PENNSYLVANIA BOREAL CONIFER FORESTS AND THEIR BIRD COMMUNITIES: PAST, PRESENT, AND POTENTIAL

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Abstract.—Pennsylvania spruce (*Picea* spp.)- and eastern hemlock (*Tsuga canadensis*)-dominated forests, found primarily on glaciated parts of the Allegheny Plateau, are relicts of boreal forest that covered the region following glacial retreat. The timber era of the late 1800s and early 1900s (as late as 1942) destroyed most of the boreal forest on a large scale, but there has been some recovery of vegetation and delayed recovery of the accompanying avian communities. Important locally from a biodiversity standpoint, these forests support the most southerly extent of the current breeding range of yellow-bellied flycatcher and blackpoll warbler. Now persistent at a few sites, yellow-bellied flycatcher was documented nesting in the 1980s after 50 years of being absent or overlooked. Blackpoll warblers were not documented as a breeding species in Pennsylvania until 1993 but have been confirmed nesting most years since. These boreal forest relicts also host numerous other species of more northerly distribution, sometimes in high densities. Historically, olive-sided flycatcher was widespread and locally common in the high elevations as late as the 1890s, but has not been documented nesting since the 1930s. Many of these boreal bird species such as the yellow-bellied flycatcher and red crossbill are not easily detected and need specialized surveys for adequate monitoring. Diversity of habitat and plant species structure are important elements of locations that support the rarest and most diverse species assemblage. Populations of some species seem to be increasing over time, but problems with wintering grounds or migration stopover sites may be limiting some species as much as nesting habitat. The best boreal conifer sites have some level of protection, but their isolation and a general lack of appreciation present challenges for conservation of this ecosystem.

On North Mountain the forest is truly primeval; the Hemlock, the Yellow Birch, and the Maple are the characteristic trees and attain great size. The Hemlocks are scattered in considerable numbers through the forest and tower above it, their huge trunks often four or five feet in diameter marking them out as giants among their lesser brethren. The underbrush is often dense and everywhere great logs, covered with green moss, lie moldering. Here and there you hear clear cold brooks that seem to imitate the song of the Winter Wren that is almost constantly heard along them. The drawling song of the Black-throated Blue Warbler is heard on every hand. High up in the Hemlocks the drowsy sound of the Black-throated Green Warbler is heard, and the lively chatter of the Blackburnian Warbler catch the ear. Is not this a bit of northern Maine? Here it was that for the first time I heard the Wood Thrush, the Hermit, and the Olive-backed all singing at the same time. The three species were abundant and the music at sundown was a concert which for sweetness would be hard to excel.

Jonathan Dwight, writing of North Mountain in 1892 (Dwight 1892).

INTRODUCTION

Size and geographical position give Pennsylvania an important role in the Appalachian Mountain forest ecosystems. Most of the state lies within the Appalachian Mountain Bird Conservation Region. Although most of the state's forests are deciduous or mixed deciduous–conifer, some areas in the state contain boreal or conifer forests. Extant boreal conifer forests are found primarily on glaciated parts of the Allegheny Plateau and are relicts of former boreal forests that were once more extensive. Most are associated with

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forested wetlands/peatlands or are part of wetland complexes at headwaters of high-quality cold water streams (Gross 2002a). Much of the current spruce (*Picea* spp.) forest areas are located in northeastern counties, but some stands also are found in northern Pennsylvania as far west as the Ohio border, along with a few stands south of the State College area in the central portion of the state (Fig. 1).

The map of current distribution of possible spruce forest is estimated and subject to further research (Fig. 1). In particular, the Pocono Mountains, especially the High Poconos near Blakeslee in the northeast; North Mountain, the eastern part of the Allegheny Plateau in the northwest; and the Northcentral Highlands all have tracts of conifer forests that sustain populations of birds generally associated with northern forests. These conifer swamps and bogs were formed from glacial kettle lakes and filled in with peat from accumulation of organic matter (Johnson 1985; Davis et al. 1991; Davis et al. 1995a, 1995b, 2002). In older texts, these areas would have been considered to be in the "Canadian" life zone (Merrium 1894, Poole 1964).

In these conifer forests, eastern hemlock (*Tsuga canadensis*) often is dominant or is a cohort associate with red spruce (*Picea rubens*). Balsam fir (*Abies balsamea*) is much rarer than red spruce and also is scattered across the highlands of Pennsylvania, but occurs most commonly in the Pocono Mountains (Rhoads and Klein 1993). Bear Meadows Natural Area of Rothrock State Forest is an outlying location for balsam fir and several other boreal conifers (Rhoads and Klein 1993, Abrams et al. 2001). Black spruce (*Picea marina*) is less common than red spruce and confined solely to wetlands, especially sphagnum bogs and peatlands with American larch or tamarack (*Larix laricina*) (Donahoe 1954; Rhoads and Block 2000, 2005). Eastern white pine (*Pinus strobus*) also is a component of boreal conifer swamps. Even when spruces are dominant, large black gums (*Nyssa sylvatica*) are often a prominent feature of the forested wetlands where some of the birds featured in this report are found.

History and Extent of Pennsylvania Boreal Forests

Pre-settlement Pennsylvania was approximately 90- to 95-percent forested (DeCoster 1995). Glaciation and European settlement have created a more patchy forest in the state with fewer old forests. Most Pennsylvania forests are now in age classes between 60 and 120 years, with the largest 10-year classes in the 81- to 100-year range (Jenkins et al. 2004). The forests of the Allegheny Plateau once comprised a much larger percentage of hemlock. Many bird species are associated with hemlocks in the Northeast and the Appalachians. On a general basis, Acadian flycatcher (*Empidonax virescens*), blue-headed vireo (*Vireo solitarius*), magnolia warbler (*Dendroica magnolia*), Blackburnian

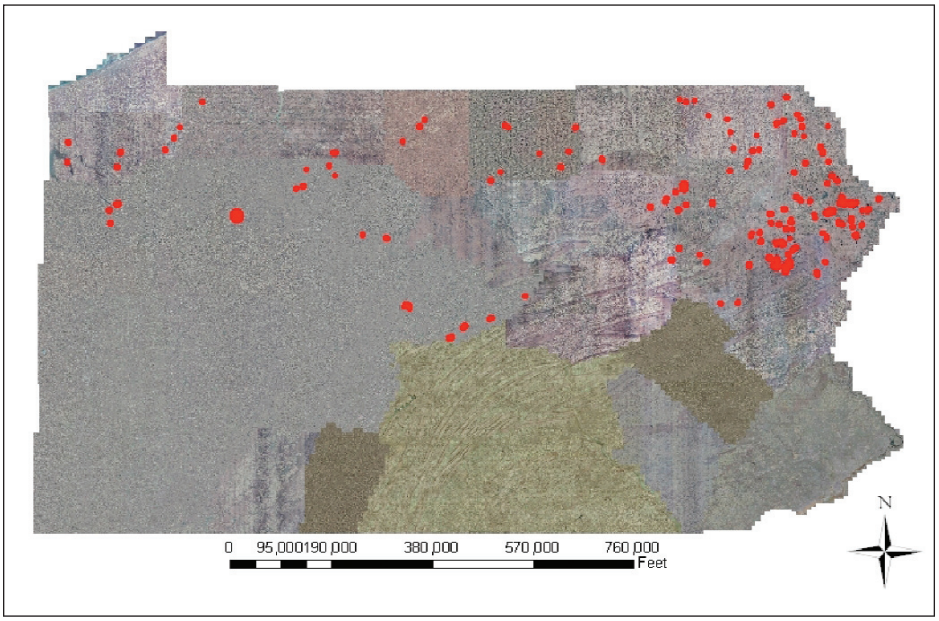

Figure 1.—Red and black spruce community distribution in Pennsylvania (red circles), PA Natural Heritage Program with The Digital Base Map of Pennsylvania and Delaware Valley Regional Planning Commission imagery as backdrop.

warbler (*D. fusca*), and black-throated green warbler (*D. virens*), are often associated with hemlock forests (Haney 1999, Ross et al. 2004, Allen et al. 2009). Conifer forests extend across Pennsylvania, and some of the most extensive and oldest are in the northwestern counties, especially in the Allegheny National Forest and in Cook Forest State Park and some public lands nearby (Haney 1999). The forests of northwestern Pennsylvania formerly had a higher component of hemlock than in present times (Lutz 1930, Whitney 1990). Only a few old-growth forests remain in the state, and most of these are dominated by conifers, particularly eastern hemlock and eastern white pine. Several bird species are broadly associated with more mature conifer forests, including red-breasted nuthatch (*Sitta canadensis*), brown creeper (*Certhia americanus*), winter wren (*Troglodytes troglodytes*), and golden-crowned kinglet (*Regulus satrapa*), as well as the Empidonax flycatcher, vireo, and Dendroica warblers just mentioned, and the hairy woodpecker (*Picoides villosus*), Swainson's thrush (*Catharus swainsoni*), and magnolia warbler (*Dendroica magnolia*) (Haney and Schaadt 1996, Haney 1999).

The loss of avifaunal elements of the "Canadian" life zone was documented and lamented by many ornithologists and ecologists in Pennsylvania (Todd 1940; Poole 1964 unpublished; Conant 1989a, b; Mellon 1989). Similar declines have been documented in West Virginia in more recent times as a result of natural forest changes (Hall 1985). The size and extent of the former boreal conifer element in Pennsylvania is often underestimated. As an example, in 1921, the amount of eastern tamarack (*Larix laricina*) in Pymatuning Swamp before timbering and subsequent flooding for reservoir creation was estimated at 800,000 board-feet (Netting and Ven Dersel 1934); virtually none remained following those disturbances (Grimm 1952). Some of the largest sawmills were active in the forests of North Mountain, where there were substantial stands of hemlock, red spruce, and white pine (Taber 1970). Fortunately, these forest communities have demonstrated some resistance to the many pressures placed upon them and have experienced some level of recovery as evidenced by the return of some yellow-bellied flycatchers and Swainson's thrushes and the occasional presence of species such as evening grosbeak and red crossbill (Conant 1994, McWilliams and Brauning 2000). Some of the characteristic birds of this diminished boreal conifer forest will be emphasized herein. One of the objectives of my paper is to share surveys and research conducted in Pennsylvania that are unpublished or have been reported in obscure reports. Findings may be relevant to similar bird conservation concerns in the Appalachians south of Pennsylvania.

The timbering era left a lasting mark on the vegetation of Pennsylvania and much of the Appalachian Mountain region. Much of the Pocono Mountain region where many of the red spruce forests occurred, was logged fairly early compared to the rest of northern Pennsylvania because of its proximity to urban areas, coal mines, and large rivers (Oplinger and Halma 1988). This region was accessible to transportation corridors, first canals and later railroads, through Stroudsburg along the Delaware River, Mauch Chunk (later Jim Thorpe) along the Lehigh River, and Wilkes-Barre along the Susquehanna River to New York, Philadelphia, and Baltimore (Oplinger and Halma 1988, Dando 1996). Large rafts of pine were floated down the Susquehanna from southern New York and northern Pennsylvania to Baltimore as early as 1794 (Harvey and Smith 1927).

The tanning industry started as early as 1822 in Stroudsburg and grew to a million-dollar industry by the 1860s. Timbering was extensive during the Civil War in the lowlands of the Poconos and culminated in the higher elevations of the Poconos in the 1870s (Mellon 1989, Dando 1996). Much of the hemlock was cut for the large tanneries, but pine was substituted by the 1880s because demand had already greatly depleted hemlock. By 1905, the area around Canadensis in Monroe County had little timber left and the Poconos were termed "a country of huckleberry barrens" (Weygandt 1905). By comparing land survey records to USDA Forest Service inventory in the 1980s, Dando (1996) determined that pines decreased in frequency from 31.5 percent to 5.7 percent, hemlock increased slightly from 9.2 to 12.4 percent, and spruces decreased from 7.3 to 1.5 percent (a nearly fivefold decrease).

In pre-settlement Pocono forests, black spruce occupied the ring immediately around wetlands and red spruce grew

farther up-slope. A history of fire-adapted communities including *Pinus rigida* and scrub barrens suggests that the southern Pocono region's pre-settlement ecosystems were influenced by Amerindians' fire regime (Dando 1996, Latham et al. 1996).

To the west of the Pocono Mountains, another spruce forest, the North Mountain area, was considered wilderness in the late 19th century and was lumbered primarily in the 1890s through 1914. North Mountain is a local name given to the eastern part of the Glaciated High Plateau Section of the Appalachian Plateau Province in parts of Sullivan, Luzerne, and Wyoming counties (Pennsylvania Department of Conservation and Natural Resources [DCNR] 2000). It includes Ricketts Glen State Park, Wyoming State Forest, and parts of State Game Lands 13, 57, and 66. Much of these properties lies in the glaciated part of the state (DCNR 2005). The last logging railroad built in Pennsylvania was constructed in 1942 to harvest Tamarack Swamp, a virgin spruce forest in western Wyoming County (Taber 1970). During the height of logging on North Mountain in the late 1890's, in a radius of about 10 miles four lumber companies cut about 300,000 board feet per day. In addition, the Stony Brook Lumber Company cut 30,000-40,000 board feet of mostly spruce daily from 1911 to 1916 in nearby western Wyoming County (Taber 1970). A major beetle infection affected the spruce forest of northern Pennsylvania in 1895-96 and stimulated massive cutting to prevent loss of the timber (Petrillo 1991). More than 11 million board feet of spruce were cut on North Mountain between the Ricketts and Kasson Brook area in a short time. A devastating storm in September 1896 felled more than 200 million feet of timber that was salvaged. By the turn of the last century, most of the spruce forest of Pennsylvania was cut as a consequence of these events.

Logging continued into the 1940s, when Hicks Jennings cut the last remaining virgin spruce in Tamarack Swamp next to the Stony Brook holdings on Dutch Mountain. The characteristics of these forests are not well known, but they appear to match the description of Appalachian-Adirondack spruce forest described by Cogbill (1996), especially those associated with wetlands and pond or lake borders. Eastern white pine was prized for masts used for ship-building and many other purposes. Hemlock was cut primarily for the tanning industry; many logs were left in the woods after their bark was stripped. Spruce was not only logged, but also shredded for excelsior. Much of this forest also burned after logging, delaying natural regeneration further. The use of fire for maintaining blueberry barrens kept some high-elevation areas in the Pocono Mountains in a stage of oak-pine scrub barrens rather than forest, but these areas are returning to forest cover (Latham et al. 1996).

The remaining conifer forests of Pennsylvania support a variety of birds and other wildlife of high conservation concern in the state (Goodrich et al. 2002). These include: northern flying squirrel (*Glaucomys sabrinus*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasiurus moctivagans*), snowshoe hare (*Lepus americanus*), and fisher (*Martes pennanti*), and formerly marten (*Martes americana*) and perhaps the lynx (*Lynx canadensis*) (Stanwell-Fletcher 1936, Genoways 1985, Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission 2005). Several rare plants also occur in these forests and wetlands (Davis et al. 1995, Fike 1999, Davis et al. 2002). The list of plants found in these forests is similar to that for old-growth spruce stands in New England (Cogbill 1996).

Boreal Birds of Pennsylvania of Concern as Target Species for Conservation or Indicator Species

The boreal bird community in Pennsylvania is a subset of conifer forests and of northern hardwood forests. A fairly long list of its members could be made, but this paper will emphasize a few of those species that serve as indicators for these habitats. Some of the characteristic birds of the North American boreal forest are found in the high-elevation forests of the Appalachian Mountains. Pennsylvania's boreal conifer forests serve as a link in a chain of "habitat islands" between the Central Appalachians and the Catskills and Adirondacks. Breeding populations of Bicknell's thrush (*Catharus bicknelli*), a boreal forest bird of high conservation priority, live within 100 miles of the Dutch Mountain wetlands and Pocono Mountains, only a short overnight flight for the long-distance migrants discussed in this paper (Rimmer et al. 2001, Rimmer 2008). Several of the birds discussed below have much larger populations in the plateau

forests of New York State. As such, the Pennsylvania boreal forests are a link, perhaps genetically, between scattered islands of habitat and populations between these larger archipelagos of conifer forest. Many bird species are commonly associated with boreal or conifer forests (Table 1). The following is a discussion of some species of particularly high concern for their conservation interest or their value as indicator species of this threatened ecosystem.

Olive-sided flycatcher (*Contopus cooperi*). Although apparently no longer breeding in the Appalachian Mountains, the olive-sided flycatcher is a priority species for conservation in Bird Conservation Region (BCR) #28 and other BCRs (U.S. Fish and Wildlife Service 2002). Before the turn of the 20th century, the big boreal pewee (as it was once called) was fairly widespread in swamps, mature forests, edges, and near ponds and lakes in Pennsylvania mountains, usually those with elevations greater that 600 m (Gross 1992b, McWilliams and Brauning 2000). It was associated with old-growth forests on North Mountain and in Tionesta forest areas (McKean and Warren counties) (Cope 1936). It was an uncommon and locally distributed breeding species in northern and mountainous parts of the state and was often associated with headwaters (Warren 1890, Todd 1940, Poole unpublished manuscript). Now, however, it is considered extirpated as a nesting species with no evidence of nesting since the 1930s (Poole 1964, Gross 1992a, McWilliams and Brauning 2000). It formerly was found principally on the Allegheny Plateau but also in the Ridge and Valley Province's higher elevations. It was not confined to the far north but was scattered throughout the highlands. This species occupied the northern corners of the state, including the Pocono Mountains and the northwestern wetlands and forests (Carter 1904, Simpson 1909, Harlow 1913, Todd 1940, Street 1954). Stone (1900) stated of this species on North Mountain of Sullivan, Wyoming, and Luzerne counties: *"Rather common; scattered at intervals over the mountains. Its penetrating call heard continually."* The loud *"Whip! Three beers!"* whistled song was also commonly heard in Pymatuning Swamp as late as 1932, which may be the last documented nesting in Pennsylvania or Ohio (Todd 1940). The Pymatuning Swamp (now Lake) was flooded and no longer has significant habitat for this or other conifer forest birds. It is notable that Hazleton, Luzerne County, was the site of the first documented nesting in Pennsylvania (Young 1898), but this forest was replaced by open pit mines that now dominate the local landscape. This location is not on the "northern tier" of counties but closer to the middle latitude near U.S. Route I-80.

Several survey challenges face managers interested in documenting nesting of this species in the Appalachians. One such challenge is that many north-bound migrants are still present in June and south-bound migrants may be moving through the state as early as July when a possible breeding bird might still be present. The few locations where summer birds have been reported are often remote locations. Persistence may be necessary to document any olive-sided flycatcher nesting in the state. Although there have been summer reports in recent decades, no nesting of the species has been confirmed since the 1930s (Gross 1992b, Pennsylvania Society for Ornithology 2006.) Singing olive-sided flycatchers have been observed in the summer in a blow-down in an old-growth forest, burned-over mountain forests, and black spruce swamps (Gross 1992b, Haney and Schaadt 1996). Recently occupied locations are consistent with the former breeding range in the state, including Lackawanna, Wyoming, Tioga, and Cameron counties. A particularly intriguing report of a territorial olive-sided flycatcher came from the old growth hemlock-beech forest in Tionesta Scenic Area of Allegheny National Forest in 1993 (Haney and Schaadt 1994). The mature forest was more open than usual because of an outbreak of the defoliating caterpillar, elm spanworm (*Ennomos subsignarius*). Territorial birds were also seen in the old tornado blowdown area nearby, where many snags provided foraging opportunities for this flycatcher. There appears to be adequate habitat in Pennsylvania for some nesting to occur. The closest location where this species has nested recently is about 100 miles northeast of the border in the Catskill Mountains (Altman and Sallabanks 2000). It also nests in New York's Taconic and Adirondack mountains (Peterson 2008a).

The olive-sided flycatcher is a paradox for bird conservation because it occurs in both mature conifer forests and disturbed forests, especially at wetland edges or in fire-

Table 1.—Bird species generally associated with boreal conifer forests and wetlands in Pennsylvania.

Bird species - common name *Scientific name*	Habitat Specifications, Distribution Notes, Limiting Factors, and Conservation Challenges.
Ruffed grouse *Bonasa umbellus*	Young and low growth of conifers and heaths; edges of forested wetlands; forest gaps. Harsh winters, lack of regeneration, and forest age are limits to population.
Sharp-shinned hawk *Accipiter striatus*	Variety of mixed and conifer forest, often nesting in conifers including exotics. Forest size and fragmentation are limiting.
Northern goshawk *Accipiter gentilis*	Extensive forest, especially where conifers are dominant and at higher elevations. Often nests in conifers, usually large-scale forests. Declining in state and region, productivity low recently. Nest predation by mammals, West Nile virus, and spring weather may be limiting factors.
Red-shouldered hawk *Buteo lineatus*	Riparian forests and forested swamps, including high-elevation forested wetlands, beaver-altered wetlands, hemlock-dominated riparian forests.
Merlin *Falco columbarius*	Expanding south into state from north, often nesting in conifers. It is not associated with extensive forests but nests in towns, cemeteries, parks near lakes.
American woodcock *Scolapax minor*	Shrubby wetlands and meadows, including bogs and swamps, and along streams in forests, as well as early-succession forest. Threatened by loss of wetlands and early-succession habitat.
Barred owl *Strix varia*	Extensive mixed or conifer forests, including riparian forests and forested wetlands. Fairly common but may be limited by competition with larger Great Horned Owl (*Bubo virginianus)* where forest is fragmented.
Long-eared owl *Asio otus*	Conifer stands in mosaic of fields and forest, sometimes in agricultural landscape and sometimes in extensive forest. Reported to have inhabited old-growth hemlocks. Poorly studied and understood in state.
Northern saw-whet owl *Aegolius acadicus*	Extensive mixed and conifer forests, especially higher than 1,500 ft and where there is dense understory of saplings and shrubs. Needs species-specific protocol for monitoring. Preyed on by larger owls.
Yellow-breasted sapsucker *Sphyrapicus varius*	Northern hardwood and mixed conifer-hardwood forests, especially where moist. Prefers foraging on softwoods. Common and widespread on plateaus, especially over 1,500 ft, increasing over the last 3 decades.
Olive-sided flycatcher *Contopus cooperi*	Formerly conifer forests, conifer and mixed forests, burned-over forest, edges of lakes and ponds. Good habitat not occupied. No confirmed nesting since the 1930s.
Yellow-bellied flycatcher *Empidonax flaviventris*	High-elevation forested conifer wetlands. Habitat is fragmented and scattered. Spruce forest and peatlands reduced by resource extraction. Population small and scattered. Good habitat unoccupied. (See text for more details.)
Alder flycatcher *Empidonax alnorum*	Shrub-scrub wetlands, riparian scrub, open sections of forested wetlands.
Blue-headed vireo *Vireo solitarius*	Conifer and mixed forests, especially riparian and swamp forests. Threatened by conifer pests and subsequent loss of hemlocks.
Common raven *Corvus corax*	Formerly confined to remote mountainous forests, now widespread in a variety of forests and mosaic of forest and fields, including some towns and agricultural areas.
Black-capped chickadee *Poecile atricapillus*	Variety of forests and forested wetlands dominated by conifers or deciduous species, or mixed.
Red-breasted nuthatch *Sitta canadensis*	Spruce, hemlock, and pine forests, including native conifers and exotic plantings. Inconsistent in occupation of many locations. Threatened by hemlock loss from pests.
Brown creeper *Certhia americana*	Mature forests and forested wetlands, primarily larger tracts of forest. Threatened by loss of large trees to diseases and pests.
Winter wren *Troglodytes troglodytes*	Cool, moist forests with downed timber and foliage diversity. Tends to be associated with conifers, especially hemlock and spruce.

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Golden-crowned kinglet *Regulus satrapa*	Native and exotic conifers, including red spruce, Norway spruce, hemlock stands; generally mature trees. Threatened by hemlock loss from pests.
Veery *Catharus fuscescens*	Not only in well-stratified forest with shrubs, but also in forested wetlands and shrubby thickets, including heaths.
Swainson's thrush *Catharus ustulatus*	High-elevation conifer forests and wetlands, including riparian hemlock and spruce woods; seeps and springs. Seems to adjust to silvicultural treatments, nesting at edges of clear cuts. Forages in blueberry shrub thickets within forests. Threatened by forest fragmentation and decrease in understory structure.
Hermit thrush *Catharus guttatus*	Mixed forest and conifers, generally at higher elevations and cooler micro-climate than Wood Thrush (*Hylocichla mustelina*). Increasing in state while Wood Thrush is decreasing.
Golden-winged warbler *Vermivora chryoptera*	Found locally in tamarack swamps, thickets, and forest edge in the Pocono region. Not found in most boreal forests or forested wetlands except at edges of beaver dam meadows, and scrub near spruce-dominated forest. Threatened primarily by lack of disturbance regime that creates desired habitat mosaic.
Nashville warbler *Vermivora ruficapilla*	Forest edges and gaps in higher elevations (>1,500 ft), including bogs, swamps, old orchards, pond and stream edges, meadows with scattered trees and bushes.
Magnolia warbler *Dendroica magnolia*	Conifer forests of various ages, including young, close-growing conifers, mixed forest, and old-growth conifers. Can have high densities in spruce and hemlock. Loss of conifers through disease and pests is a threat.
Black-throated blue warbler *Dendroica caerulescens*	Northern hardwood/hemlock and spruce forests with well-stratified woody vegetation. Forest simplification and fragmentation are major threats.
Yellow-rumped warbler *Dendroica coronata*	Conifer forests, both natural and planted,including pine plantations. Expansion in state has been documented since 1980s.
Black-throated green warbler *Dendroica virens*	Mixed and conifer-dominated forests. Higher densities in older forests.
Blackburnian warbler *Dendroica fusca*	Tall conifers and sometimes deciduous trees. Strongly associated with hemlock and spruce, but also found in oaks. Benefits from old growth attributes. Greatest threat is loss of large conifers, especially hemlocks, from pests.
Northern waterthrush *Seiurus noveborecensis*	Boreal forested wetlands, and edges of slow-moving streams and ponds with dense understory. Limited by forest fragmentation and simplification at higher elevations and by the health and size of peatlands with shrub cover.
Canada warbler *Wilsonia canadensis*	Forest interior species usually found at higher elevations and where there is cool, moist forest with high foliage density in understory and shrub layer. Found in peatlands and in mixed habitat dominated by large hemlocks at elevations below 1,000 ft. Threatened by loss of shrub layer, simplification of vegetative structure, forest fragmentation, and pests of hemlock.
White-throated sparrow *Zonotrichia albicola*	Forest and wetland with cool microclimate and strong shrub component. Often in peatlands. Also found in rights-of-way, stream and lake edges at higher elevations (generally >2,000 ft).
Purple finch *Carpodacus purpureus*	Edge of conifer and mixed forests, including forested wetlands. Increasing on Pennsylvania BBS routes.
Red crossbill *Loxia curvirostra*	Nests occasionally in native conifer forests and swamps, including lower-elevation riparian conifers and pine barrens. Limited by the size, health, diversity, and distribution of conifer forests. Nests in Norway spruce in New York.
White-winged crossbill *Loxia leucoptera*	Possibly nests in eastern and northern Pennsylvania. Forages on small-coned conifers, including exotics.
Pine siskin *Carduelis (Spinus) pinus*	Erratic nester throughout the State including towns. Not associated with native spruce or fir forests in Pennsylvania. Can nest in backyards and towns. Feeds not only on conifer seeds but also on annual and perennial herbs and grasses.
Evening grosbeak *Coccothraustes vespertinus*	Occasionally nests in high-elevation mixed forests, including edges, backyards with trees, and conifer swamps. Responds to caterpillar outbreaks (elm spanworm).

disturbed forests. It is among those species associated with "disturbance maintained woodlands" (Hunter et al. 2001). Suppression of forest fires in some areas and lack of support for conifer forests in others are two of the limiting factors for this species in its breeding range (Altman and Sallabanks 2000, Wells 2007). Like other migrant songbirds that winter primarily in southern Central America and northwestern South America, the olive-sided flycatcher has declined in recent decades. The highest known winter densities occur in the Colombian Andes (Altman and Sallabanks 2000). Other similarly declining species that winter in the same region include golden-winged warbler (*Vermivora chrysoptera*), cerulean warbler (*Dendroica cerulea*), and Canada warbler (*Wilsonia canadensis*) (DeGraaf and Rappole 1995, Stotz et al. 1996, Wells 2007). The decline of olive-sided flycatcher even where the nesting habitat has not changed or has been restored is an obvious reason for concern and suggests that limiting factors on the wintering grounds or in migration may also be important (Marshall 1988, Wells 2007).

Yellow-bellied flycatcher (*Empidonax flaviventris*). Emphasis has been placed on the yellow-bellied flycatcher because some research has been conducted on it in the state, and it illustrates many of the challenges facing ornithologists who are attempting to conduct monitoring or advance conservation on behalf of the wildlife that depends on this habitat.

The yellow-bellied flycatcher often occurs with other species associated with conifer forests. In particular, almost all territories overlap with active nesting territories of northern waterthrush (*Seiurus noveboracensis*), Canada warbler (*Wilsonia canadensis*), white-throated sparrow (*Zonotrichia albicolla*), and purple finch (*Carpodacus purpurea*). All of these species benefit not only from the conifer component of the forest, but also from canopy gaps. White-throated sparrow was not a common bird in the region before deforestation, and subsequently its population increased in shrubby areas (Dwight 1892). Concern has been raised in the last two decades for this suite of birds, but even in the 1980s the boreal forest element in the Pennsylvania avifauna was generally neglected (Gill 1985).

The yellow-bellied flycatcher is one of the most characteristic breeding birds of the boreal conifer forest ecosystem (Gross and Lowther 2001, Dunn and Blancher 2004). This species reaches the southern extent of its current breeding range in Pennsylvania, but formerly nested occasionally at isolated high-elevation forests of the southern and central Appalachians as far south as Grandfather Mountain, NC (Gross and Lowther 2001). These Appalachian Mountain sites tend to be characterized by old-growth structure or elements within large core forest matrices. The few locations where yellow-bellied flycatchers have nested in recent decades are in the highlands of the Allegheny Plateau west of the Susquehanna River from North Mountain to the Allegheny National Forest (Gross 2002a, 2002b; Second Pennsylvania Breeding Bird Atlas 2009). Pennsylvania locations have not had major human disturbance for over 70 years (Mellon 1990, Gross 2002b).

Contrary to previous reports (Bent 1942, American Ornithologists' Union 1953), yellow-bellied flycatchers have not nested in the Pocono Mountain region for several decades (Gross 1992a, 2002b), but some suitable habitat does exist in that region. Most Pocono bogs and swamps supporting yellow-bellied flycatcher were destroyed, some in the late 1930s (Street 1954), for peat bog excavation, dam building for recreational lakes, vacation home development, and road-building (P. Street, personal communications at Pocono Lake Preserve, Berwyn, PA, 2001). The yellow-bellied flycatcher is designated as a stewardship species for the Northern Forest (Dunn and Blancher 2004). Although Breeding Bird Survey (BBS) routes have not indicated a decline in this species, it is poorly served by a roadside survey such as BBS because much of its range either is in the mountains and wetlands of the northern United States or lies north of the road network in Canada (Gross and Lowther 2001). This species has increased in New York State, especially in the Adirondacks (Peterson 2008b) and in Ontario (Bird Studies Canada et al. 2006), but seems to have declined in the White Mountains of New Hampshire (King et al. 2008). Yellow-bellied flycatcher has the deserved reputation to be quiet and unobtrusive, so it is easy to overlook in surveys and, as a result, some breeding locations may be unidentified or the extent of use underestimated.

Locations where yellow-bellied flycatchers have nested in Pennsylvania have certain macrosite characteristics. They have been found nesting only in large, unfragmented forests above 1,600 feet and generally above 600 feet. Almost all occupied nesting sites are in the glaciated section of the Allegheny Plateau. The largest and most regular population of yellow-bellied flycatcher is in a boreal conifer wetland complex (Dutch Mountain wetlands of western Wyoming County), and most other sites are some kind of conifer-forested wetland (Fike 1999; Gross 2002a, b). Most regular sites are headwater wetlands surrounded by contiguous forest in all directions for at least 1 mile. Conifer forests that support this species are sometimes still in "recovery" from timbering >70 years previously. Peatlands were removed for the commercial production of peat and also flooded to create recreational water bodies. Flooding by beavers and subsequent reforesting and moss reestablishment may also be a factor in the increasing suitability of sites for yellow-bellied flycatcher (Mellon 1989). Spatially, many of these breeding locations appear quite isolated and dispersed even within a localized area.

The yellow-bellied flycatcher was rediscovered nesting in Pennsylvania during the first Pennsylvania Breeding Bird Atlas after 60 years without nesting evidence (Gross 2002a, 2002b). Microsite characteristics are cool, shady, moist forest usually with a high percentage of moss as ground cover, giving the species a nickname of "moss tyrant." The only regular nesting grounds in recent decades are in conifer swamps, but this species also may nest along cool, shaded streams with moss and downed timber. Yellow-bellied flycatcher territories often have attributes of old-growth conifer forest with a diverse age and size structure of trees, a pit and mound microtopography, diverse herbaceous and small woody plants, and large volumes of standing and fallen dead timber (Tyrrell and Crow 1994). Territories occur in gaps in the canopy produced by soil characteristics or windfalls. Territories always have conifer trees as dominants in the overstory, but also contain nearly equal amount of coverage by deciduous trees, generally those associated with northern hardwood forests. Pennsylvania sites are usually dominated by conifers such as red spruce, eastern hemlock, eastern white pine, and sometimes American tamarack or black spruce. Red spruce typically are dominant, some reaching or exceeding 100 years old (Davis et al. 1995). Mixed in with the conifers are usually red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), and black tupelo and, more marginally, American mountain ash (*Sorbus americanus*) and American beech (*Fagus grandifolia*). Some Pennsylvania sites are dominated by eastern hemlock, including older specimens of each. Sites also tend to have a diversity of shrubs, especially blueberries (*Vaccinium* spp.), swamp azalea (*Rhododendron viscosum*), sheep laurel (*Kalmia angustifolia*), Labrador tea (*Ledum groenlandicum*), wild raisin (*Viburnum cassinoides*), leatherleaf (*Chaemaedaphne calcyculata*), bog rosemary (*Andromeda glaucophylla*), and mountain holly (*Nemopanthus mucronatus*).

The ground cover usually includes diverse broad-leafed herbs, sedges (*Carex* spp.), and mosses. Some forest floor plant species characteristic of boreal forests are usually associated with yellow-bellied flycatcher territories, including goldthread (*Coptis trifida*), starflower (*Trientalis borealis*), bunchberry (*Cornus canadensis*), creeping snowberry (*Gaultheria hispidula*), blue bead-lily (*Clintonia borealis*), twinflower (*Linnaea borealis*), and cinnamon fern (*Osmunda cinnamomea*). Cinnamon fern can be dominant in yellow-bellied flycatcher territories, providing extensive cover. Most nests have been found where sphagnum moss is prevalent ground cover; some nests are well-concealed in deep moss or tree roots. This species can respond to large-scale natural disturbances of mature forests as long as certain attributes of its micro-habitat are retained. A massive tornado hit the Tionesta area of the Allegheny National Forest in May 1985, flattening about 400 hectares of old-growth forest and toppling almost all canopy trees (Peterson and Pickett 1991). Yellow-bellied flycatchers nested along a small stream in this blowdown area in the early 1990s, where blowdowns of large trees created shady areas and regenerating seedings and saplings were abundant. Yellow-bellied flycatchers tend not to nest in unbroken spruce stands, preferring openings in the spruce canopy caused by soil conditions, wind-throw, or other disturbances. Family groups (fledglings) use not only the forested wetland but also adjacent conifer forest during post-nesting dispersal, when young are still dependent on parents. Some measurements of yellow-bellied flycatcher nesting habitat allow inferences of the preferred

characteristics, but these data are incomplete and subject to change as more territories are measured. Of three occupied locations, vegetation samples were taken from 11 sample circles. In these sites, there was approximately 46-percent canopy cover with 29 percent by evergreen conifer trees. Within the territory, shrub cover was about 50 percent, fern cover 80 percent, and moss cover 88 percent. Litter cover also was very high at 96 percent. The profile of vegetation cover is presented in Table 2.

The yellow-bellied flycatcher's behavioral ecology promotes its persistence in the Appalachian Mountain landscape. Like other tyrant flycatchers, the yellow-bellied flycatcher demonstrates strong anti-predator behavior. Its nest is notoriously difficult to find, usually well hidden under vegetation, a leaning tree, or a log, or tucked in among roots of a tree or a tip-up blow-down (Gross and Lowther 2001; Fig. 2). The female tends to sit very tight, confident in the concealment provided by its mossy nest. She also protects the nest location by furtively travelling to and from the nest through dense vegetation. Pairs readily defend their nest areas from other songbirds, including blue jay (*Cyanocitta cristata*), a potential nest predator, as well as warblers and sparrows of a similar size. Like other *Empidonax* flycatchers and unlike other forest flycatchers, yellow-bellied flycatchers forage with sally gleans and upstrikes on leaves and stems within the dense vegetation of their nesting area (Fitzpatrick 1980, Remsen and Robinson 1990, Gross and Lowther 2001). This far south, pairs of this species will double-brood; the female builds a new nest as the male tends young of the first nest. The tendency for double-broods seems correlated with early arrival of the female in a territory (and perhaps philopatry), allowing time for the second nest. However, males can remain unpaired as late as mid-June before successfully pairing with a mate. Territories tend to be clustered in likely habitat with unmated males near pairs.

Table 2.—Vegetation present at various heights in yellow-bellied flycatcher territories.

Height in Feet (m)	Percent Cover (%)	Standard Deviation
2 (0.6 m)	87	12.2
4 (1.2 m)	63.6	21.8
6 (1.8 m)	35.1	17.6
8 (2.4 m)	22.1	11
10 (3.0 m)	26.4	5.9
12 (3.7 m)	23.4	13.2

The breeding population in Pennsylvania is quite small and varies yearly. Some locations are occupied only intermittently or abandoned after a year or two of occupation. The population of yellow-bellied flycatcher is difficult to track because site occupancy is variable and some singing males are not paired. The population in the Dutch Mountain wetlands of Wyoming and eastern Sullivan counties has ranged from three to 13 territories (Gross 1992c; D.A. Gross, unpublished data). Five other sites in the Northeast counties have produced young in at least one year, but unevenly through the years. Only one site has been occupied for at least 19 consecutive years and it is not always productive. Only one site in western Pennsylvania, the Tionesta Scenic and Research Area of Allegheny National Forest, is known to have produced young in each of the last 20 years. In some cases, alder flycatcher (*Empidonax alnorum*) occupies the same territories as yellow-bellied flycatcher previously occupied, implying some intra-generic competition in which the larger species dominated and replaced the other. Here is a summary of populations in Pennsylvania, acknowledging that site occupancy is variable:

- Dutch Mountain wetlands: 3-13
- Loyalsock State Forest: 1-3
- Other northeastern Pennsylvania sites: 8 (1-3 populations each)
- Northwest county sites: 2-4 sites (1-2 populations each)

Total: less than 25 known in any year (more sites than blackpoll warbler).

Blackpoll warbler (*Dendroica striata*). The first recent breeding evidence for blackpoll warbler was in 1993, when a male was heard on territory in Coalbed Swamp, Wyoming County (Davis et al. 1994, Gross 1994). The following year, a nesting pair was located and the first nest found (Gross 1994). Another nest was found in 1995 and breeding was confirmed during each of the next 10 years, 1994-2003 (Gross 2002, unpublished data). In 2005, blackpoll warbler

was added to the state's list of endangered species on the recommendation of the Ornithological Technical Committee of the Pennsylvania Biological Survey after 10 consecutive years of breeding in the state. This population extends its breeding range south from the Catskill Mountains of New York (Hunt and Eliason 1999). Similar to other blackpoll warbler populations in the northeastern United States, the Pennsylvania population lives is an isolated island of boreal conifer habitat. The closest nesting population is about 100 miles northeast in the Catskills (Hunt and Eliason 1999).

In Pennsylvania, blackpoll warblers are found breeding only in spruce-dominated parts of forested wetlands. They often are found in the territories of yellow-bellied flycatchers but can also be found where spruces and other conifers are more dominant and few deciduous trees or other vegetation is present. Blackpoll territories may include upland conifer forest with its characteristically tall and large red spruce and eastern hemlock. Thus far, this species has been confirmed in only two conifer wetlands, but it may be found elsewhere. Singing males have been reported in various locations in the Pocono Mountains and the north-central highland forests. The history of this species is not well-understood in the state because much of the conifer forest of northeastern counties was cut before ornithologists visited and inventoried it. Blackpoll warblers could easily have nested in pre-timbered Pocono spruce forests without detection. Their territories often overlap with those of con-generic magnolia (*D.magnolia*), blackburnian (*D. fusca*), and yellow-rumped (*D. coronata*) warblers. The blackpoll warbler has one of the most restricted ranges and one of the smallest populations of any breeding species in the state. The last thorough survey, conducted in 2002 (Gross 2002), found 14 breeding territories and an additional four unattached but singing males. All of these blackpolls were in the Dutch Mountain wetlands of western Wyoming County (State Game Lands 57) in spruce swamps and forests. Surveys of some locations since the 2002 study suggest that this species is declining in areas where it has nested recently. The current total population is probably less than 25 pairs and possibly less than 15 pairs.

Northern saw-whet owl (*Aegolius acadicus*). Although not a rare breeder or migrant in Pennsylvania, the saw-whet is a priority species for the Appalachian Mountain BCR (U.S. Forest Service 2002), thus deserving mention here. One of the most enigmatic yet charismatic of the region's birds, the northern saw-whet owl has received long-overdue attention recently. For several years, this species was considered a "Candidate-Undetermined" in Pennsylvania due to the lack of documentation of its breeding population. Many factors have led to consideration of the northern saw-whet owl as a rare breeding bird in Pennsylvania; it is now viewed as deserving more monitoring and inventory as part of the night bird group (Brauning et al. 1994, Gross 1998a).

The northern saw-whet owl has posed challenges to ornithologists for several reasons. Saw-whets are diminutive, nocturnal, and well hidden in the dense vegetation they inhabit. Although notoriously tame when found, they are easily overlooked. Individuals freeze in place when discovered, apparently as a means of concealment (Swengel and Swengel 1992). The saw-whet vocalization period is fairly short and confined to early spring (although they respond to imitations of their calls much later) (Palmer 1987, Swengel and Swengel 1987). During night hours when saw-whet owls are vocally active, birders do not visit the forested areas they inhabit. Until only recently, most vocalizations were not available in commercial products or at free websites that allowed interested observers to learn identification by recognizing these sounds. Because the saw-whet is migratory, it is important to avoid confusing migrating individuals with breeding birds. Northbound saw-whets are still migrating when some pairs have begun nesting in Pennsylvania. According to some observers, migrants do not respond vocally to taped song, so an audio-lure (tape/CD/MP3 playback) method may not sample many nonbreeders (D. Brinker, Maryland DNR, personal communication). Observers may find it difficult, however, to separate migrants from breeders in single short-term visits.

Recent studies have shed more light on this diminutive nocturnal bird. In a statewide breeding survey project (known as "Project Toot Route"), volunteers conducted eight-point road routes with an audio-lure protocol that changed our impression of its nesting range and abundance in Pennsylvania (Gross 2000, 2001). Project Toot Route

and the subsequent Second PBBA have revealed that the number and distribution of saw-whets is larger than previously documented (Stone 1894, Sutton 1932, Todd 1940, Poole 1964, Gross 1992a, Cannings 1993, Milling et al. 1997, Second Pennsylvania Breeding Bird Atlas 2009). At least three singing saw-whets were found within 20 miles of the Mason-Dixon Line in Pennsylvania mountains, including the Allegheny Plateau and South Mountain (perhaps continuing south to the Catoctin Mountains, MD). The perceived gap in breeding range in southwestern Pennsylvania and east-central West Virginia probably reflects lack of coverage in surveys rather than a paucity of owls.

Routes with the larger number of saw-whets were primarily on North Mountain or in the northwest counties, especially in and near Allegheny National Forest (Gross 2000, 2001). Most northern saw-whet owls live up to their reputation for breeding in cool, higher-elevation forests with a well-diversified foliage structure. The higher vegetative cover enables saw-whets to forage low near their rodent prey without detection and also to avoid predation from larger owls (Cannings 1993). Virtually all saw-whets found on "toot routes" were in large patches of forest, but some have been reported at the edges of forests. They can be fairly common in forested wetlands with a healthy shrub and sapling layer. Good vegetative structure and conifer cover seem to be components important to its breeding habitat. Cool summer temperatures may also be necessary for saw-whets.

Brief Mention of Other Avian Members of the Boreal Forest Community

Yellow-bellied sapsucker (*Sphyrapicus varius*). This medium-sized woodpecker is one of the characteristic breeding birds of the Pennsylvania mountains (Gross 1992d). It is widespread and common across the Allegheny Plateau and higher elevations of the Ridge and Valley section. Sapsuckers may be the most common breeding woodpecker of the North Mountain region and the Allegheny National Forest. It is found not only in large forest tracts but also in yards and orchards of the plateau. It is one of the most common birds in boreal conifer forests and wetlands and is also found in northern hardwoods and mixed hardwoods and eastern hemlock forests. South of Pennsylvania, this medium-sized woodpecker is declining.

Swainson's thrush (*Catharus ustulatus*). The rarest of the thrushes in Pennsylvania is associated with conifer and mixed conifer-deciduous forests at higher elevations (Brauning 1992). It is found most commonly in northwestern counties, where there are extensive forests at higher elevations. It seems to be increasing in northeastern Pennsylvania, although not always occupying locations where it was found prior to the exploitative logging period (Cope 1936, Brauning 1992). Some ornithologists consider the Appalachian Mountain population as a distinctive subspecies in the olive-backed group of Swainson's thrush (*Catharus ustulatus appalachiensis*) (Ramos and Warner 1980, Pyle 1997, Mack and Yong 2000), The Appalachian subspecies spends the winter in Colombia and northeastern Peru, where bird conservation is considered problematic due to loss of habitat (Ramos and Warner 1980, Mack and Yong 2000). Its breeding distribution is rather localized but much more widespread in the northwestern Pennsylvania counties than elsewhere. The old-growth eastern hemlock-white pine forest of the Tionesta Natural and Scenic Area in the Allegheny National Forest probably has the largest population in the state (Haney and Schaadt 1994a, 1994b, 1996). Formerly, it was common in Tamarack Swamp, Clinton County (Cope 1901), but has not been found in return visits for several decades (Reimann 1941, Pennsylvania Society for Ornithology 2006). It formerly was fairly common on North Mountain, Sullivan County, especially in the "virgin forests" (Dwight 1892, Cope 1936), but now it is only scattered and local (Gross 2003, Sauer et al. 2005, Pennsylvania Society for Ornithology 2006). Not only is Swainson's thrush rare, but it is also secretive and easily overlooked by observers.

At one time, Swainson's thrush was reportedly locally common to abundant in Pennsylvania's northern counties (Poole unpublished manuscript; Brauning 1992). It was rare and local in Warren County where it was found nesting to "deepest parts of the virgin forest" in Tionesta (Cope 1936). This species also once was more common in the Appalachians south of the Mason-Dixon Line. It was locally common in red spruce forests in West Virginia before timbering (Bent 1949, Hall 1984). It certainly is more common and widespread in the extensive mixed forests of northwestern Pennsylvania than in the Northeast, where many of the reports of this species singing in forests turn out

to be unmated males (personal observation).

Recent surveys suggest that this species is gradually reclaiming parts of its breeding range. Although it is common in Pennsylvania's largest old-growth conifer forest, the Tionesta Scenic Area of Allegheny National Forest (Haney and Schaadt 1994a, 1994b, 1996), it also is found at edges of clearcuts, in openings caused by windthrow or forest roads, and in blueberry glades within forests. It is another paradoxical species that responds to attributes of both old-growth forest and disturbed forests (Mack and Yong 2000, Hunter et al. 2001). It also forages for insects on the wing and by up-striking more than do other forest thrushes, giving it the "mosquito thrush" nickname in the past (Bent 1949, Mack and Yong 2000). No matter what the micro-habitat features, this thrush is found almost exclusively in large-scale forests at higher elevations in the Appalachians.

Canada warbler (*Wilsonia canadensis*). This priority species for the Appalachian Mountain region has been declining in the Northeast for several years, apparently as a result of habitat changes (Conway 1999, U.S. Fish and Wildlife Service 2002, Lambert and Facchio 2005, Wells 2007). Although declining in Pennsylvania as well, the Canada warbler can still be locally abundant in boreal forested wetlands. In Pennsylvania, the Canada warbler breeds in cool, moist forests and forested wetlands, especially where conifers and heaths are dominant. It particularly favors eastern hemlock and spruce. Canada warblers are notorious for their preference for dense growth of rhododendron and other heaths along mountain streams and moist forests. It tolerates minor disturbances, responds well to gaps in canopy cover, and is not particularly area-sensitive within a forested landscape, but it is generally found in large-scale forests. Like other species discussed here, the Canada warbler benefits from greater vegetative structural diversity found in naturally occurring and manmade canopy gaps of forests and forested wetlands. It can be locally abundant in boreal conifer swamps of North Mountain and the Pocono region (Gross 2002a; D. Speicher, Pocono Avian Research Center, personal communications, 2009).

Red crossbill (*Loxia curvirostris*). One of the most enigmatic conifer-obligate bird species that has merited recent conservation concern is the red crossbill. Red crossbills are very rare and erratic in Pennsylvania and most of the northeastern United States (Fingerhood 1992, Atkisson 1996). Historically, this species has nested (or attempted to nest) in several counties of Pennsylvania ranging from the northern tier to the Philadelphia area (Fingerhood 1992, personal observation). In the last two decades, red crossbills have apparently nested or attempted to nest near Lopez, Sullivan County; near Pine Creek Gorge, Tioga County; and in Sproul State Forest, Clinton County. The Second PBBA results may reveal more locations. The red crossbill may actually be a group of very similar-looking bird taxa that could be considered species (Groth 1993a, Parchman et al. 2006). These proposed "cryptic species" are at least nine distinct "types" that vary by size of bill and body, as well as by vocalizations (Groth 1993a, 1996; Benkman et al. 2009). Each type of crossbill is best adapted to certain species of conifer for which its bill is especially efficient in opening the cone (Benkman 1987). Red crossbill types 1 and 2 have been confirmed nesting in the Appalachians (Groth 1988). These types are best identified by subtle differences in their call notes, which allow them to sort out with little mixing between ecotypes (Groth 1993a, 1996). Several types probably nested in New York during the latest PBBA, between 2000 and 2005 (Young 2008a).

In Pennsylvania, red crossbills of Type 1 have been observed feeding on eastern hemlock, eastern white pine, and white spruce (*Picea glauca*) (personal observation). The "old Northeastern" red crossbill (Dickerman 1987) is probably the Type 1 red crossbill, a medium-sized form with an upward inflected flight note that also is found in the southern Appalachians and the Pacific Northwest (Groth 1993a, 1996; personal communication). In New York, red crossbills have been feeding and nesting in Norway spruce (*Picea abies*) and feeding in red pine (*Pinus resinosa*) and white spruce (*Picea glauca*) (Young 2008a). White-winged crossbills also have been reported breeding in Pennsylvania. This more northerly crossbill nests in New York within 50 miles of the Pennsylvania border and feeds primarily on soft-bracted conifers, including both Norway and white spruces (Young 2008b). Both crossbills possibly occur in native as well as planted conifer forests. Current distribution of the red crossbill may not include its historic range.

Historically, they have been found nesting at a variety of sites, including riparian pines at various locations along the Susquehanna River and pine barrens near the Philadelphia area (Fingerhood 1992, Brauning et al. 1994).

Other conifer specialists, such as evening grosbeak, have a history of nesting in Pennsylvania. The evening grosbeaks were responding to an outbreak of elm spanworm (Conant 1994, personal observation). Infestations and then declines of spruce budworm (*Choristoneura fumiferans* Clem.) in southern Canada are possible cause of increases, subsequent declines, and consequent irruptions of many boreal songbird species, including crossbills, chickadees, and purple finches, into the northeastern United States (Bolgiano 2005). Opportunities may arise for both the birds to colonize new locations and for researchers to study these distribution changes. As conifer specialists, crossbills are particularly sensitive to the availability of conifers on a large scale (Benkman 1993). Older conifers produce more cones, and management for older conifers would probably result in an increase in these species. More crossbills breed where there are larger cone crops (Benkman 1990; Young 2008a, b).

CHALLENGES AND FUTURE DIRECTIONS

Inventory and Monitoring Challenges

One of the most obvious challenges for management and conservation of boreal conifer bird species is the inventory and monitoring of populations. The size and regularity of these populations are not well understood, so it is difficult to develop and implement management plans. The difficulties are raised because these species:

1. Occupy remote locations, often without convenient trail or road systems for survey access.
2. Need specialized survey protocols, including audio–lure and mapping of territories, and a need to regularly conduct surveys to determine persistence and trends.
3. Require multiple survey visits, including early and late seasons, within one nesting season. (Some species nest fairly early and others nest late.)
4. Tend to be more difficult to detect and, when present, easily overlooked, even by accomplished observers.
5. Occur in biologically sensitive sites incompatible with repeated or high human visitation.
6. Occupy locations rather irregularly due to uneven environmental conditions or other constraints, such as cone crop size and varying rain amounts that affect swamp conditions.
7. May be somewhat nomadic, depending on species, and do not regularly occupy locations even under the best conditions.
8. May have uneven sex ratios in some species, requiring extra effort to determine occupancy of pairs, not only singing males, and viability of the breeding population.
9. May not occupy locations every year as a breeding pair. Some locations nevertheless are occupied persistently if not annually, so multiple-year studies are necessary to determine population status.

Challenges for monitoring and inventory of these rare boreal birds include basic identification issues that are important to address for the credibility of the methods and results. The yellow-bellied flycatcher is a member of the *Empidonax* genus of tyrant flycatchers, one of the most challenging groups of birds to identify (Kaufman 1990, Kaufman and Sibley 2002). It serves well as an example of this challenge.

Despite perceived advances in birding skills, knowledge of the avifauna, and bird identification products, some difficulties remain in coverage of yellow-bellied flycatcher, including confusion with other species, and identification challenges presented to the observer. For many decades, the genus *Empidonax* has posed difficulties with visual identification, to the point where some texts used the same illustration for multiple species.

Few observers have much experience with this species on the nesting grounds. Its vocalizations still can be confused with other birds, especially eastern wood-pewee (*Contopus virens*) and least flycatcher (*Empidonax minimus*). Most commercial products of bird vocalizations condense in the same track

sounds that are rarely given in the wild together as a short sequence. These audio products also compress the vocalizations, decreasing the time between calls and giving the illusion of a faster pace than the actual frequency of the advertising song (*che-bunk*). The *"che-bunk"* advertising song (also an abrupt, hoarse *killink* or *killik*) is similar to least flycatcher's but given at a more leisurely pace of 6-8 times per minute, compared to the frenetic pace of about 60 times per minute by a male least flycatcher. In fact, this is a diagnostic identification feature of a yellow-bellied flycatcher's advertising song. Males tend to switch to a single-syllable song, perhaps as a demonstration of status—*schleck!*, *psek!*, or *kik!*—similar to the call of downy woodpecker (*Picoides pubescens*) or hairy woodpecker (*P. villosus*) when they become paired. This switch from an advertising song to another song is similar to the pattern found in Pacific-coast flycatchers, *Empidonax difficilis* (Lowther 2000), and many wood-warblers (Spector 1992). Migrating males also will sing the advertising song in early June, confusing the situation for observers. Many males that sing the advertising song after early June are unmated males attempting to find a mate, which they sometimes do successfully. If they wander widely (more than 90 m from a center point), they also are likely to be unmated males. Individual males are sometimes rewarded for their persistence on territory. On the other hand, once pairs have young in nests, they are generally quiet and males often do not respond to audio-lure at this stage.

Other identification challenges include the red crossbill types, which are most easily verified by their call notes (Groth 1993a). If possible, aural recordings should be made of questionable records to review and verify an identification.

Possible Solutions for Inventory and Monitoring

Concerted efforts will be needed to inventory and assess bird species populations in the boreal community. Some individuals may occupy territories but not reproduce for lack of a mate. It may be necessary to design and implement surveys that include an assessment of territory occupancy as well as breeding status and success. Off-road bird surveys will need to be devised and maintained to assess population sizes and persistence of the indicator species of this ecological suite. Some surveys may require special audio-lure (tape playback) protocols as part of their design. Some standardized bird monitoring techniques such as point counts have their place in such habitats, but more focused procedures such as the mountain bird monitoring protocol (Hart 2007) or Monitoring of Avian Productivity and Survivorship (MAPS) (DeSante et al. 2009) might be more appropriate and successful in some locations. These approaches, however, require extensive commitment and resources from individuals or organizations. An older technique known as "spot-mapping" or "territory mapping" has been successfully implemented in monitoring trends in spruce forests (Robbins 1970; Hall 1983, 1984). Although time-consuming, this technique could be useful with geo-referencing and other improvements for monitoring a bird community of particular concern.

Some solutions proposed for surveying this suite of birds could act as a monitor of these threatened ecosystems' health (Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission 2005):

1. Involve the public in "citizen science" projects that inventory and monitor areas of greatest interest (e.g., eBird, BBS routes, Important Bird Areas (IBA) monitoring, Breeding Bird Censuses, Breeding Bird Atlases).
2. Adopt off-road point counts in high-elevation forests and wetlands, especially in IBAs and locations that support the most rare and sensitive species.
3. Initiate or support specialized surveys of this habitat, particularly the Mountain Bird Monitoring Protocol (Hart 2007) and MAPS (DeSante et al. 2009).
4. In addition to completing standardized surveys, conduct species-specific surveys that target habitat associated with the species; use geo-referencing and audio-lure when appropriate.
5. Track territory-occupancy and the breeding status and success of selected species by mapping (digital geo-referencing).
6. Synthesize various bird surveys with geo-referenced appropriate measurements of habitat health (e.g., vegetation measures and tree pests).
7. Use banding and other methods of tracking individuals to better determine philopatry, nest success, and habitat use,

including post-nesting dispersal; follow MAPS protocol in selected locations.

8. For diurnal forest raptors and nocturnal bird species in this landscape, adopt special surveys, which may be part of or complement statewide standardized surveys.
9. Track changes in bird populations in areas where treatments are implemented or natural changes in the habitat have occurred (a fire, for example) to better understand how these changes in habitat affect bird species of conservation concern.

Promise and Potential for Boreal Conifer Forests

Threats to boreal forests and wetlands: One of the most pervasive threats to the boreal forests and forested wetlands of Pennsylvania originates from the lack of awareness that these ecosystems are part of the state's natural communities and therefore merit protection and management on their behalf. There also are competing values even among the wildlife community, which places more emphasis on flooding wetlands to create standing water that support waterfowl and sport fisheries. The cool, comfortable highlands of Pennsylvania have been a recreation and second-home destination for many decades. Conifer forests and wetlands often suffer in competition with recreational space and housing. In addition, wind energy and gas exploration promise to compete for resources in the Pennsylvania highlands, potentially replacing conifer forest permanently, severely fragmenting the remaining tracts of forests, and threatening to pollute boreal conifer wetlands.

Ornithologists and conservationists have long lamented the loss of forested wetlands and conifer forests, often to peat excavation, reservoir creation, and the long-term effects of logging on a grand scale in Pennsylvania and elsewhere in the Northeast and mid-Atlantic. Past widespread land alterations have had long-time negative impacts on both the avian populations and the potential for recovery. Draining, diking, damming, and other hydrological disruptions have irrevocably changed habitat with potential for these rare species. The recreational industry has caused the loss of many wetlands, including peatlands, through flooding to create recreational water bodies. Since yellow-bellied flycatcher and other ground-nesting birds often use sphagnum moss or dense ground cover, mosses must be protected by preventing desiccation and excessive trampling.

Another threat to these habitats is forest fragmentation, especially from road construction. Wind energy development is a looming threat to any high-elevation natural community because of its infrastructure development and consequential fragmentation (U.S. Fish and Wildlife Service 2003, National Research Council 2007). As a result of these concerns, the Pennsylvania Game Commission has instituted a cooperative agreement with wind-power development companies with a bird population and mortality protocol (Pennyslvania Game Commission 2007). Forest would be replaced by grassy and weedy areas most likely dominated by invasive plant species and at a scale not helpful to species of conservation priority. Acidic atmospheric deposition is another threat to the forests of highland Pennsylvania, but that subject has been covered by other presenters at this conference and other authors and so will not be covered thoroughly here. Atmospheric acid deposition is a possible concern for reproductive capacity of many forest songbirds, including common species (Hames et al. 2002). Global climate change also has potential for a significant impact on this group of species (Rotenhouse et al. 2008). Concern for effects of this change on bird and wildlife populations could stimulate more specific monitoring of species and habitats most sensitive to possible habitat changes.

Conifer forests do not seem to have recovered as quickly as have the deciduous forests from the lumbering era. The remaining boreal conifer forests and wetlands are isolated and fragmented, often with dissimilar habitat bordering them. Conifer stands tend to be dense and without interruption in the canopy. Gaps that imitate the effect of wind-throw would imitate conditions conducive to several species discussed in this paper. These forests tend to be either destroyed or ignored. Some management of the forests for characteristics that favor priority species is possible with proper planning and commitment of resources.

The quality of forests also suffers from various tree pests and diseases. Among these are the hemlock woolly adelgid

(*Adelgis tsugae*) and the elongate hemlock scale (*Fiorinia externa*). Forest pests such as hemlock woolly adelgid and spruce beetles are significant threats to the state's conifer forests. Hemlock woolly adelgid infestations can be severe in the Appalachians, where high tree mortality dramatically changes the forest canopy and understory. Drought exacerbates these pests' effects on eastern hemlock. Excessive white-tailed deer (*Odocoileus virginianus*) herbivory is a constant threat to forest health in Pennsylvania (Latham et al. 2005). The forest vegetation structure is simplified and plant diversity diminished by excessive deer browsing. Some of the species discussed in this paper benefit from a rich and diverse understory that excessive deer browse can destroy. Many of the boreal conifer forests are in extensive forest tracts, generally in their favor, but these areas sometimes do not receive the hunting pressure on the deer herd necessary for good forest health.

Unoccupied habitat remains available for some of our target conservation bird species. In some cases, males declare territory but cannot attract females. This pattern suggests that there are some population limits on the wintering ground and migration route. It will be a challenge to address limitations that may be occurring on the wintering grounds for these species and partner with organizations to find solutions to these challenges (Pashley et al. 2000, Wells 2007). Global climate change also is a threat to these conifer forests (Rotenhouse et al. 2008). Species with narrower elevational ranges are particularly vulnerable to rapid climate change, and isolated populations will be challenged by shrinking size and connectivity of these habitat islands. Many of the higher-elevation and northern species of Pennsylvania are probably at greatest risk to state extirpation by rapid changes in climate, especially warming. On the other hand, possible increases in precipitation may create some conditions conducive to spruce in areas now too dry for propagation and growth.

Potential for boreal forest conservation and management:
In recent years people have increasingly recognized and appreciated these forests in recent years. Several sites are listed in the Pennsylvania Important Bird Area Program (Crossley 1999, Audubon Pennsylvania 2009). Most sites with significant boreal conifer forest are owned by public entities, particularly the Pennsylvania Game Commission, the U.S. Forest Service (Allegheny National Forest), and DCNR Bureau of Forestry. Several species are listed in the Pennsylvania Wildlife Action Plan (Pennsylvania Game Commission and Pennsylvania Fish Boat Commission 2005). The bird species are not alone in this regard. Among those species given priority for conservation is the Northern Flying Squirrel, which has endangered status in Pennsylvania. Planning and management for wildlife lands have incorporated protections for those species listed by the Pennsylvania Natural Heritage Program.

Planning for the restoration of older forests is critical for the future of conifer forests and wetlands. An old-growth forest system is being planned for Pennsylvania, with most projected old growth in the central part of the state (Jenkins et al. 2004). Such forests would primarily be northern hardwood, hemlock, pine, and mixed forests. These forest types would not be optimal for many of the boreal conifer forest bird species but certainly would benefit many. Increasing the area of older conifer forest would be particularly beneficial to crossbills (Benkman 1993). Planning for older forests does not preclude planning for early-succession forests and disturbance regimes necessary to create gaps sufficient to support a suite of species that depend upon that habitat (Hunter et al. 2001). Indeed, a matrix of forest types will benefit forest bird species that now are not flourishing where most forests are middle-aged and lacking the foliage and spatial heterogeneity necessary to support them.

The Pennsylvania Important Bird Area program is a key bird conservation initiative that prioritizes areas for conservation, inventory, and research. Some locations designated as Pennsylvania Important Bird Areas that include boreal forest are: Heart's Content and Tionesta Scenic and Research Natural Area of Allegheny National Forest, McKean and Warren Counties; Tamarack Swamp Natural Area, Clinton County; Black Moshannon State Park, Centre County; Rothrock State Forest, including Bear Meadows Natural Area, Center, Elk, Cameron, and Clearfield Counties; Loyalsock (formerly Wyoming) State Forest, Lycoming and Sullivan Counties; Ricketts Glen State Park/Creveling Lake area (State Game Lands 13 and 57), Sullivan, Luzerne, and Wyoming Counties; Dutch

Mountain Wetlands, State Game Lands 57, Wyoming County; Promised Lake State Park and Bruce Lake Natural Area, Pike County; Pocono Lake Preserve area, including the Thomas Darling Preserve (Two Mile Run Swamp), Monroe County (Crossley 1999, Audubon Pennsylvania 2009). Some important sites may not be designated by the IBA system; if they were given this status, they might garner more support for protection.

Concerns are not limited to birds. Several areas also are designated as Important Mammal Areas because of their importance to particular mammals of conservation concern. These kinds of conservation plans overlap in many places because of shared concerns for certain ecosystems that support priority species.

Interest in the inventory and monitoring of birds in this ecosystem has increased as the knowledge and appreciation for the bird community has grown. More birders are seeking out these areas as part of their recreational birding and as part of their participation in "citizen science" projects, such as the BBA and eBird. Active research is taking place in the format of the MAPS program and owl banding (Project OWLNET) at the Tom Darling Preserve, Monroe County, on a boreal forested wetland bird community (D. Speicher, personal communication;, www.poconoavian.org).

Silvicultural practices have been shown to increase the amount and quality of spruce in mixed forest where regeneration is occurring slowly or not at all (Rentch et al. 2007). Thinning the deciduous component in the canopy of Allegheny Plateau forests (in Pennsylvania, generally red maple and American beech) where there are regenerating spruce seedlings and saplings could be an effective ways to increase the spruce component of our forests. Reducing basal area of the canopy by 50 percent has the potential to double red spruce basal area in a mixed forest after 20-40 years. Such strategies may be helpful to replace the hemlock that will inevitably be lost to hemlock woolly adelgid and other pests and diseases. The regenerating spruce also provides benefits for species needing thermal protection in winter, such as ruffed grouse (*Bonasa umbellus*) and snowshoe hare. Partnerships between different advocacy groups and agencies taking a multi-species ecosystem approach to forest management would generate results meeting the goals of many diverse organizations.

The natural regeneration of Pennsylvania boreal conifer forests has been taking place primarily through benign neglect. Natural recovery of spruce forests has progressed slowly as spruce regeneration has fanned out from core areas of mature trees. These core areas are primarily in forested peatlands but also in isolated uplands sites. Headwater wetlands are getting increased attention through advocacy for watershed protection. The spruce- and eastern hemlock-dominated wetlands are generally in headwaters of high-quality coldwater streams, important for trout fishing and as a water source for communities and industry. The loss of eastern hemlock, the State tree, could have devastating effects on populations of several bird species, trout, and other wildlife found more commonly in its deeply shaded forest. Application of insecticides and release of *Sasajiscymnus tsugae* beetles have potential for local treatment of hemlock wooly adelgid. County conservation districts, sportsmen's groups, and watershed protection organizations support the protection of headwater wetlands and forests. Concern for the loss of deep-shaded hemlock-lined streams is a common denominator between trout fishing and conifer-related birds that would encourage partnerships for the common cause of habitat and watershed protection. Some basic silvicultural techniques could significantly increase the size of spruce forests where natural regeneration is already occurring. Such advocacy and restoration efforts would benefit many bird species as well as mammals, including the northern flying squirrel. It will not be easy, but the path is paved for some successes with conservation of the ecosystems that support this overlooked suite of birds.

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