that wildlife diversity staff should continue to coordinate this yearly project and recruit new people into the survey. USACE is a strong partner in this project and its staff conducts many surveys on its associated projects. The winter survey also serves to locate new nesting pairs and roost sites and recruit eagle nest watchers.

Migrant Population: As part of raptor migration efforts, the bald eagle is monitored regularly at hawk watch sites in Pennsylvania and throughout the world (Zalles and Bildstein 2000). A network of dedicated volunteers monitors migrating raptor populations as part of the Raptor Population Index project (RPI, Hussell and Ruelas Inzunza 2008). Most contributors to this coordinated effort are members of the Hawk Migration Association of North America (HMANA) that collects data using standardized method and forms (http://hmana.org/) (Farmer and Hussell 2008, Hussell and Inzunza 2008).. These data are used to find long-term populations trends. The RPI project regularly posts results of its trend analyses on its website: www.rpi-

project.org. Several new modern records for bald eagle migration counts have been met or broken by Pennsylvania hawk watches, documenting the region-wide recovery of bald eagles and highlighting the success of the bald eagle management programs.

The PGC Wind Energy Voluntary Cooperative Agreement, drafted in February 2007, includes monitoring for raptors where there is a perceived risk to migrating birds of prey (PGC 2007). This agreement between the PGC and cooperators requires one year of pre-construction surveys and two years of post-construction monitoring at wind sites. Effort level and length of surveys is determined by assigned risk levels that are designated by the PGC using criteria listed in the agreement. Both bald and golden eagles are species that are at risk from the development of wind power in the Central Appalachians (Brandes 2005, PGC 2007). The PGC protocol uses field sheets and basic raptor counting protocols used by HMANA for the sake of consistency of approach and ability to compare data between sites. The PGC cooperative agreement protocol also includes data collection of eagle behavior observed at monitoring locations. Information collected as part of this survey includes the following: species observed, time, eagle's age, view or aspect (dorsal or ventral), height and direction of flight, type and path of flight, and any notable behavior. These data should inform PGC and its cooperators of ways to avoid unnecessary mortality of raptors, including eagles, from wind power development.

As part of our bald eagle conservation efforts, we encourage monitoring of eagle migration at hawk watches and other sites. The framework of monitoring protocols and organization strengthen the value and usefulness of these data. We recommend that the agency continue to work with the HMANA, RPI, and other organizations to encourage more eagle monitoring sites in the state, including private lands and locations where wind energy development is possible. Knowledge of the major and minor flight lines of bald eagles will better inform planning and avoidance of mortality of eagles by wind turbines or other man-made structures. Generally, few bald eagles are seen at any site on any give day, but their numbers have been increasing in the northeastern states as bald eagle populations have recovered (Farmer 2006). Watch sites are registering record number of bald eagles, generating news of positive trends by this species in recovery (Farmer et al. 2008).

Communal Roost Site Monitoring: As the bald eagle population grows, there is an increasing chance that many will gather at locations where eagles aggregate in diurnal or nocturnal roosts. Migrating and over-wintering eagles often congregate at specific locations, usually in a grove of trees, for the purposes of resting and feeding. These communal roosts may or may not be associated with large bodies of water, but often are regularly used by the eagles. Where populations are high and food resources concentrated, bald eagles will gather into large roosts (Buehler 2000). Sites where eagles roost overnight for thermal protection, especially in winter, have conservation value. The eagles conserve energy at such roost sites that could be lost, lowering their fitness, if the roost trees were not available or the site not protected from human disturbance. The National Bald Eagle Management Guidelines propose protections of eagle roost sites under the Eagle Act (USFWS 2007). PA Game Commission intends to follow these guidelines in Pennsylvania where possible. Therefore, any communal roost sites in Pennsylvania should be inventoried and monitored for activity. They also should be submitted to the Pennsylvania Natural Heritage Program (PNHP) for protection. We should be able to learn about regularly used roosts from agency staff, other government agencies, and our partners in research,

conservation, and monitoring as well as the general public. Emphasis will be placed on roosts of at least ten eagles.

Communal roost sites also have potential value for research because individuals may be identified by DNA from dropped feathers, aiding population and demographic research (T. Katzner, pers.comm.). By sampling feathers of eagles at communal roost sites, it has been found that the population size of eagles can be much larger than previously appreciated from field observations and includes many individuals that have migrated from outside the immediate area as well as local nesters (Rudnick et al. 2008). Roost populations are usually dynamic and include birds nesting in other areas. Therefore, protection of roost sites can have positive effects beyond the apparent census of eagles at any one time in terms of numbers and geographical scope. Protection of roosts has regional consequences. Energy development along river and lake shores may be a particularly large threat to these roost sites.

We will monitor eagle communal roost sites and collect data on roost location and sizes. Through the network of birding and raptor enthusiasts, more volunteers will be used to monitor roost sites. Private property privileges will be respected, but a proactive approach to roost site protection may be needed to comply with the Eagle Act's intent to protect communal roosts. Several approaches are possible for protection including private landowner agreements, signage at roost sites, and protecting sites through PNHP and environmental review processes. Agricultural practices around roost sites are often part of the pre-existing conditions that the eagles accept. Protections given communal roost sites are not necessarily the same as those given to a nest site because the conditions and sensitivities are often very different. A tiered or priority categorization of roost sites and high use areas may be necessary to protect sites to the extent and in the manner most appropriate to their use and the sensitivities of the birds in the context of the location and their reaction to human usage. A proactive approach of educating the public and landowners about their value also has merit and can be incorporated into our eagle education programs.

Bald Eagle and their Nests Protection Options

A recent set of guidelines proposed by the USFWS serves as a model for avoiding disturbance of bald eagle nesting sites within the context of the landscape and the human activity that is being considered (USFWS 2007). However, each state has a prerogative to protect bald eagle nests as it sees appropriate, based on sensitivities observed in the state, perceived need to protect the resource, and abilities of the public to sustain protections.

Each bald eagle nest would be protected with a buffer distance (core polygon) of 1,000 feet (305 meters) from the nest location. Any substantial form of human development such as paved roads and buildings (houses) within that distance would be exempted from the buffer protections. The protection polygon buffer should end at the line of sight from the nest. This situation applies to a nest positioned on an incline (the line of sight would end along a contour line or break in elevation behind which buildings would not be seen from the top of the nest support, usually a tree, not the ground). Prohibited activities within the protective zone include construction and the following activities: water impoundment; construction of roads, trails, canals, power lines; and linear utilities and structures. Flight lanes from nest to foraging area

(river, lake, wetland) should remain open. If nest is on hillside, the buffer can follow a topographic contour line at highest point in line of sight of the nest.

In order to prevent nest abandonment or mortality of nestlings or fledglings, steps should be taken to avoid disturbance of roosts and foraging sites (foraging core area varies by location.) The quality of stream, lake, or swamp where eagles regularly forage may need to be protected in order to sustain the bald eagles at this location. Nesting territories of bald eagles most often consist of an area close to 2.6 km^2 (1 mi^2) in size in which a pair will build one or more nest.

Supporting polygon should include:

1. Area between the nest and the body of water (stream, lake, swamp) where the eagles forage,
2. An area of 1.6 kilometer in each direction from the closest point on the shore of the water body that includes the water body (and 30.5 meters on land from the shoreline),
3. All known alternative nests,
4. An area of land around each nest for a distance of at least 800 meters (0.5 mile) or to a point where the line of site is broken from the supporting nest structure,
5. If the nest is located at a swamp or emergent wetland, the supporting watershed to the wetland with appropriate buffer.

If there is an extensive watershed in support of the wetland, the "Wenger riparian corridor guidelines" (Wenger 1999) should be used to draw the supporting polygon. At the minimum, a 30.5 meter (100 foot) buffer, measured from the stream edge, plus 0.61 meter (2 feet) per 1% slope should be employed to protect the stream and wetland water quality. If nest is associated with a lake, swamp, or small stream, a buffer should be imposed to protect hydrology of system and quality of water habitat: the buffer should include the catch-basins of the sub-watersheds connected to water body using a topographically based contour line. This line also helps delineate part of the sub-watershed and will ecologically protect the wetland or lake from outside source threats. It may be helpful to delineate between these different buffers in the supporting polygon.

Particularly sensitive pairs should be protected by larger buffers, usually possible because of location. Agency staff and volunteer watchers often learn of eagle sensitivity to human activity by observing their reactions. Although pairs are more sensitive to human activities in the flight path area between nest and regular feeding area (usually downhill), they can be particularly sensitive to approaches from above. By flushing eagles from nests, humans can allow predators to take advantage of the absence of adult eagles at the nest and take the contents. Predators of nests are likely to approach from an uphill position. Flushing adults from the nest could result in nest failure from exposure of eggs or nestlings to bad weather (cold, rain, wind) or to nest predators (hawks, corvids, raccoons). Pairs often react to human approach to nests by lying lower on the nest or by flying away from the nest.

Both major and minor construction activities, quarry operations, and mining activities should be avoided within 1 mile of a nest or delayed until after nesting season. Noises from these operations often disturb eagles and disrupt nesting activities. The placement of electrical lines is increasingly understood to be an important mortality factor for avian mortality, including eagles. Decreasing these potential conflicts could have important consequences for eagles near their

nests, communal roosts, and activity centers. Power companies that have been made aware of injuries or mortality caused by their equipment have often modified the equipment to make it safer for eagles. Increasingly, bald eagle pairs are becoming more tolerant of human activities. Some nests are built within a kilometer of human structures. In such cases, the agency can be flexible about buffers and seasonal restraints on a case-by-case basis according the tolerances of the eagles and the local human activities to which the eagles are or are not sensitive. This adaptive approach to eagle nest protection should result in greater public support of eagles nesting in human-affected landscapes.

The PGC often enters into agreements with the landowner of the eagle nest. These agreements are usually made between the PGC legal team and the landowner with the WCO acting as an intermediary. More agreements may be necessary to protect eagle nests on private lands and may facilitate educating the landowner on ways to allow eagles to persist on that property, providing wildlife viewing opportunities, while the landowner still makes use of the property.

Power lines and their associated infrastructure cause injury and mortality for many raptors, including eagles. The issues, biology, and practical solutions (suggested practices) are available in "Suggested Practices for Avian Protection on Power Lines: the State of the Art in 2006" (APLIC 2006). The voluntary Avian Protection Plan (APP) Guidelines were developed in a jointly and collaboratively by the Edison Electric Institute's (EEI) Avian Power Line Interactive Committee (APLIC) and the U.S. Fish and Wildlife Service (EEI APLIC and USFWS 2005). The APP Guidelines and current information on related issues can be downloaded from the Avian Power Line Interaction Committee (APLIC) (http://aplic.org) and EEI (http://eei.org) websites. Pennsylvania power companies have a fairly good track record of working with government agencies to correct situations where power equipment is particularly dangerous to eagles. However, injury or mortality often has to occur before electric equipment is altered. These guidelines should be consulted for more details of the many issues confronting the industry and wildlife agencies in respect to avian protections at power facilities.

Eagles provide a particular challenge in regards to electrical equipment because of their large size and extensive wingspan, greater than other species that use such equipment as a perch or nesting site in Pennsylvania. Their wingspan is sufficient that a bald eagle with outstretched wings is more likely to bridge the distance between conductors. Since dry feathers provide insulation, the birds usually are electrocuted only by contacting the equipment with their fleshy parts (bill, mouth, feet, and wrists). Eagles are perhaps more susceptible to electrocution than most large birds because they can get wet from a foraging flight to a water body and because they might make contact with the wet fish they are carrying in their talons. Bird mortalities are more likely to occur at medium (4.0 to 34.5 kV) and high voltage wires than lower voltage (secondary distribution) lines. Basic principles of avian-safe electric structures are to enhance isolation and insulation. Isolation is providing a minimum separation of at least 150 cm (60 inches) between phase conductor and grounded hardware/conductor. By insulation, it is meant to cover the phases or grounds where adequate separation is not feasible.

There also is potential for collision by eagles with powerlines. Low light conditions around roosts are an additional risk factor for eagles. These risks increase with bad weather when visibility decreases and distractions increase. As eagles colonize more suburban and urban areas,

they will be more likely to encounter this electrical power infrastructure. With the proliferation of energy development in areas where eagles forage, nest, and congregate this source of injury and mortality may continue to grow and merit attention. The wildlife agencies will continue to work with electric utilities to make these facilities safer for eagles and other birds.

Raptors can be attracted to alternative perch and nest sites so as to avoid electrocution. An increasing number of avian-safe designs of equipment are available for implementation. In the Aberdeen Proving Ground, Maryland, eagle electrocution was most often associated with electric lines near shoreline, with exposed lines, and where electric lines were concealed by vegetation (Mojica et al. 2009). Avoiding such conditions should decrease eagle mortality in Pennsylvania where conditions are similar, especially along the Lower Susquehanna. Pro-active approaches to electrocution avoidance should be taken in partnership with the utility companies where there are concentrations of eagles and higher potential for electrocution (or evidence of injury and mortality). It would be in the best interest of eagles to find and address power lines or electric facilities that show a pattern of eagle injury or mortality by electrocution. The USFWS and PGC work with Pennsylvania public utilities to correct electrocution threats to eagles and other protected migratory birds in a voluntary manner. Cooperation by the public utilities is generally excellent. Perhaps future injuries can be avoided through mitigation or correction.

Some management practices can be used to protect nest sites, being incorporated into management plans for state game lands, state parks, state forests, DCNR natural and wild areas, as well as cooperative agreements with private companies (such as residential developments and wind power energy companies), and Private Landowner Assistance Program plans (PLAP). The retention and promotion of tree cover along waterways has many benefits including visually shielding the eagles from human activities. Big trees are particularly beneficial to eagles and other kinds of wildlife. This better allows humans and eagles to coexist in the same landscape, using similar resources.

- Avoid potentially disruptive activities including hiking trails and ATV paths in the direct path from the eagle nest and roost site to important foraging areas, particularly bodies of water.
- If the nest is located on a slope above a body of water, avoid construction between the eagle nest and top of slope.
- If the nest is located on an island, avoid potentially disruptive activities between nest and the nearest shores of the island.
- Avoid boating activities, especially with motorized water craft, near eagle foraging areas especially during peak feeding times (early morning and late afternoon).
- Canoe and kayak camping and portage areas should be planned to avoid regular contact between humans and eagles nesting or foraging nearby with at least 1,000 feet (305 meters) distance between the recreational areas and the eagle nest and regular roost sites.
- Continue to protect a nest site as long as 3 years after the nest has been blown down. Eagles will rebuild a nest or reoccupy a site.
- Retain mature trees along waterways for nest and perch sites, emphasizing the protection of large trees especially for wildlife uses.

- Promote tree retention and plantings in lightly recreated areas near waterways such as rails-trails and walking / bike paths.
- Site wind turbines and high voltage transmission power lines away from eagle roost sites and foraging areas along a shoreline. Bury utility lines along forested shorelines and roadways.
- Site wind turbines at a distance (at least 50 meters) from the edge of an escarpment or summit where eagles and other raptors are most likely to travel in migration.
- Avoid placing trails or scenic overlooks directly uphill from an active bald eagle nest and restrict human foot traffic between an eagle nest and top of the hill above the nest when possible.
- Avoid unnecessary use of pesticides, herbicides, fertilizers, and other chemicals; and use only in accordance with federal and state laws.
- Use an approved non-toxic shot when hunting waterfowl. Eagles can be poisoned by elevated levels of lead after feeding on fish and waterfowl that have ingested lead shot or carrion killed with lead shot.

SECTION V: PARTNERSHIPS AND PUBLIC INVOLVEMENT FOR MONITORING, PROTECTING, AND EDUCATING THE PUBLIC ABOUT BALD EAGLES AND THEIR HABITAT

Partnerships for Bald Eagles and Bald Eagle Habitat Conservation

Success with bald eagle conservation and management depends on the cooperation of many parties and will rely increasingly on public involvement. Conservation of birds the size of bald eagles necessitates a large-scale approach geographically and sociologically. As has been mentioned several times, bald eagles require a combination of high quality water bodies, a sufficient food supply that principally comprises fish, and a place to build large and bulky nests, usually in a large tree or snag. They also can migrate over long distances and tend to be found where there are larger tracts of mature trees. The population of bald eagles may be limited in Pennsylvania by the availability of nest sites at or near large bodies of water. Conserving this habitat will involve a multitude of organizations, government agencies, land owners, and private citizens. Partnerships will be necessary.

There are several established wildlife habitat and monitoring programs already in place that provide opportunities for partnerships and for contributions by cooperators and volunteers. Below, we will review some of these opportunities, some of which are not designed for eagle conservation but are suited for it because of the eagle's habitat preferences.

Monitoring

The bald eagle population is increasing at a steady rate and challenging the resources of the PGC for monitoring that population. Fortunately, there are many very interested and energetic parties willing to participate in eagle monitoring. There are three basic forms of monitoring of eagles in the state at this time: 1. nesting population, 2. winter population, and 3. migrant population.

Nesting population: The nesting population surveys are coordinated each year by the Wildlife Diversity Division's ornithologist with the assistance of a biologist-aide and the wildlife management supervisor of each PGC region. This process was discussed previously in the management plan. Many people are capable of and willing to contribute information about nesting eagles. They either report their observation directly to a wildlife conservation officer (WCO), to the regional office, or to the biologists or bio-aide involved with bald eagle monitoring. This involves experienced birders such as members of the Pennsylvania Society for Ornithology (PSO) or Audubon Pennsylvania. Organizations that emphasize raptors also contribute volunteers to eagle monitoring and conservation. This is especially true of the Eagle Institute based in Barryville, New York. The Eagle Institute promotes recreational eagle-watching and eagle conservation. Another source of volunteers for eagle nest monitoring is the county conservation districts and watershed protection organizations. The protection of stream quality and eagle conservation are naturally linked because bald eagles nest along streams with healthy fish populations and good water quality. Audubon Chapters that are involved with the Important Bird Area project have an interest in protecting the bald eagle habitat that their IBA includes. Bird club members also report on nests in their area. On occasion, the PGC learns of

eagle nests from citizens that either live or recreate near the active nest. Sometimes the person who reported the nest is willing to monitor its progress and inform a PGC staff member of that information. These volunteers can be valuable assets, allowing additional information about sites and nest productivity.

Wintering population: Each winter, Pennsylvania participates in the national mid-winter bald eagle survey previously discussed. The PGC has important partners in this survey each year. The U.S. Army Corps of Engineers (USACE) conducts surveys at several of its flood control facilities and locks each year and regularly contributes at least 19 surveys each winter. The Lower Susquehanna River bald eagle monitoring team is lead by an employee of the Chester County Conservation District. PPL employees also participate in the survey. Like the nesting survey, birders affiliated with the PSO, Audubon chapters, and local bird clubs also contribute.

Migrating population: Pennsylvania is an important state for passage migration of raptors both biologically and organizationally. The PGC has access to eagle migration data because of the contributions of many volunteers at hawk watches throughout the state. These volunteers usually are members of the Hawk Migration Association of North America (HMANA) and contribute to the RPI database that is available on-line.

We are committed to retaining and increasing our partnerships with these organizations. As the bald eagle population grows, so too will the time needed to collect and share data. This will be impossible without volunteers and the good cooperation of the organizations that represent their interests. Volunteers can work directly through regional staff or through an organization that in turn reports its collected data to the agency. Hawk watch data are a valuable way to monitor the migration population of bald eagles and other raptors. The standardized protocols, qualified observers, and data management make this project appropriate for monitoring trends in eagle and other raptor migration populations (Farmer and Hussell 2008, Hussell and Ruelas Inzunza 2008).

Several IBAs include bald eagle nests, sometimes multiple nests, passage migration sites (ridges and summits), or wintering areas (Crossley 1999, http://pa.audubon.org/iba/). We will continue to work with Audubon to list, define, monitor, manage, and protect IBAs for the future of birds in the Commonwealth.

Protection of bald eagle nest sites

The PGC has worked well with other state and federal agencies and municipalities to protect eagle nests sites and associated habitat. This includes the DCNR, the U.S. Army Corps of Engineers, Pennsylvania Fish and Boat Commission, and county and municipal parks. It also has worked with private entities including water companies, power companies, communication companies (towers), golf courses, and hunting / gun clubs. PGC staff work with landowners to protect nests in a manner already discussed in this management plan. With such a popular flagship conservation species, we anticipate a lot of voluntary protection and cooperation with our eagle management plan including cooperation from private landowners.

At some nests, the PGC enters into an agreement with the landowner. This agreement specifies some of the conditions necessary to protect the nest site and ensure success of the

nesting season. In effect, this agreement constitutes a partnership between the agency and the landowner. Landowners also can receive management assistance through the PGC's Private Landowner Assistance Program. A wildlife diversity biologist visits the site and then writes a management plan for wildlife habitat on that property. A plan could be written for a property where there is a bald eagle nest that targets bald eagles and other riparian forest species for conservation and management. Species that are not as charismatic as the bald eagle could benefit from the umbrella of protection granted this species. These species may be just as deserving of protection because of their declining status or the high responsibility our state has for its continued existence (PGC and PFBC 2005). Local land conservancies and land trusts can support these efforts with conservation easements and landowner agreements that protect forested streamsides and wetlands that support eagles. PA Game Commission will work with these organizations to protect eagle habitat.

Education of public

In addition to PGC education and outreach, other government agencies and conservation organizations can provide important educational opportunities for the public about eagles and eagle habitat. The DCNR Bureau of State Parks provides signage and educational information about eagles from viewpoints of eagle nests. Environmental education centers, both public and private, can be important learning centers for wildlife education. Our national wildlife refuges (NWR) and national parks feature bald eagles in their exhibits and outreach materials. Pennsylvania's John Heinz and Erie NWRs host bald eagle nests, regular migrants and wintering birds so it offers citizens with opportunities for views and education. Power companies also educate the public with a variety of initiatives; their properties often including waterfront or reservoirs that are important nesting or congregation areas for eagles. Their visitor centers feature exhibits and displays about eagles, raptors, and watershed quality. Organizations such as the Eagle Institute and Audubon chapters also educate the public through published materials, website pages, tours, and events.

Since bald eagles are dependent upon high quality watersheds, any organization or government agency that educates the public about the value of watershed protection and actions that protect stream quality are partners in eagle conservation. Thus, county conservation districts are a natural partner in eagle habitat education. These partnerships serve to make our agency more efficient and effective in its education efforts because we share a common message. They can dispense materials produced by the agency or link to our website pages devoted to the subject. Redundant messages may be helpful, given the diverse audience that needs to be addressed. Bald eagles have increasingly colonized the urban landscape creating more opportunities for the general public to encounter eagles. Indeed, the bald eagle has become an "ambassador for wildlife" in some of our urban areas. Along with the urban peregrine falcons (*Falco peregrinus*), these eagles offer opportunities for the PGC and its partners to reach out to the urban public and increase the appreciation of our wild heritage and the potential for free-flying raptors in the urban and suburban landscape.

Materials and events should be coordinated with these several partners to further the education of the public about eagles. Certain consistent messages should be adopted so government agencies and conservation organizations do not give contrary messages. This has

worked very well in Pennsylvania with a great spirit of cooperation. These partners can, in turn, disperse information about eagles and habitat conservation. The long-established prejudices against eagles and other birds of prey should not be underestimated as significant barriers for conservation of this and other raptor species. Basic education about the role of predatory birds in ecosystems is important for future appreciation and protection of eagles. For these reasons, raptor conservation organizations such as Hawk Mountain Sanctuary, HMANA, and the Eagle Institute are important partners in education of the public about raptors.

Protection of habitat

There are many reasons to conserve eagle habitat. Bald eagles occupy the same kind of habitat that many other high conservation priority species inhabit, but are more conspicuous and more popularly known than most. Eagles use riparian, wetland, and riverine habitats that have their own constituencies that converge on this charismatic species. Other listed species such as American bittern (*Botaurus lentiginosus*) also occupy wetlands and several conservation priority bird species such as cerulean warbler (*Dendroica cerulean*) also are found in riparian forests. Several of these species are Species of Greatest Conservation Need for native habitats given priority for management in the Pennsylvania Comprehensive Wildlife Conservation Plan (PGC and PFBC 2005) and derived from prioritization lists for Bird Conservation Regions (Rich et al. 2004). There are many species that share the same habitat as bald eagle, but are not as well-known or well-protected through their association with bald eagle. Some of these species are listed in Table 5, but there also are many other bird species in these habitats. In addition to the birds, there is a long list of mammals, reptiles and amphibians of conservation concern that also use the same riparian and wetland habitats (PGC and PFBC 2005). This includes not only birds but also mammals such as river otter (*Lutra canadensis*), mink (*Mustela vison*), Allegheny woodrat (*Neotoma magister*), as well as salamanders, turtles, snakes, fishes, and freshwater mussels, several of which are of conservation concern or federally listed (PGC and PFBC 2005). The fishes of higher quality rivers include the catadramous American eel (*Anguilla rostrata*), the anadromous Atlantic sturgeon (*Acipenser oxyrinchus*), and cold-water stream specialist brook trout (*Salvelinus fontinalis*).

There is potential for overlapping conservation initiatives for waterfowl and other water birds, especially species such as wood duck (*Aix sponsa*), hooded merganser (*Lophodytes cucullatus*), and common merganser (*Mergus merganser*) that nest and forage in forested wetlands and riparian zones. Conservation organizations such as Ducks Unlimited and other waterfowl organizations are potential partners for comprehensive habitat protection and management in an All-Bird Conservation approach This umbrella extends to species such as belted kingfisher (*Ceryle alcyon*) and spotted sandpiper (*Actitis macularia*) often associated with high quality waterways. Even upland game birds and mammals live in riparian forests and benefit from the large trees found there that produce abundant hard mast and provide homes for cavity-using wildlife. Wild turkey (*Meleagris gallopavo*) and American woodcock (*Scolopax minor*) are associated with eagle habitat in river forests and islands.

The U.S. North American Bird Conservation Initiative (NABCI) Committee is a coalition of government agencies, private organizations and bird initiatives in the U.S. that is dedicated to securing the long-term health of native bird populations (see the North American Bird Conservation Initiative website http://www.nabci-us.org/). The overall strategy is called All-

Bird Conservation with benefits for all species and those that support them. This would include shorebirds and "webless" water birds such as rails and coots. Since bald eagles use riparian forest and swamps, there is great potential for synergistic cooperation with waterfowl habitat protection and management. Many land birds of conservation concern nest or stop over in riparian forests and wetlands. Most of Pennsylvania is in the Appalachian Mountain Bird Conservation Region #28 which is organized as the Appalachian Mountain Joint Venture (JV) (see http://www.amjv.org/). The Piedmont Bird Conservation Region #29 is organized as part of the Atlantic Coast JV (see http://www.acjv.org/index.htm). The Lower Great Lakes / St. Lawrence Plain Bird Conservation Region #13 covers many of the wetlands and rivers where eagles nest in the Northwest counties. Information about land birds of conservation concern can be found at the Partners in Flight website: www.PartnersInFlight.org

Many areas where eagles nest are designated as Important Bird Areas, giving them priority for conservation (Crossley 1999, Audubon Pennsylvania 2010). Eagles often nest near high quality streams that are protected for their value for a many kinds of recreational uses such as angling and boating, but also for the value of water as a human resource. There are programs already in place that could protect eagles and their cohorts if implemented. Several species associated either with wetlands or riparian habitats are associated with bald eagles, many of which are important environmental quality indicators or have special conservation needs (Gross and Haffner 2009, Master 2009). Using the bald eagle as a flagship and umbrella species for conservation of these habitats has the potential to benefit many species including several game species, Partners in Flight conservation priority species, Pennsylvania Species of Special Concern, and Pennsylvania Bird Species of Greatest Conservation Need (USFWS 2002, Rich et al. 2004, PGC and PFBC 2005, Gross and Haffner 2009, Master 2009). Bald eagles are particularly appropriate in this role because they usually require large trees for nesting and extensive sections of river or lake shoreline forested to meet their foraging perch needs. Species that are not as conspicuous or as popularly supported as bald eagles depend on these quality forests and streams. As such, bald eagle populations will serve as sentinels for that ecosystem and its many denizens.

Table 5. Bird species of conservation concern that share habitat with bald eagle in Pennsylvania.

Bird Species ***Scientific name***	**State Status and Habitat Association**
Acadian flycatcher *Empidonax virescens*	Breeding and passage migrant. Riparian forests especially with hemlock.
Alder flycatcher *Empidonax alnorum*	Breeding and passage migrant. Wetlands and shrublands especially at higher elevations.
American bittern *Botaurus lentiginosus*	Breeding and passage migrant. Large wetlands especially marshes with emergent vegetation.
American black duck *Anas rubripes*	Breeding, wintering, and passage migrant. Variety of wetlands and ponds.
American coot *Fulica americanus*	Breeding and passage migrant. Wetlands with deep open water and emergent vegetations.
Bank swallow *Riparia riparia*	Breeding and passage migrant. Embankments along rivers, islands, and lake shores.
Black tern *Chlidonias nigra*	Breeding. Large wetland complexes with open water. Migrant along rivers.
Blackburnian warbler *Dendroica fusca*	Breeding and passage migrant. Riparian forests especially with hemlock and pine.
Black-crowned night-heron *Nycticorax nycticorax*	Breeding and passage migrant. Riparian areas especially islands for nesting.
Blue-headed vireo *Vireo solitarius*	Breeding and passage migrant. Riparian forests especially with hemlock and pine. Extensive forest.
Broad-winged Hawk *Buteo platypterus*	Breeding and passage migrant. Extensive forests including riparian areas.
Cerulean warbler *Dendroica cerulea*	Breeding and passage migrant. Mature upland and riparian forests and islands.
Common moorhen *Gallinula chloropus*	Breeding and passage migrant. Wetlands especially with floating vegetation.
Great blue heron *Ardea herodias*	Breeding and passage migrant, few wintering. Nests in trees near water including riparian forest and swamps.
Great egret *Ardea alba*	Breeding and post-nesting dispersal, migrant. Riparian forest and wetlands, especially islands and shallows.
Kentucky warbler *Oporornis formosus*	Breeding and passage migrant. Extensive and riparian forests.
King rail *Rallus elegans*	Breeding and passage migrant. Large wetlands.
Least bittern *Ixobrychus exilus*	Breeding and passage migrant. Wetlands.
Louisiana waterthrush *Parkesia motacilla*	Breeding and passage migrant. Riparian forest and ravines.
Marsh wren *Cistothorus palustris*	Breeding and passage migrant. Wetlands.
Northern goshawk *Accipiter gentilis*	Breeding and passage migrant. Large-scale forests.
Northern harrier *Circus cyaneus*	Breeding, wintering, passage migrant. Open and extensive wetlands.
Northern waterthrush *Parkesia noveborecensis*	Breeding and passage migrant. Forested wetlands, pond and lake edges.
Osprey *Pandion haliaetus*	Lakes, impoundments, and large streams. Often nests on human-made structures.
Pied-billed grebe *Podilymbus podiceps*	Breeding and passage migrant. Open wetlands and open water.

Table 5, continued. **Bird Species** ***Scientific name***	**State Status and Habitat Association**
Prothonotary warbler *Protonaria citrea*	Breeding and passage migrant. Swamps and riparian forests including islands.
Red-shouldered hawk *Buteo lineatus*	Breeding and passage migrant. Riparian and extensive forests.
Rusty blackbird *Euphagus carolinus*	Passage migrant and wintering. Moist forests, streams, wetlands. Forages in shallow water.
Sedge wren *Cistothorus platensis*	Breeding and passage migrant. Wetlands.
Solitary sandpiper *Tringa solitaria*	Passage migrant along rivers and in wetlands.
Sora *Porzanoa carolina*	Breeding and passage migrant. Emergent wetlands.
Tundra swan *Cygnus columbianus*	Passage migrant. Rivers and reservoirs, especially the Lower Susquehanna River and Middle Creek.
Willow flycatcher *Empidonax traillii*	Breeding and passage migrant. Shrubby riparian areas.
Wilson's snipe *Gallinago delicatae*	Breeding, wintering, and passage migrant. Shrub swamps, peatlands, sedge bogs, and fens.
Winter wren *Troglodytes troglodytes*	Breeding and passage migrant. Extensive forests and ravines especially with conifers.
Wood duck *Aix sponsa*	Wooded swamps, riparian forests and flooded timber.
Wood thrush *Hylocichla mustelina*	Breeding and passage migrant. Extensive forests especially in lowlands.
Yellow-crowned night-heron *Nyctanassa violacea*	Breeding and passage migrant. Riparian areas in southeastern counties.
Yellow-throated vireo *Vireo flavifrons*	Breeding and passage migrant. Riparian forests.

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