Hawk Mountain Sanctuary

LAND MANAGEMENT PLAN

December, 2000

Prepared by:

Natural Lands Trust

Hawk Mountain Sanctuary Association

Geography Department, Kutztown University

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Pennsylvania Department of Conservation & Natural Resources

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Map List

Note: Unlisted maps can be found in the Atlas that accompanies this document

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Introduction & Summary

The Mission of Hawk Mountain Sanctuary Association is "to foster the conservation of raptors worldwide and to create a better understanding of the natural environment, particularly in the central Appalachian region."

To achieve this mission, it is important that the Sanctuary constituencies have an understanding of the Hawk Mountain environment. Toward that end, over the past four years, Hawk Mountain Sanctuary has undertaken several related studies which have now culminated in this Land Management Plan. In 1996 and 1997, Hawk Mountain Sanctuary received funding from the McLean Contributionship, the Pennsylvania Department of Conservation and Natural Resources, and the National Park Service Natural Landmark program to prepare its first-ever sanctuary-wide GIS mapping and inventory of its biotic resources, completed in 1998. This was followed in 1998 by another grant to undertake further studies in areas of interest identified during the initial inventory and to prepare this Land Management Plan for the Sanctuary's holdings. These grants were supplemented by a grant from the Berks County Community Foundation for a land protection model, and by a Forest Stewardship grant from the U.S. Department to Agriculture for preparation of a Forest Stewardship Plan.

During the inventory, many physical, biological and cultural attributes of Hawk Mountain and surrounding areas were mapped. Bird communities, both wintering and breeding were mapped over the entire 2400 acres. Migrant birds were sampled in an array of habitats and elevations to gain understanding of habitat associations. Plant and forest communities were inventoried and mapped. For many taxa groups, e.g. mosses, fungi, lepidoptera, mammals, amphibians, the focus of the inventory was to develop a comprehensive species list for the sanctuary, identify species of special concern, and to define special habitats or communities of management concern. Because of financial and resource limitation, not all communities could be mapped in this initial inventory effort. Some taxa were inventoried because expertise was readily available. Other experts were recruited to inventory species or communities of concern to Hawk Mountain. Sanctuary historical records were also researched and incorporated, particularly for rare species. The initial inventory was intended to act as a basis for developing management guidelines in the Plan, and for encouraging future inventory efforts to further the knowledge of Sanctuary and regional biodiversity.

The HMS Land Management Plan focuses on long-term ecological stewardship of Sanctuary lands. The planning process was conducted by a team of staff from the Hawk Mountain Sanctuary, the Natural Lands Trust, and the Geography Department of

Kutztown University, supplemented by the specific investigations of a team of outside scientists.

The Plan has been divided into sections based on related resource and management issues. Each section contains goals and management objectives, resource descriptions, issues discussions, and recommendations. In many cases the Plan merely formalizes long-standing, informal practices. In other cases, new policies and practices are recommended.

The *Hawk Mountain Long Range Plan*, adopted in 1997, deals comprehensively with HMS programs and sets out specific goals for raptor monitoring, hemispheric raptor conservation, visitor experience, educational outreach, land protection and Appalachian ecology, facilities, fundraising, and volunteers. Because the *Long Range Plan* touches on many areas dealt with in more detail within this Land Management Plan, it was an invaluable reference to the preparers of this document and was extensively referred to for policy guidance.

It is intended that information gathered in preparation of the inventory and this Plan will be a resource from which the Sanctuary can draw for many different purposes, including guiding staff in land management policy issues and reports for specific audiences, like neighbors and state agencies. Other parts of the plan can be incorporated into the educational programming of the Sanctuary.

Major challenges, findings and conclusions are summarized below:

- **Migrating Birds**. The Sanctuary should work with neighbors to promote stopover habitat protection along the ridge as well as to limit construction of structures on the ridge top. The Sanctuary will maintain its forest habitats for resting and feeding birds.

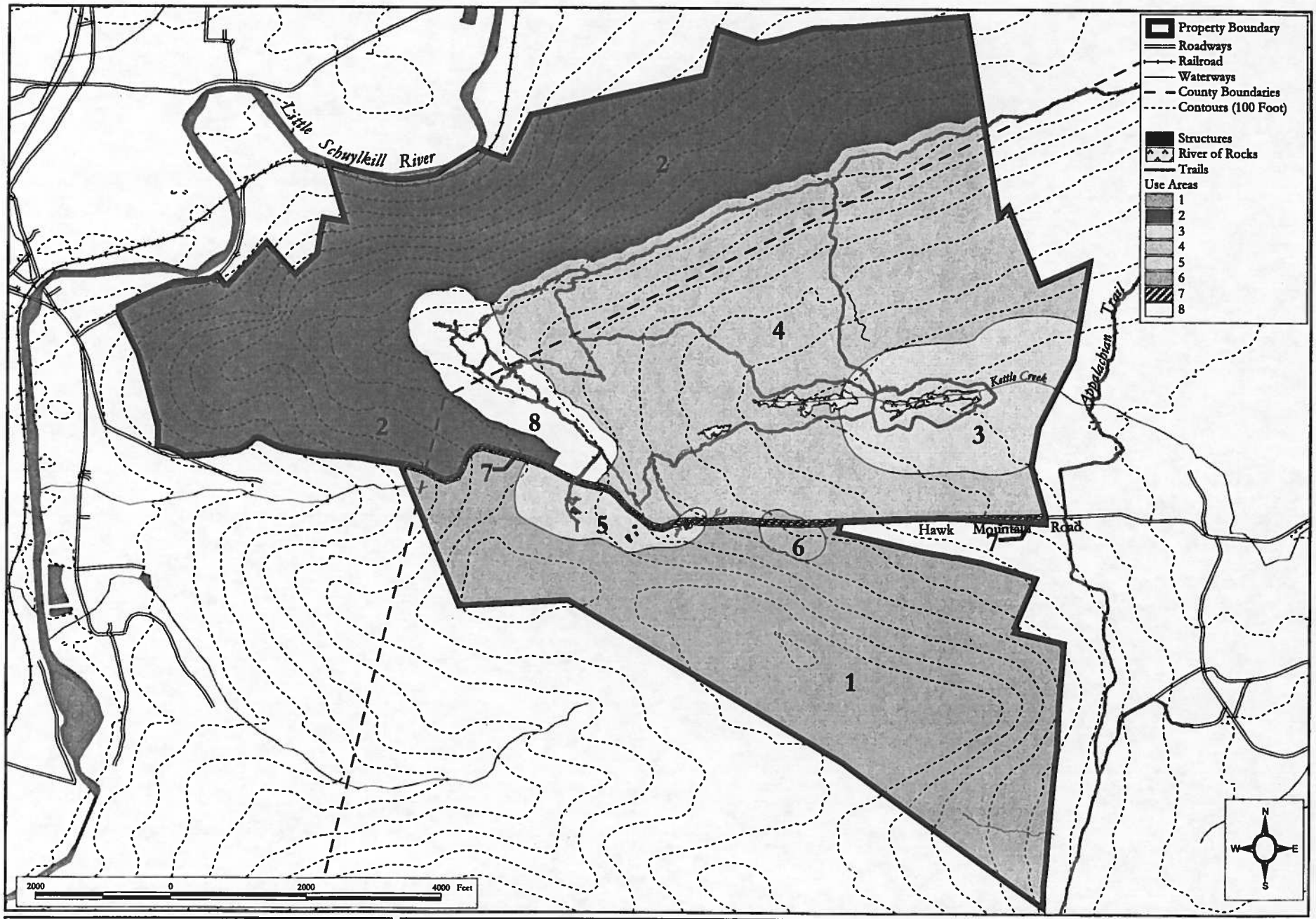
- **Wintering & Nesting Birds**. Because results of the survey showed forest interior neotropical migrants to be abundant, HMS is well suited to continue to provide habitat for forest interior birds. More information is needed on impacts to breeding birds from human activities, trails and other human use areas. Protection of additional contiguous low elevation and mixed coniferous forest will benefit breeding birds and hawks. To stop high levels of shrub herbivory with its consequences to shrub-dependent birds, deer populations must be controlled and reduced to ecologically sustainable levels.

- **Forest Ecosystem Stewardship.** Deer management and invasive plants control must be a major emphasis to maintain and improve forest health and function, as well as achieving a good balance between human use and resource needs.

- **Special Habitat Areas & Unique Fauna.** Now that many (but not all) special communities have been identified, the challenge will be to monitor, maintain and in some cases restore the health and function of these communities and species. Other surveys are needed to further elucidate HMS biota and should be pursued as expertise and funding become available, e.g. bats.

- **Monitoring, Research & Education Programs; Visitor Programs; Trails & Lookouts; Facilities & Historic Sites.** An overriding challenge to the Sanctuary will be to balance mission-related programs like education and encouragement of visitation, which build conservation awareness, with the need to maintain a healthy and functioning ecological system. Sanctuary staff and board have an acute awareness of this balancing act. The plan proposes several techniques, including formal reviews of new proposals, staff training, and standardized protocols for achieving that balance.

Many of the recommendations, strategies and issues covered in the Plan are summarized in the following maps and tables. The Use Area Map (Map 1A) and table divides Sanctuary holdings into eight areas, which are described based on use and program emphasis. The Off-Site Land Management Issues Map (Map 1B) and table describes areas where activities on adjacent lands influence resources on the Sanctuary and where, therefore, the Sanctuary will work with neighbors, principally the Pennsylvania Game Commission and Bureau of Forestry, but also some private owners, to protect Sanctuary resources.



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Schuylkill and Berks Counties, PA

Use Areas

MAP 1A

DCR 3/29/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Martin, Kutztown University.

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HAWK MOUNTAIN USE AREAS

Unit	Description	Human Use	Natural Lands Management Emphasis	Special Needs
1	Forest south of Mountain Road	**Very Low** Primarily natural lands management, research and limited education purposes	**High** Maximize natural ecological function, health and values	Deer management; invasive plants control; monitor health of hemlocks
2	Forest north of Mountain Road and ridgeline	**Very Low/Moderate** Primarily natural lands management and research purposes	**High** Maximize natural ecological function, health and values	Deer management; monitor health of hemlocks
3	East low elevation forest	**Low** Primarily natural lands management and research activities with some passive recreation and education	**High** Maximize natural ecological function, health and values	Close area to human use during bird breeding season; deer management; address AT trail issues
4	Kettle Creek basin	**Low** Primarily natural lands management and research activities with some passive recreation and education	**High** Maximize natural ecological function, health and values	Address trail issues: erosion and habitat encroachment; deer management
5	Existing facilities complex	**High** All permitted human uses occur here	**Low** Focus is on mitigation of human impacts and education	Address impact from high use and facilities, e.g., erosion
6	Campground	**Moderate** Moderately used, seasonal campground facility	**Low** Focus is on mitigation of human impacts and education	Address impact from facilities, e.g., erosion
7	Hawk Mountain Road corridor	**High** Public road use and maintenance, road drainage	**Low** Focus is on mitigation of road impacts, especially drainage, invasive plants	Control invasive plants, mitigate erosion; requires working with PennDOT
8	Lookouts and high use trails	**Moderate to High** High use trails and lookouts, educational programming, monitoring activities	**Moderate** Focus is on mitigation of human impacts, monitoring and education	Trail and lookout maintenance

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Off-Site Land Management Issues

MAP 1B

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NOTES:
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SUMMARY OF OFF-SITE LAND MANAGEMENT ISSUES

Unit	Description	Human Use	Natural Lands Management Emphasis	Special Needs
A	Low elevation and riparian zones	**Moderate to Low** Low density residential and private land use activities	**High** Offer to work with private owners to enhance habitat and ecological function	Create and maintain wildlife corridors for organisms living and migrating through these areas; work with neighbors to maintain natural ecological community
B	AT Corridor	**Moderate** Moderate trail use	Help ATC monitor and conserve sensitive ecological community as needed	Inappropriate trail use and ingress into Sanctuary needs to be monitored/controlled
C	500' Buffer strip on lands along HMS boundary	**Moderate to Low** Mostly hunting, recreation and resource management activities, especially on public lands	**High** Offer to work with landowners to enhance habitat and ecological function, and minimize negative effects on HMS forest	Work with neighbors to conserve buffer along HMS boundary wherein timber removal and disturbance of forest is minimized.

Physical Setting of the Sanctuary

Geology & Hydrogeology

The Sanctuary is located on the Blue Mountain, the "first" or southernmost ridge in the Ridge and Valley Physiographic Province in Pennsylvania, just east of the water gap through which the Schuylkill River flows. According to a recent study by Timothy Hazlett, Ph.D.:

> "The geology at the Hawk Mountain Sanctuary is complex. Three different stratigraphic units are present: the Silurian age Shawangunk Formation ([also known locally as the] Tuscarora [Formation]), The Ordovician age Martinsburg Formation, and a shale and greywacke[1] facies of the Martinsburg. All of the units are steeply dipping and nearly vertical in places. A large reverse fault, locally known as the Eckville Fault, runs directly through the Sanctuary striking along a northeast to southwest direction. The amount of vertical displacement along the fault is not known.
>
> "The Martinsburg Formation is found in the Pennsylvania stratigraphic section of the Valley and Ridge Province...The Shawangunk Formation, locally known as the Tuscarora Formation, caps the mountaintop at the Sanctuary. The Tuscarora Formation formed in a beach environment and consists of thick-bedded conglomerate horizons interbedded with finer grained sandstone units.
>
> "In all formations, water in the Valley and Ridge flows along fractures and bedding planes, and in solution openings in the carbonate rocks (Wright, et. al., 1979)... The combined effects of the alternating sequences of upfolded and downwarped rocks in the Valley and Ridge Province and the stream network that has developed in the folded rocks, creates a series of shallow, isolated, local groundwater flow systems...Weathered rock (regolith) that covers much of the consolidated bedrock serves as an area of recharge, conveying fluids through the regolith and into competent bedrock or into the valleys where it is discharged to springs or streams. Along the ridges, hard and resistant sandstone, conglomerate, and quartzite have low permeabilities. However, the steeply dipping beds and large topographic gradients provide adequate drive to move fluids into the valleys (Forster and Smith, 1988).
>
> "Another source of water and recharge to the aquifers in the Valley and Ridge is the thick colluvium (i.e. - River of Rocks) that flanks the lower parts of the ridges in many places. These areas can temporarily store quite large quantities of water, which can then recharge the bedrock aquifers in the valleys. Within the colluvium, clayey horizons can produce perched water zones which may be expressed on the surface as permanent to intermittent ponds. Numerous groundwater discharges of this type are found in the Sanctuary area."

Thus, by protecting over 2,400 acres in an undeveloped state the Sanctuary provides for recharge of groundwater to the lower elevation areas that surround it.

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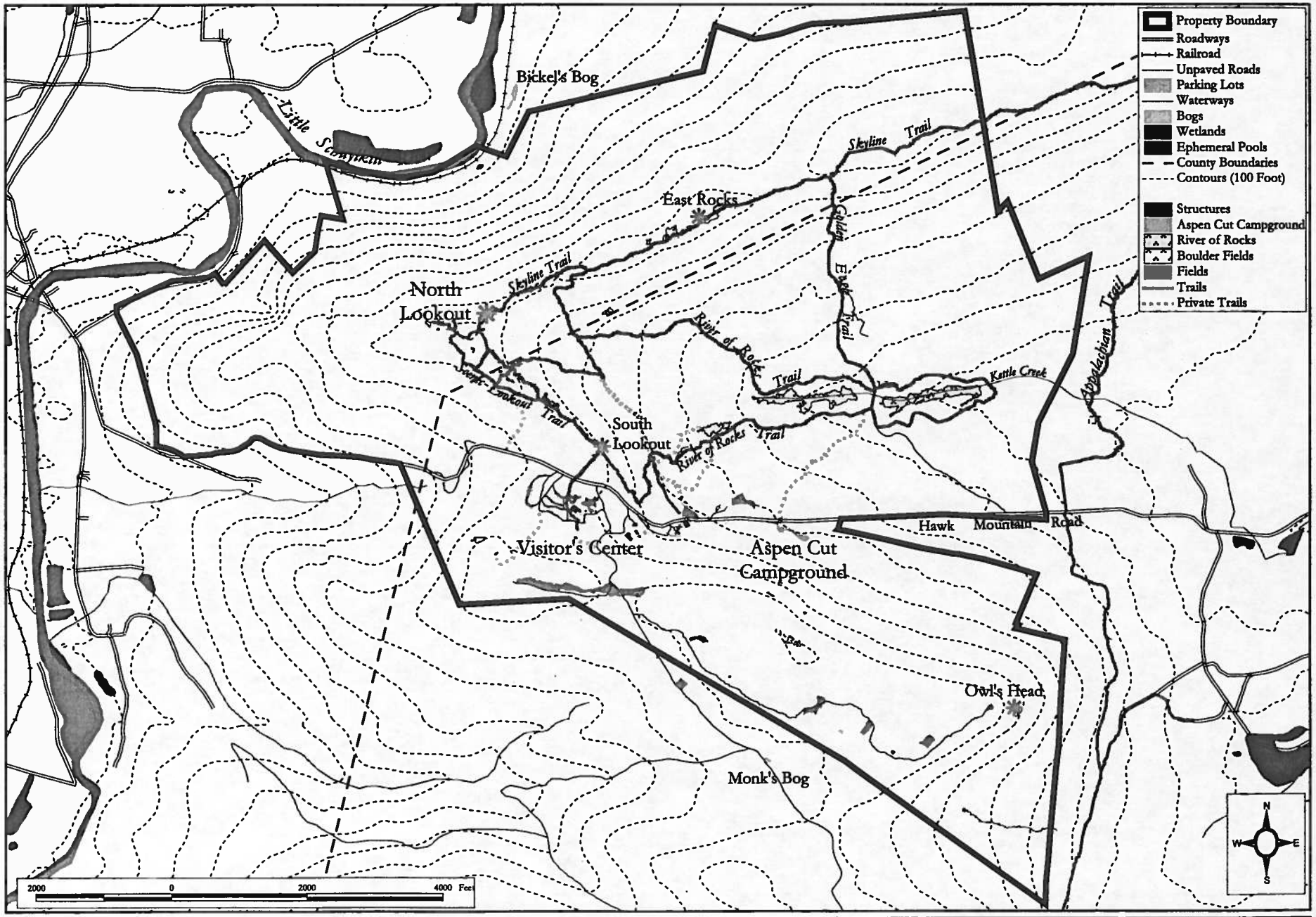
1 A type of sandstone marked by: (1) large detrital quartz and feldspar (phenocysts) set in a (2) prominent to dominant "clay" matrix (Dictionary of Geologic Terms, 1976).



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Schuylkill and Berks Counties, PA

MAP 2A

Hawk Mountain Site

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NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Marsh, Kutztown University.

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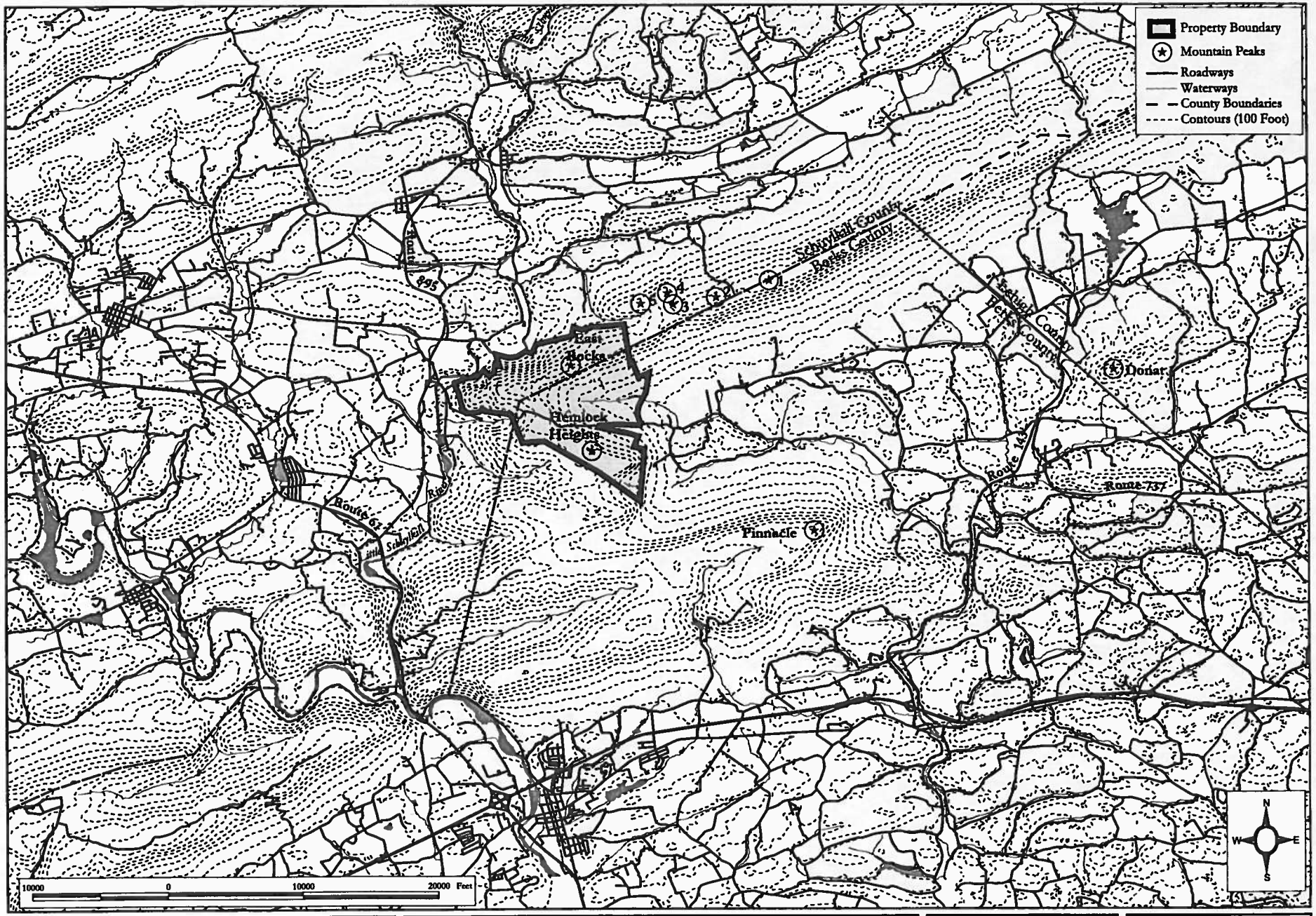

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Regional Location

MAP 2B

DCR 3/29/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Mardo, Kutztown University.

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Geology

MAP 3

DCR 3/29/00

NOTES:
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2. Property boundary, railroad, trails, contours, River of Rocks, structures, and geology from Professor Robert Martin, Kutztown University.

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Topography

The physical character and biological communities of the Sanctuary are heavily shaped by its topography (Maps 1A, 1B, 2). As shown on the accompanying maps, much of the Sanctuary consists of very steep slopes where the land drops away from the top of Kittatinny Ridge to the north, west and east. A relatively small portion of the Sanctuary acreage consists of more level slopes fewer than eight percent in grade. These more level areas are concentrated on the ridge top south of Hawk Mountain Road and in the lower slopes of the Kettle Creek basin, around the River of Rocks.

Slope aspect (the direction which a slopes faces) also influences biological communities. The extensive north facing slopes are more shaded and moist; south facing slopes sunnier and drier (Map 4).

Soils

Soil mapping for the Sanctuary is somewhat confusing because HMS straddles the boundary between Berks and Schuylkill Counties. Unfortunately the soil units, which in reality continue seamlessly across the County line with identical soil characteristics, have been mapped as noncontiguous, and somewhat different soils by the mapping agencies responsible for each county (this problem is not limited to soils nor to these two counties alone). The following table attempts to correlate soil names in the two counties.

Schuylkill County Soils		Slope (%)	Berks County Soil Equivalent		Slope (%)
			BwB	Buchanan very stony loam	0 - 8
DkB	Dekalb extremely stony sandy loam	3 - 8			
DkC	Dekalb extremely stony sandy loam	8 - 15			
DMF	Dekalb and Lehew extremely stony soils	Steep			
DR	Dekalb-Rubble land association	-	RU	Rubble land	-
HfB	Hazleton extremely stony fine sandy loam	3 - 8			
HfC	Hazleton extremely stony fine sandy loam	8 - 25	RU	Rubble land	-
HGC	HGC Hazleton-Clymer association	sloping	EdD	Edgemont and Dekalb very stony sandy loams	8 - 25
LdC	Lehew extremely stony loam	8 - 15	LdD	Laidig very stony loam	8 - 25

The following table gives the depth to bedrock and seasonal high water table for the soils of Hawk Mountain.

Schuylkill County Soils		Depth to Bedrock (in)	Depth to Water Table (ft)	Berks County Soils		Depth to Bedrock (ft)	Depth to Water Table (ft)
				BwB	Buchanan very stony loam	4 - 30	1.5 - 3
DkB	Dekalb extremely stony sandy loam	20 - 40	> 6				
DkC	Dekalb extremely stony sandy loam	20 - 40	> 6				
DMF	Dekalb and Lehew extremely stony soils	20 - 40	> 6				
DR	Dekalb-Rubble land association	20 - 40	> 6	RU	Rubble land	-	-
HfB	Hazleton extremely stony fine sandy loam	40 - 60	> 6				
HfC	Hazleton extremely stony fine sandy loam	40 - 60	> 6	RU	Rubble land	-	-
HGC	Hazleton-Clymer association	40 - 60	> 6	EdD	Edgemont & Dekalb very stony sandy loams	3.5 - 7	3+
LdC	Lehew extremely stony loam	> 60	2.5 - 4	LdD	Laidig very stony loam	4 - 20	3+

The *Soil Survey of Schuylkill County*, issued in 1982, appears to have a greater number of map units than the *Soil Survey of Berks County* which was issued in 1971. The following generalized description is from the *Soil Survey of Schuylkill County*.

The soils on Hawk Mountain are in the Udorthents-Dekalb-Hazleton association (Map 5). Typically these soils are found on uplands, are deep to moderately deep, and are well drained. The slope of the soils is variable, ranging from gently sloping to very steep. Udorthents soils are the mixed overburdened material that results from strip mining. This component is not found on Hawk Mountain. The Dekalb and Hazleton association is formed from residual material on uplands and is underlain by sandstone and conglomerate. Laidig, Buchanan, and Clymer soils are minor members of the association, and have the same general characteristics of Dekalb-Hazleton. Rubble associated with these soils is generally found on steep slopes and is relatively devoid of soil. The soils in this association have a poor suitability for agriculture. Rapid permeability, shallow bedrock, steep slopes, and large surficial stones limit development potential to small isolated sites.

The *Soil Survey of Berks County* describes the Edgemont-Dekalb association as those steep to very steep, well drained soils derived from sandstone and quartzite on the upper slopes and crests of Blue Mountain. The soils have low natural fertility, are

droughty, and are poorly suited to agriculture. Use for forestry, wildlife habitat, and recreation is recommended. The Laidig-Buchanan-Andover Association is found on the lower slopes of Blue Mountain and is derived from colluvium. The Association has deeper soils, a higher moisture retention capacity, and a moderate natural fertility. Nevertheless, these soils are very stony, generally sloping, and may have areas of rubble. This association is not recommended for cultivation. A potentially high water table in Buchanan soils and slow permeability of Laidig soils severely limits the construction of on site sewage disposal systems.

Hydrology

Streams. Because the Sanctuary is centered on the top of a mountain, its hydrologic resources are modest (Maps 1A, 1B, 6). Three intermittent tributaries to Kettle Creek flow on the surface for short distances down the steep sides of the mountain before disappearing into the colluvium. Kettle Creek, the largest stream within HMS, drains the River of Rocks on the extreme eastern end and thence flows southeastward into Pine Creek. The Pine Creek watershed is classified as Exceptional Value by the Pennsylvania Department of Environmental Protection. Another intermittent tributary of Pine Creek flows off the ridge just south of Owls Head.

On the western side of the Sanctuary, an unnamed intermittent stream parallels Hawk Mountain Road with an origin about 200 yards downhill of the Sanctuary Visitor Center parking lots. On the extreme western end of the Sanctuary, a tributary to this stream flows southward about 200 yards before crossing Hawk Mountain Road and leaving Sanctuary lands.

In addition, many small ephemeral streams are scattered along Sanctuary slopes, appearing after rains, then quickly disappearing.

Ponds, Wetlands and Vernal Pools. An artificial pond, Schaumboch's Pond, is situated behind the Cottage and fed by a small stream which passes under Hawk Mountain Road. Eight vernal pools fed by seeps and springs have been identified on the property: four in the vicinity of the River of Rocks, three along the property boundary with SGL 106, and one in the swale created by the railroad along the Little Schuylkill River at the east end of HMS ownership, fed by an intermittent stream that comes off the mountain. More may exist.

Little Schuylkill River Riparian Zone. The Little Schuylkill River flows along the northwest boundary of the Sanctuary, where HMS owns about 800 yards of riverbank. The river has historically had poor water quality due to the effects of acid mine drainage. However, quality has been improving and promises to continue to do so under new and proposed programs in Pennsylvania.

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Land Management Issues for Hawk Mountain

1

Migrating Birds

Goal

- Maintain natural, central Appalachian forest habitats for resting and feeding migrants and "protect the Sanctuary heritage as a natural wild place" (*Hawk Mountain Long Range Plan*, 1997).

Management Objectives

1. **Maintain Forested Habitat for Migrant Stopover.** Keep the Sanctuary in as natural a state as possible consistent with other goals, such as maintaining forested habitat, minimizing disturbance of the natural landscape, and allowing natural ecosystem processes to occur.

2. **Limit Pesticide Applications.** On the Sanctuary, limit pesticide or herbicide applications except when deemed necessary for resource protection.

3. **Limit and Reduce Impacts of HMS Buildings on Birds.** Continue to promote limiting light dispersion at night through building design and modified lighting techniques, e.g. keeping lights on timers, etc.; continue to limit window kills with features such as netting or nonreflective window designs.

4. **Riparian Stopover Habitat.** Improve local riparian habitat and increase stream and river health and function, particularly along Little Schuylkill River; and provide natural migrant bird stopover habitat, on the Sanctuary and regionally, through cooperative efforts with others.

5. **Structures on Ridge.** Continue to maintain unobstructed ridge top with no structures above the tree line on ridge tops in Sanctuary except for an unlit weather/research instrument tower as needed. Cellular telephone and other types of towers that extend above tree line and that have guy wires should be prohibited on Sanctuary grounds.

Background

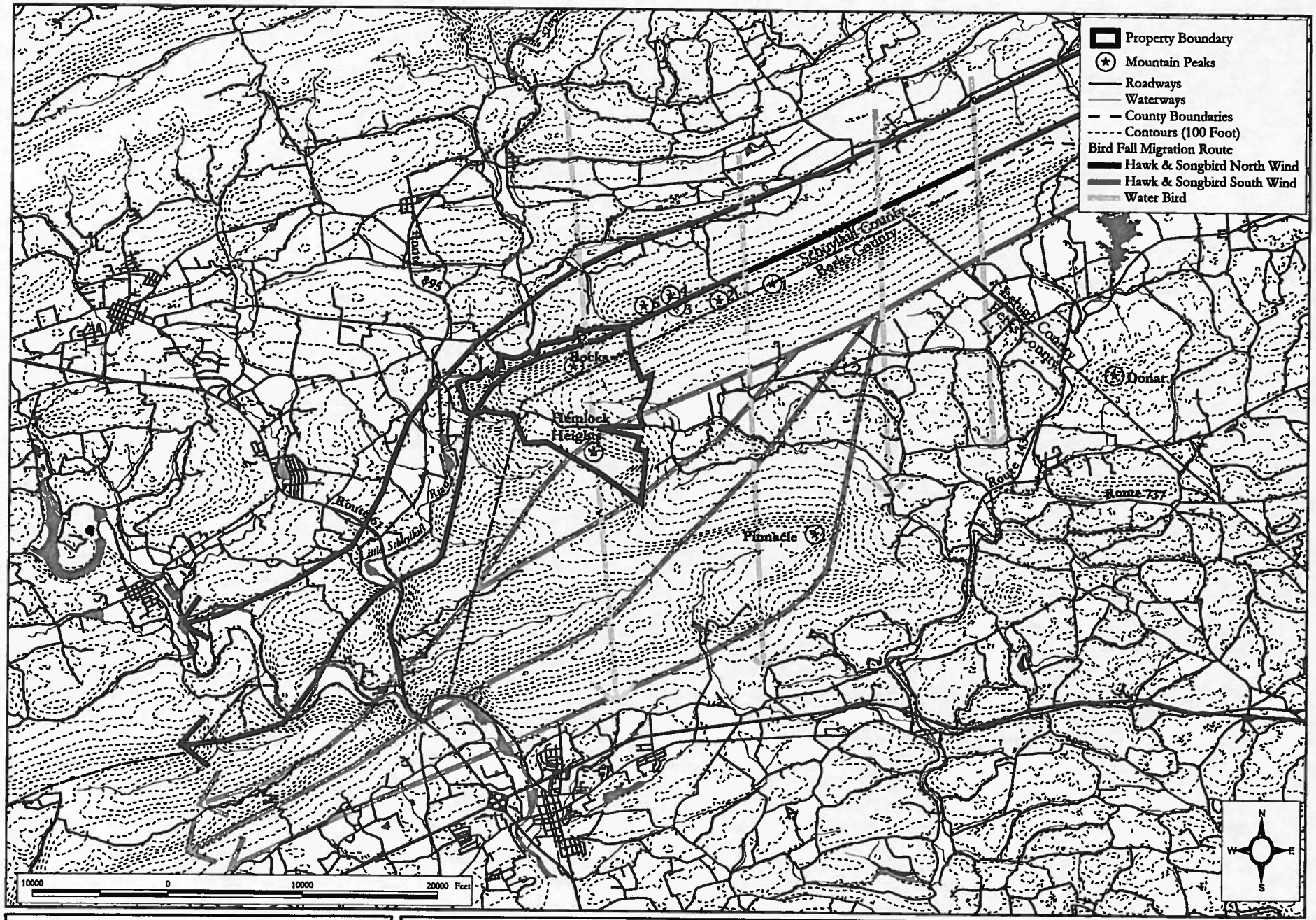
Hawk Mountain Sanctuary was founded in 1934 by Rosalie Edge and the Emergency Conservation Committee as the first Sanctuary in the world with a mission to conserve migrating birds of prey. Located on a major flyway for raptors heading south in the fall, an average 19,000 raptors of 16 species are sighted per fall in the last 10 years (from the Sanctuary's North Lookout from mid-August through mid-December). The most abundant species includes the Broad-winged Hawk, with a 10-year average of 6,209, the Sharp-shinned Hawk, 6,281, and Red-tailed Hawk, 3,844.

HAWK MOUNTAIN SANCTUARY RAPTOR MIGRATION SUMMARY, 1934-1999

Species	10-Year Average	Highest Count	Year	Lowest Count	Year
Turkey Vulture*	138	376	1949	84	1992
Black Vulture*	40	80	1999	21	1992
Osprey	625	872	1990	17	1934
Bald Eagle	84	186	1999	13	1974
Northern Harrier	275	475	1980	89	1934
Sharp-shinned Hawk	6,281	10,612	1977	1,259	1965
Cooper's Hawk	603	1,121	1998	61	1964
Northern Goshawk	62	347	1972	3	1953
Red-shouldered Hawk	294	468	1958	87	1971
Broad-winged Hawk	6,209	29,519	1978	2,886	1946
Red-tailed Hawk	3,844	6,208	1939	1,525	1956
Rough-legged Hawk	11	31	1961	0	6 years
Swainson's Hawk	<1	2	1982, 1987	0	52 years
Golden Eagle	75	141	1998	12	1966
American Kestrel	631	839	1989	11	1934
Merlin	99	168	1995	7	1972
Peregrine Falcon	37	51	1989	6	1982
Gyrfalcon	<1	2	1934	0	58 years
All raptors	**19,489**	**40,696**	**1978**	**7,892**	**1934**

*Data for Turkey and Black Vultures are based on counts since 1990

Early in the century, thousands of hawks were shot from rocky lookouts along the Kittatinny Ridge during the fall migration. Early conservation efforts of the Sanctuary focused on stopping the shooting of birds of prey along the ridge and throughout the region. The Sanctuary dedicated considerable time to educating the public about birds of prey, their migration biology and integral role in the environment. Maurice Broun, the Sanctuary's first curator established the "school in the clouds" atop the North Lookout, using the spectacle of the migrant hawks to excite and educate people about



Hawk Mountain Sanctuary
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MAP 9

Bird Fall Migrations

DCR 3/29/00 Rev. 9/6/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Martin, Kutztown University.
3. Migration routes from Hawk Mountain Sanctuary.

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conservation of the environment. Maurice also initiated the annual autumn hawk migration count in 1934, which today remains one of the continent's longest running databases on bird populations. The long-term counts of raptors have documented the importance of the Sanctuary and the Kittatinny Ridge corridor for migrant raptors.

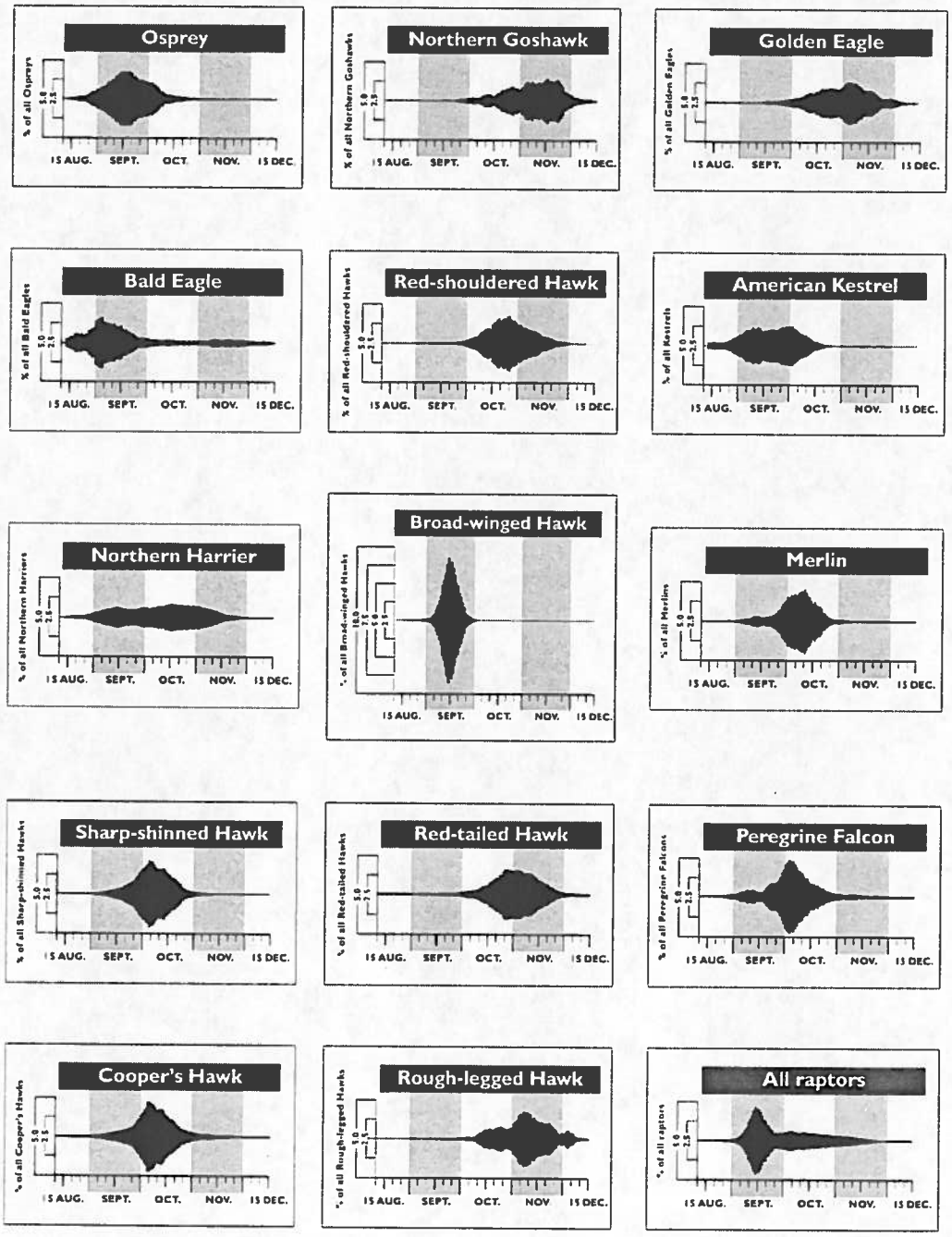
Maurice Broun, a consummate naturalist, collected data on all migrant birds, ranging in size from Tundra Swan to Ruby-throated Hummingbird. This tradition continues today. Long-term records suggest that Hawk Mountain and the Kittatinny Ridge form an important migration corridor for many other southbound migrant birds in addition to northeastern hawks. Up to 200 species of migrants have been recorded flying through and over the Sanctuary in the spring and fall. Some songbirds' species, such as Black-throated Green Warbler may migrate along the Appalachians in greater abundance than along other eastern routes, including the Atlantic coast. Data collected in recent years suggest a minimum number of 50,000 to 100,000 non-raptor migrants migrate by Hawk Mountain each fall. Most species follow the ridge line (e.g. Blue Jay, warblers, Ruby-throated Hummingbird), similar to the raptors, while others fly cross-ridge heading directly south (Canada Geese, Common Loon) (Map 9).

Hawk Mountain Sanctuary is a designated National and Pennsylvania Important Bird Area primarily for its significance to migrating birds (Maps 7, 8, 9). The entire Kittatinny Ridge is designated a Pennsylvania Important Bird Area, recognizing that birds that fly along the ridge past Hawk Mountain are using the entire ridge as their route southward. More raptors use the Kittatinny during fall migration than the other parallel ridges of the Appalachians, although some species such as the Golden Eagle may be more prevalent on western ridges.

The timing of the fall migration varies for the different species. The most abundant raptor migrants such as the Broad-winged Hawk, Sharp-shinned Hawk, and Red-tailed Hawk peak in September, October, and late October or November respectively. Rarer species such as Osprey, Bald Eagle, Peregrine Falcon, and Rough-legged Hawk each pass through on their own time schedule. Migration sightings in spring are less frequent overall as migrant raptors tend to head directly northward and not concentrate along sanctuary slopes (Maps 7, 8).

The Sanctuary's forested landscape provides important migration stopover areas for many of the migrants using the Kittatinny Corridor. Although the study of avian stopover ecology is still young, preliminary research suggests that some migrating birds may select resting areas by finding the most suitable sites once they arrive after their flight, rather than by flying to a specific area. In contrast, some banding recovery data suggests some individual migrants may rest and feed in the same site year after year. Such data indicate that stopover habitat may be needed all along the migration route and that migrant behavior may vary within and among species or species groups.

RAPTOR MIGRATION
Annual Timing, August through December



From 1996 through 1998, the Sanctuary investigated migrant use of Hawk Mountain Sanctuary as part of its resource inventory. These data along with the Sanctuary's long-term records suggest that at least some migrants use all areas and habitats on the

Sanctuary property. Migrant distribution varied with elevation and habitat with some species more concentrated in some habitats (e.g., forest versus edge, slope versus ridge-top). Although data were collected in only two years for each spring and fall, species habitat selection on stopover correlated strongly with the species' known breeding habitat. For example, Hermit Thrush was most numerous on migration in ridge-top forest with associated scrub-heath openings, which also is where they concentrate during the nesting season. Wetland or riparian-associated birds, e.g. Osprey, Belted Kingfisher and Wood Duck, were seen primarily along the Little Schuylkill River. The river and associated mature forest provided habitat for some birds not found elsewhere on the Sanctuary. Some of the regionally uncommon raptors such as the Bald Eagle, Osprey, Red-shouldered Hawk may only find appropriate habitat in this small area of the Sanctuary. Some non-raptor migrants such as Yellow-throated Vireo and Great Blue Heron were found only on the river during the surveys. Because older low elevation, riparian forest is a rare habitat generally in Pennsylvania and on the Sanctuary, this region of the Sanctuary is important to conserve.

Overall, migrant numbers detected at North Lookout exceeded counts of migrants from other sites on the Sanctuary. This suggests that migrant birds may migrate in flocks along the ridge top, or fall out here after a night of migration, and then when they rest and feed, they disperse over the Sanctuary. For example, it is not unusual to observe 20-50 Black-throated Green Warblers in the trees around North Lookout in the early hours of an autumn day, while bird surveys in other areas of the Sanctuary never intercepted Black-throated Green Warblers in a group this large. Over 200 Blue Jays may fly low through ridge top trees but rarely do we sight sizeable groups within the forest. Migrant distribution also varies seasonally with migrants concentrating more in the valley and lower slope forest during the spring migration than on the ridge-top (Map 7). Such seasonal patterns have been documented in other studies and may be related to the timing of leaves emerging earlier in lower elevation forest. Food supplies for insectivores will be more abundant in lower elevation, emergent moist forest in early spring.

Because night migrants often may fly low over the landscape, particularly on cloudy nights, the Kittatinny ridge top is an area where towers or other structures protruding above the tree canopy should be limited. Night migrants, such as warblers and vireos, are particularly vulnerable to lighted towers or tall structures. And, low flying raptors and other birds are susceptible to injury by guy wires. Lighting confuses the night migrants and traps them near the structure in a 'circle of light' increasing their chance of collision. Structures taller than 200 feet are more dangerous to birds, but any structure above the tree line on the ridge top may pose a risk. Additional research is needed to determine the extent of avian migration at different altitudes above the ridge and how tower design features contribute to avian collisions.

TABLE OF NON-RAPTOR MIGRANT COUNTS FROM NORTH LOOKOUT, 1991-1999 (AUGUST-DECEMBER)[1]

SPECIES	1991	1992	1993	1994	1995	1996	1997	1998	1999	MIN.	MAX.	9-YR AVG.
COMMON LOON	164	346	382	158	455	306	672	592	322	158	672	377
RED-THROATED LOON	0	0	0	0	4	0	2	1	0	0	4	1
UNID. LOON	0	0	0	0	0	0	3	0	0	0	3	0
BONAPARTE'S GULL	0	0	0	0	0	60	0	0	0	0	60	7
HERRING GULL	14	177	2	11	10	11	55	79	5	2	177	40
RING-BILLED GULL	391	258	515	1	1129	177	849	162	275	1	1129	417
GREATER BLACK-BACKED GULL	1	0	0	0	0	0	0	0	0	0	1	0
LESSER BLACK-BACKED GULL	0	1	0	0	0	0	0	0	0	0	1	0
UNID. GULLS	0	70	213	122	1	442	34	4	145	0	442	115
COMMON TERN	0	0	0	0	0	0	0	0	0	0	0	0
DOUBLE-CRESTED CORMORANT	109	233	416	107	274	1115	1079	816	878	107	1115	559
COMMON MERGANSER	0	4	10	0	0	10	2	4	0	0	10	3
RED-BREASTED MERGANSER	0	0	0	0	0	6	0	0	43	0	43	5
MALLARD	1	0	0	10	6	38	23	6	2	0	38	10
GADWALL	0	0	0	0	0	0	6	0	2	0	6	1
AMERICAN BLACK DUCK	0	0	0	1	12	29	8	4	15	0	29	8
AMERICAN WIGEON	0	0	0	0	0	0	0	0	0	0	0	0
GREEN-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0
BLUE-WINGED TEAL	0	0	0	0	0	0	0	0	0	0	0	0
NORTHERN PINTAIL	0	0	0	0	0	56	0	0	0	0	56	6
WOOD DUCK	0	0	0	0	0	1	0	0	0	0	1	0
REDHEAD	0	0	0	0	0	0	0	0	0	0	0	0
BUFFLEHEAD	0	0	0	0	0	0	0	0	0	0	0	0
UNID. SCOTER	0	0	0	0	0	35	65	0	20	0	65	13
UNID. WATERFOWL	0	354	9	1	0	210	0	0	224	0	354	89
SNOW GOOSE	329	10	196	92	401	130	234	109	670	10	670	241
CANADA GOOSE	10333	13538	9511	7520	9046	11630	22055	14321	12609	7520	22055	12285
BRANT	85	65	0	0	50	0	0	51	270	0	270	58
TUNDRA SWAN	5	17	63	0	17	124	25	203	12	0	203	52
WHITE-FRONTED GOOSE	0	0	0	1	0	0	0	0	0	0	1	0
GREAT BLUE HERON	11	8	31	14	8	46	20	3	40	3	46	20
UNID. HERONS	0	0	0	0	0	3	0	0	0	0	3	0
GREAT EGRET	0	0	1	0	0	0	0	0	0	0	1	0
SANDHILL CRANE	0	0	0	0	0	0	0	9	0	0	9	1
UNID. SHOREBIRDS	0	0	5	4	1	10	0	0	7	0	10	3
GREATER YELLOWLEGS	0	0	1	0	0	0	1	0	0	0	1	0
UNID. YELLOWLEGS	0	0	0	0	0	0	11	0	1	0	11	1
UNID. SNIPE	0	0	0	0	0	0	0	0	1	0	1	0
UPLAND SANDPIPER	0	0	0	0	3	0	0	0	0	0	3	0
PLOVER ?	0	17	0	0	0	0	0	0	0	0	17	2
DOWITCHER	0	0	18	0	0	0	0	0	0	0	18	2
KILLDEER	0	1	0	0	0	0	0	2	1	0	2	0
RING-NECKED PHEASANT	0	0	0	0	0	0	1	0	0	0	1	0
RUFFED GROUSE	2	0	2	0	1	5	4	6	0	0	6	2
WILD TURKEY	2	0	1	49	0	6	429	68	26	0	429	65
ROCK DOVE	2	30	6	0	9	43	96	164	24	0	164	42
MOURNING DOVE	1	0	2	4	0	11	7	11	0	0	11	4
YELLOW-BILLED CUCKOO	0	0	0	0	0	1	0	0	0	0	1	0
BLACK-BILLED CUCKOO	0	0	0	0	0	0	0	0	1	0	1	0
SHORT-EARED OWL	0	0	0	0	1	0	0	0	1	0	1	0
GREAT HORNED OWL	0	0	0	0	0	1	5	4	0	0	5	1
EASTERN SCREECH OWL	0	0	0	0	0	0	0	2	0	0	2	0
BELTED KINGFISHER	0	1	0	1	0	0	4	3	0	0	4	1
HAIRY WOODPECKER	0	0	6	1	3	2	30	16	3	0	30	7
DOWNY WOODPECKER	1	5	3	6	2	3	61	74	7	1	74	18
YELLOW-BELLIED SAPSUCKER	0	0	2	4	7	1	6	11	11	0	11	5

[1] Other years of non-raptor counts are available. MIN and MAX counts refer to only the 1991 to 1999 period, not counts from before this time.

SPECIES	1991	1992	1993	1994	1995	1996	1997	1998	1999	MIN.	MAX.	9-YR AVG.
PILEATED WOODPECKER	1	2	2	6	3	2	29	44	0	0	44	10
RED-HEADED WOODPECKER	7	6	4	6	3	3	8	11	10	3	11	6
RED-BELLIED WOODPECKER	4	2	6	7	19	16	16	25	16	2	25	12
NORTHERN FLICKER	72	24	29	39	26	48	113	157	73	24	157	65
COMMON NIGHTHAWK	4	6	7	4	8	11	20	31	5	4	31	11
RUBY-THROATED HUMMINGBIRD	59	88	141	127	101	128	178	200	188	59	200	276
EASTERN KINGBIRD	0	0	116	4	0	0	10	0	0	0	116	14
GREAT CRESTED FLYCATCHER	1	0	0	8	2	3	3	0	2	0	8	2
EASTERN PHOEBE	4	3	1	9	2	11	22	20	10	1	22	9
OLIVE-SIDED FLYCATCHER	4	5	7	14	2	1	8	2	1	1	14	5
EASTERN WOOD PEWEE	5	5	10	17	6	2	18	40	13	2	40	13
YELLOW-BELLIED FLYCATCHER	0	0	3	0	0	0	0	1	0	0	3	0
UNID. FLYCATCHER	0	0	0	1	0	0	1	0	0	0	1	0
EMPIDONAX SPECIES	0	0	0	10	0	6	6	13	1	0	13	4
LEAST FLYCATCHER	0	0	16	0	0	0	1	1	0	0	16	2
ACADIAN FLYCATCHER	0	0	1	0	0	0	0	1	0	0	1	0
ALDER FLYCATCHER	0	0	0	0	0	0	2	0	0	0	2	0
WILLOW FLYCATCHER	0	0	0	0	0	0	0	1	0	0	1	0
CHIMNEY SWIFT	694	643	0	1030	615	1034	907	1038	784	0	1038	749
PURPLE MARTIN	0	8	0	0	3	2	20	2	2	0	20	4
CLIFF SWALLOW	69	431	116	203	93	45	96	66	5	5	431	125
BARN SWALLOW	566	613	460	576	894	262	759	1555	377	262	1555	674
TREE SWALLOW	194	68	600	79	2017	2149	5411	8682	346	68	8682	2172
BANK SWALLOW	5	57	11	4	31	0	58	41	7	0	58	24
N.ROUGH-WINGEDSWALLOW	9	52	45	161	53	15	39	121	6	6	161	56
UNID. SWALLOWS	0	451	171	939	122	1864	0	0	72	0	1864	402
HORNED LARK	0	21	20	0	18	7	29	34	21	0	34	17
BLUE JAY	482	336	1226	395	2032	182	2240	384	1857	182	2240	1015
COMMON RAVEN	41	39	54	69	24	35	120	141	9	9	141	59
AMERICAN CROW	3665	3264	3643	4393	5223	4427	5726	6319	5416	3264	6319	4675
FISH CROW	0	0	0	0	0	0	0	0	0	0	0	0
CAROLINA WREN	3	9	0	0	0	0	1	14	0	0	14	3
BEWICK'S WREN	0	0	0	0	0	0	0	0	0	0	0	0
HOUSE WREN	0	0	0	2	2	0	0	0	1	0	2	1
WINTER WREN	2	3	2	8	5	4	15	33	10	2	33	9
BROWN CREEPER	0	1	1	3	0	0	8	3	6	0	8	2
WHITE-BREASTED NUTHATCH	0	1	1	1	7	0	40	9	25	0	40	9
RED-BREASTED NUTHATCH	12	28	51	4	63	2	168	4	81	2	168	46
TUFTED TITMOUSE	0	1	0	0	0	0	3	6	1	0	6	1
BLACK-CAPPED CHICKADEE	7	4	0	12	10	8	397	329	35	0	397	89
CAROLINA CHICKADEE	0	0	0	0	1	0	0	0	0	0	1	0
BOREAL CHICKADEE	0	1	1	0	0	0	0	0	0	0	1	0
GOLDEN-CROWN KINGLET	49	53	54	48	36	12	139	245	101	12	245	82
RUBY-CROWNED KINGLET	72	77	38	133	33	52	267	439	61	33	439	130
BLUE-GRAY GNATCATCHER	0	1	9	1	0	5	12	8	5	0	12	5
BOHEMIAN WAXWING	0	0	103	0	0	0	0	0	0	0	103	11
CEDAR WAXWING	1795	1697	871	6173	1150	5195	4405	14057	4051	871	14057	4377
WATER PIPIT	7	9	0	6	0	48	0	0	3	0	48	8
GRAY CATBIRD	2	2	3	6	0	2	2	5	4	0	6	3
NORTHERN MOCKINGBIRD	0	0	0	0	0	1	0	1	0	0	1	0
BROWN THRASHER	0	0	0	0	0	0	0	0	1	0	1	0
WOOD THRUSH	0	0	0	5	0	4	9	4	0	0	9	2
SWAINSON'S THRUSH	1	0	0	0	0	1	0	0	2	0	2	0
GRAY-CHEEKED THRUSH	0	0	1	0	0	0	0	0	0	0	1	0
HERMIT THRUSH	1	0	4	4	1	9	1	2	2	0	9	3
UNID. THRUSH	0	0	0	0	0	0	0	0	1	0	1	0
AMERICAN ROBIN	3806	2055	6688	7708	2200	9968	7774	30679	7423	2055	30679	8700
NORTHERN SHRIKE	1	0	0	0	1	1	0	0	1	0	1	0
EASTERN BLUEBIRD	244	43	77	97	42	73	73	159	124	42	244	104
TOWNSEND'S SOLITAIRE	0	0	0	0	0	0	0	0	1	0	1	0
RED-EYED VIREO	4	0	15	35	2	30	95	154	27	0	154	40
PHILADELPHIA VIREO	1	0	1	0	1	5	14	28	15	0	28	7
WARBLING VIREO	0	0	0	0	0	0	1	2	0	0	2	0
YELLOW-THROATED VIREO	3	0	0	1	0	1	6	7	9	0	9	3

SPECIES	1991	1992	1993	1994	1995	1996	1997	1998	1999	MIN.	MAX.	9-YR AVG.
SOLITARY(BLUE-HEADED) VIREO	5	0	7	11	11	16	24	40	27	0	40	16
WHITE-EYED VIREO	0	0	1	0	1	0	0	0	0	0	1	0
BLACK AND WHITE WARBLER	8	0	12	28	5	22	50	89	18	0	89	26
PRONTHONOTARY WARBLER	0	1	0	0	0	0	0	0	0	0	1	0
WORM-EATING WARBLER	0	0	0	1	0	1	0	1	0	0	1	0
BLUE-WINGED WARBLER	0	0	0	1	0	0	0	3	0	0	3	0
GOLDEN-WINGED WARBLER	0	0	0	0	0	0	1	7	0	0	7	1
NASHVILLE WARBLER	0	0	4	12	5	10	30	67	14	0	67	16
ORANGE-CROWNED WARBLER	0	0	0	0	0	0	1	0	0	0	1	0
TENNESSEE WARBLER	2	0	1	10	3	6	23	44	0	0	44	10
NORTHERN PARULA	0	1	2	11	7	8	15	46	4	0	46	10
CAPE MAY WARBLER	6	6	20	101	9	28	23	76	30	6	101	33
YELLOW WARBLER	0	1	0	0	0	0	1	0	1	0	1	0
BLACK-THROATED BLUE WARBLER	15	7	19	67	21	32	73	93	43	7	93	41
YELLOW-RUMPED WARBLER	19	24	61	80	32	41	151	351	42	19	351	89
MAGNOLIA WARBLER	0	14	14	19	7	18	48	101	30	0	101	28
CERULEAN WARBLER	0	0	0	1	0	0	0	0	1	0	1	0
CHESTNUT-SIDED WARBLER	3	1	6	10	5	25	24	35	15	1	35	14
BAY-BREASTED WARBLER	9	0	4	5	0	4	27	53	7	0	53	12
BLACKPOLL WARBLER	16	0	3	16	4	8	35	38	7	0	38	14
BLACKBURNIAN WARBLER	4	1	19	49	12	48	83	129	44	1	129	43
BLACK-THROATED GREEN WARBLER	37	21	82	185	63	172	466	509	154	21	509	188
PINE WARBLER	2	2	1	8	1	1	3	0	1	0	8	2
PALM WARBLER	0	0	1	6	1	1	3	3	0	0	6	2
PRAIRIE WARBLER	0	11	0	3	0	0	2	0	1	0	11	2
HOODED WARBLER	0	0	0	0	0	0	0	0	1	0	1	0
BAYPOLL WARBLER	0	0	0	0	0	0	0	0	4	0	4	0
OVENBIRD	1	0	2	3	0	2	7	12	2	0	12	3
NORTHERN WATERTHRUSH	0	0	1	0	0	0	0	0	0	0	1	0
LOUISIANA WATERTHRUSH	0	0	0	0	0	0	0	0	0	0	0	0
CONNECTICUT WARBLER	0	0	0	0	3	3	0	2	0	0	3	1
MOURNING WARBLER	0	0	0	0	0	0	0	0	0	0	0	0
COMMON YELLOWTHROAT	0	0	1	2	3	0	2	1	5	0	5	2
YELLOW BREASTED CHAT	0	0	1	0	0	0	0	0	0	0	1	0
CANADA WARBLER	0	1	3	14	3	2	5	11	12	0	14	6
WILSON'S WARBLER	0	1	2	1	0	1	7	8	2	0	8	2
AMERICAN REDSTART	1	1	8	15	6	13	12	12	9	1	15	9
UNID. WARBLER	0	0	1	38	0	17	0	0	103	0	103	18
RUFOUS-SIDED TOWHEE	0	1	4	6	6	4	8	4	4	0	8	4
NORTHERN CARDINAL	0	1	2	3	3	5	1	6	1	0	6	2
ROSE-BREASTED GROSBEAK	38	14	29	47	19	68	112	118	37	14	118	54
EVENING GROSBEAK	0	20	371	6	190	5	172	16	292	0	371	119
PINE GROSBEAK	0	0	0	0	0	0	0	0	0	0	0	0
WHITE-THROATED SPARROW	0	9	1	7	4	4	22	35	5	0	35	10
WHITE-CROWNED SPARROW	0	0	0	1	0	1	0	0	0	0	1	0
AMERICAN TREE SPARROW	0	0	0	0	5	0	1	0	0	0	5	1
FIELD SPARROW	0	0	0	1	0	0	0	0	0	0	1	0
CHIPPING SPARROW	0	0	0	0	2	4	0	1	2	0	4	1
SONG SPARROW	0	0	0	0	0	0	2	0	0	0	2	0
FOX SPARROW	0	14	1	4	0	2	11	17	1	0	17	6
SWAMP SPARROW	0	0	0	0	0	0	0	0	0	0	0	0
LINCOLN SPARROW	0	0	0	0	0	0	0	0	3	0	3	0
DARK-EYED JUNCO	24	91	102	42	20	37	178	425	88	20	425	112
OREGON JUNCO	0	0	0	0	1	0	0	0	0	0	1	0
INDIGO BUNTING	3	0	0	4	1	2	3	1	6	0	6	2
SCARLET TANAGER	25	15	62	150	24	85	183	243	52	15	243	93
SUMMER TANAGER	0	0	0	3	0	0	0	0	0	0	3	0
EUROPEAN STARLING	964	123	718	148	424	93	967	1098	958	93	1098	610
BOBOLINK	0	0	0	0	0	0	3	86	0	0	86	10
EASTERN MEADOWLARK	5	0	0	0	0	0	0	0	0	0	5	1
BROWN-HEADED COWBIRD	8	0	11	80	159	193	9	31	18	0	193	57
RED-WINGED BLACKBIRD	3770	1050	928	252	2726	4323	4462	2712	1601	252	4462	2425
NORTHERN (BALTIMORE) ORIOLE	2	5	2	35	3	9	14	0	4	0	35	8

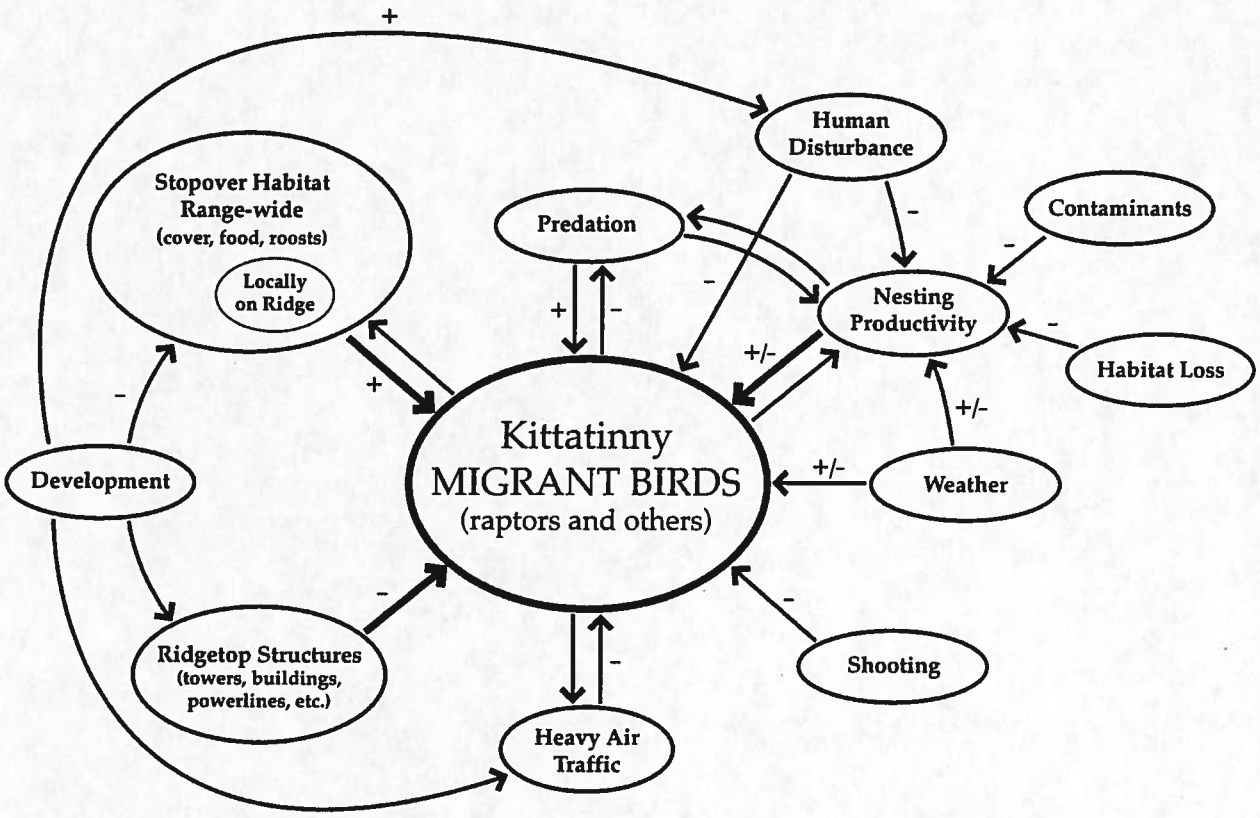
SPECIES	1991	1992	1993	1994	1995	1996	1997	1998	1999	MIN.	MAX.	9-YR AVG.
RED-WINGED BLACKBIRD	3770	1050	928	252	2726	4323	4462	2712	1601	252	4462	2425
NORTHERN (BALTIMORE) ORIOLE	2	5	2	35	3	9	14	0	4	0	35	8
UNID. ORIOLE	0	0	0	0	0	0	0	0	1	0	1	0
RUSTY BLACKBIRD	72	8	182	0	53	22	21	268	0	0	268	70
COMMON GRACKLE	0	646	214	278	337	2180	2922	4206	801	0	4206	1287
UNID. BLACKBIRDS	123	0	1768	134	0	798	1611	1650	11019	0	11019	1900
PURPLE FINCH	4	28	157	3	68	63	516	62	1785	3	1785	298
UNID. FINCH	17	0	0	0	0	1	159	13	475	0	475	74
HOUSE FINCH	33	28	114	21	36	48	75	120	67	21	120	60
ROSE FINCH	0	0	0	0	0	1	0	0	0	0	1	0
RED CROSSBILL	0	0	0	0	3	0	149	3	0	0	149	17
WHITE-WINGED CROSSBILL	0	0	2	0	0	0	509	0	3	0	509	57
UNID. CROSSBILL	0	0	0	0	0	0	0	0	11	0	11	1
COMMON REDPOLL	0	0	25	0	37	0	1556	0	65	0	1556	187
AMERICAN GOLDFINCH	583	853	754	805	850	537	2447	1473	1943	537	2447	1138
PINE SISKIN	65	5	76	0	29	4	1240	11	850	0	1240	253
SNOW BUNTING	17	2	136	24	68	15	31	13	14	2	136	36
UNID. SONGBIRD	0	0	0	0	0	0	0	0	159	0	159	18
TOTAL BIRDS	**29228**	**28250**	**33217**	**33206**	**31561**	**49169**	**73557**	**96186**	**57668**	**	**	**48,005**
MONARCH BUTTERFLIES	**	532	2660	1861	442	1397	5705	1095	2304	**	5705	1777

Model of Migrating Bird Population at Hawk Mountain

The migrating bird model diagram on the following page illustrates the many factors that can impinge on migrating birds in the Kittatinny corridor. "Kittatinny Migrating Birds" includes all bird communities including raptors, nocturnal birds, etc. In some cases, the arrows indicate migrating birds can impact other factors or each other as well. Impacts can be positive or negative depending on the species in question. Heavier arrows, such as "Nesting Productivity" indicate a stronger influence in one direction as compared to others.

The migrating bird population, in spring and autumn, may vary with a number of external factors. The numbers of birds migrating south along the ridge each fall is correlated to the nesting productivity of the source populations on the breeding range. Migrants on the Appalachian corridor derive from a nesting range north and east of the Sanctuary from Ontario, Quebec, and Canadian maritime provinces, as well as New England south to northern New Jersey and eastern New York. Nesting productivity in these regions can vary annually with fluctuations in weather conditions, food supplies, and other factors. An early spring allows hawks to start nesting activities earlier than average and enhances overall productivity. For songbirds, variations in weather, nest predator activity, and various other factors may influence nesting productivity and indirectly the numbers of birds migrating south.

MIGRATING BIRD MODEL DIAGRAM



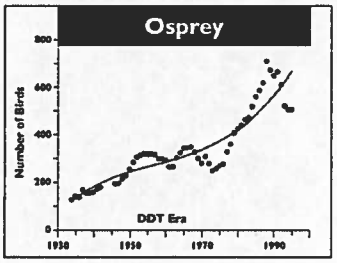
Human disturbance, pesticide misuse, and habitat alterations on the breeding range can cause short or long-term declines in productivity and influence the potential migrant population for Hawk Mountain Sanctuary. Increasing sprawl development and habitat alteration of field and marsh habitat throughout the northeast may have caused recent declines in field nesting species such as the Northern Harrier in some parts of their range.

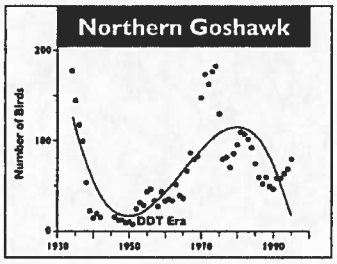
Bald Eagle and Peregrine Falcon populations declined precipitously during the 1950s and 1960s due to the widespread use of DDT, which led to reproductive failure. These population-wide declines were reflected in declines in the numbers counted at Hawk Mountain. Similarly, in the early years, widespread shooting of raptors undoubtedly depressed numbers of birds, particularly along the ridge where migrants were especially vulnerable.

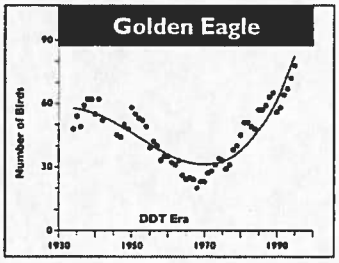
RAPTOR MIGRATION

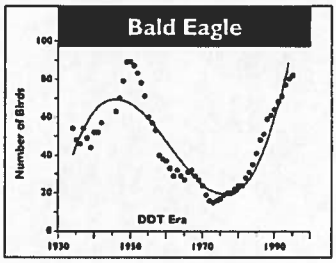
Long Term Trends, 1934 to 1995

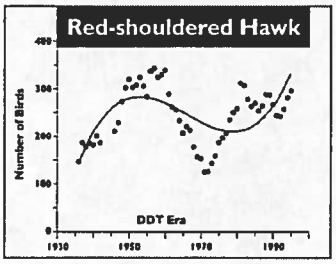
The Hawk Mountain migration counts below reflect long-term changes in regional populations of raptors. Each point represents a three-year running average for the species

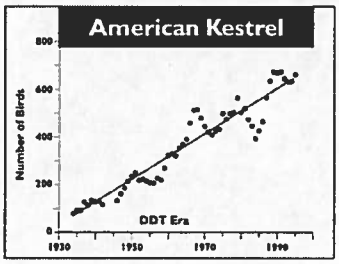


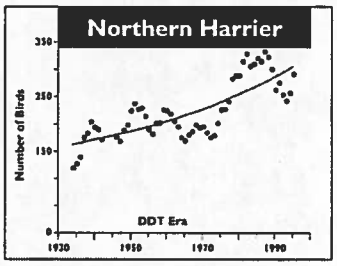


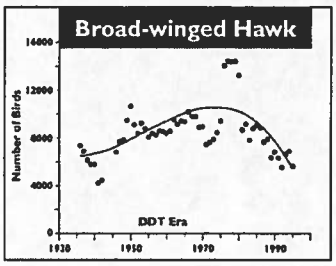


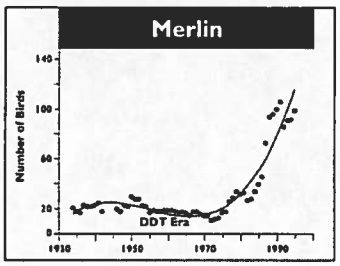


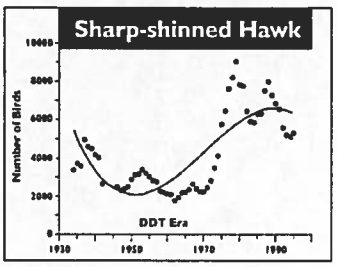


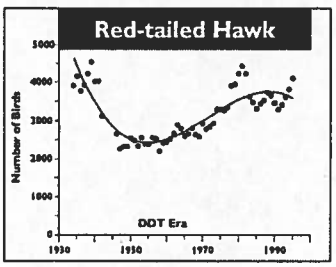


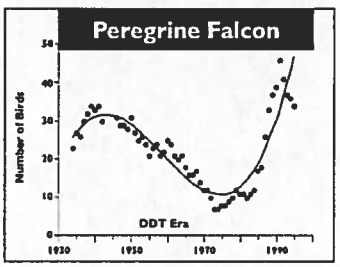


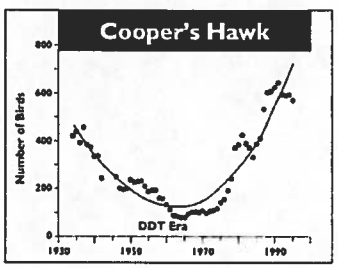


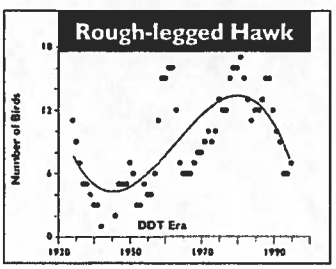


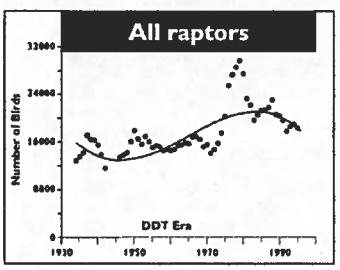












Migration is a risky time in a bird's life. It is estimated that over half of the raptors that start their migration south in the fall will not survive to nest the following year. For songbirds the risk is often more. Finding food and cover in strange regions is just one of the challenges facing migrants. As the numbers of people living in the northeastern United States continues to increase, the issue of stopover habitat availability will become increasingly important. Migrants need areas to rest and feed along their migration routes. Ospreys that migrate past Hawk Mountain are regularly seen carrying fish with them, as if they are packing a lunch. Although many birds, particularly long-distance migrants, will build up subcutaneous fat layers before they leave, not all birds can pack food with them. Insectivores such as warblers and vireos build up fat before they leave on their migration, but for their migration journey that may last weeks, they still they must find food and rest along the way to ensure survival. Providing areas for feeding, resting, and roosting are key to maintaining a healthy migrant population on the Kittatinny Ridge and beyond.

Sanctuary research conducted on Red-tailed Hawks affixed with radio-telemetry units, showed that even this widespread, tolerant species avoided flying over urban areas on migration. These results suggest that large developed areas generally may be avoided by raptor migrants, and less developed rural areas remain important ones for migrant stopover.

Another challenge that comes with the increasing human population in the northeastern United States is how structures and aircraft may impact migrant birds. Low flying aircraft along the ridge or over the Sanctuary could disrupt the migrants using the same air space. In addition, large birds on migration can damage aircraft if they collide in the air. There are many documented cases where bird-aircraft collisions have caused loss of human life. Although aircraft collisions have not been a problem on the Kittatinny Ridge as of yet, models of bird migration and migration altitude patterns may help prevent future collisions.

Migrant birds flying along the ridge maybe susceptible to impact from cellular towers and other structures protruding above the trees. The extent of this problem remains unknown, however dead songbirds are regularly found beneath a set of ridge-top towers above Harrisburg. Raptors have been killed by striking tower wires and windmill blades during migration and during foraging activities. As these structures increase across the landscape, migrant birds may be increasingly affected. Even if small numbers of birds are killed at each tower, the cumulative impact of many towers erected along the ridge could be substantial. Warblers and other night migrants are particularly susceptible to kills at towers. Lighted structures are the most deadly to night migrants, as lights attract and confuse the birds, increasing their propensity to strike wires and other obstructions. Towers above 200 feet in height are required to be lighted by the Federal Aviation Administration. Red lights appear to attract more birds than white lights. Some biologists have estimated that two to four million birds are killed in the northeastern U.S. each year due to collisions with towers. A recent

compilation of 149 bird kill studies in the United States prepared by the American Bird Conservancy documents 545,000 birds of 230 species which were killed by towers. Many more cellular and digital television towers are scheduled to be built, thus the problem may increase in future years.

Songbirds also are susceptible to striking windows and glass of any kind. Hundreds of millions of birds are estimated to be killed each year by striking window glass. Birds may see the reflection of trees in the glass and assume it is a continuation of natural habitat. Nesting forest birds may be particularly susceptible to this confusion, e.g. Ovenbirds. In addition, birds on migration are also killed in great number at night-lit buildings. Studies in Toronto, Chicago and New York City, cities located along migration pathways, find hundreds of migrant birds may be killed annually by striking lighted buildings. Limits on lighting of buildings at night along the migrant corridor (e.g. Kittatinny Ridge), and covering of windows with netting can help reduce such kills.

Weather during spring and autumn can also impact the numbers of birds concentrating along the ridge and using the Sanctuary for resting and feeding. For example, sightings of raptor and other migrants increase following a cold front as birds take advantage of favorable weather to save energy during their journey south. Some soaring migrants may disperse away from the ridge or fly higher when winds are light using thermals rather than updrafts to migrate, such as the Broad-winged and Red-tailed Hawks. Although more research is needed, preliminary analyses suggest that the total numbers of raptor migrants are not influenced by number of cold fronts during a fall season, but rather that the cold front frequency may alter the distribution of migrants seasonally. The numbers of songbirds sighted on the Sanctuary are higher after a cold front passage, however research is needed to examine migrant stopover patterns more completely. Inclement weather also can cause additional physical stress on migrants and limit feeding time.

The Model of Migrating Bird Populations shows how the population of raptors and other migrating birds is affected by factors internal and external to Hawk Mountain Sanctuary. Internally, Hawk Mountain can conserve migrant birds by conserving stopover habitat, reducing structures above the tree canopy, working to limit potential impacts with buildings on and off site, and working regionally on limiting development, air traffic, and habitat destruction along the migration corridor. Understanding the many external factors affecting migrant numbers can help the Sanctuary interpret annual fluctuations in the migration counts and help set priorities for off and on site conservation efforts.

Conserving Migrating Birds: Issues, Rationale, And Action Steps

Maintain Forested Habitat for Migrant Resting and Feeding. Results of the Sanctuary's 1996 to 1998 resource inventory showed that migrant birds use an array of habitats on Hawk Mountain, and that individual species use different habitats according to species requirements and preferences. Overall, numbers of migrants were higher on the ridge-top during the fall (e.g. North Lookout counts) and in low elevation forest during the spring. Some rare migrants were found in specific habitats that often were similar to the habitat they use for nesting. In summary, to conserve migrant birds on Hawk Mountain, we should continue to maintain forest cover and natural habitats at all elevations, and maintain minimal human disturbance to these habitats. Because some disturbance is necessary to fulfill the Sanctuary's mission in research, education and conservation, some forest with minimal human disturbance should continue to be provided on site. Hawk Mountain also should continue to provide large areas where human visitation is restricted or limited to provide undisturbed resting and feeding sites for raptors and other birds.

Because Hawk Mountain currently is primarily forested, we should focus on-site efforts on maintaining the forested habitat on-site and on contiguous forested lands. HMS should encourage native shrubs that provide food for migrants around Sanctuary facilities, openings, and access routes, and plant native grasses as a seed source for seed-eating birds, such as sparrows, in parking areas or other necessary open areas.

The sanctuary should work with owners of non-forested lands within the nearby community to conserve resting and feeding sites for non-forest migrant birds, e.g. water birds, shorebirds, and early-successional or old-field birds. To accomplish this goal, we need to ask landowners to consider keeping at least some land in natural native plant cover conducive to resting and feeding by migrating birds. We will cooperate with local and regional land conservancies to encourage conservation of local areas with birds and other wildlife benefits. The Sanctuary might encourage others in the community to work on promotion of native plantings for wildlife on private and public properties near the Sanctuary and ridge, and consider periodic newsletters or community outreach on needs of migrant birds and ways landowners can landscape for birds.

Limit Pesticide Applications. Many of the species migrating through the Sanctuary feed during stopover on-site to refuel after a long night or day's migration. Such refueling may be critical to their survival. Many long-distance migrants are insectivorous (e.g. warblers and vireos) or feed on insectivorous species (e.g. Sharp-shinned Hawk, Merlin). Because application of pesticides can limit the numbers and diversity of insect life and disrupt natural cycles in ways that we may not fully understand, the Sanctuary should strive to restrict the use of pesticide or herbicides on-

site. To date, the Sanctuary has not used pesticides or herbicides on site. The only cases where such action might be considered on the Sanctuary would be where aggressive non-native species are killing or out-competing native species and endangering sanctuary wildlife or plant life for the long-term. Manual removal of pests or invasive plants should be used as the first choice in all cases. Any proposed applications should be reviewed thoroughly for non-target impacts and long-term ecological impacts or benefits with help from outside experts. The long-term approach the Sanctuary has taken towards Gypsy Moth infestations should be the model for the hands-off approach towards pesticide or herbicide application. Bio-control agents and natural control methods should be fully explored and tested before pesticide application would be considered. Applications would only be considered for use careful review by a committee of staff in consultation with experts on the species in question, and when extensive severe loss of native habitat or species are documented to be occurring. If application is shown to be necessary, a small area should be applied first to assess the potential for unintended effects applied by certified or trained staff.

Continue to Limit Impacts of HMS Buildings on Birds. Continue to promote limiting light dispersion at night through building design and modified lighting techniques, e.g. keeping lights off when not in use and using lighting with skyward coverings to focus light towards the ground. The sanctuary should continue to strive to limit window kills with features such as window netting and special window designs. Because the Sanctuary straddles a major migratory pathway, special care must be taken in how facilities may impact birds. All current buildings should be evaluated for their threat to migrant or resident birds. Windows with repeated bird kills will be covered with netting. All outside lights should be retrofitted to limit upward dispersion of light and placed on automatic shut-off systems where possible. New structures should be designed to limit window reflectivity and have windows covered with netting where necessary. The Sanctuary should keep most buildings below treetop height to limit obstructions above the canopy where low flying migrants might encounter them.

Improve Riparian Stopover Habitat. Improve local riparian habitat and stream and river function and health, particularly along Little Schuylkill River, to provide for migrant bird stopover habitat, on the Sanctuary and regionally, through cooperative efforts with others. Many species of raptors and non-raptors rest and feed along the Little Schuylkill River including Bald Eagle, Osprey, and Great Blue Heron. Such species need relatively undisturbed riparian habitat, a habitat that can be limited locally. Protecting large trees along the river will benefit perching raptors.

The Sanctuary should cooperate with landowners along the Little Schuylkill River to increase local awareness on the importance of the region to migrant birds, and the importance of natural riparian forest to birds and other wildlife. Where possible, the Sanctuary should work with neighbors and land conservancies to preserve this rare

habitat for migrant birds. Bog and wetland habitats along the river and base of mountain also need protection to provide stopover opportunities for wetland species, e.g. ducks, shorebirds, herons. Purchase of conservation easements to protect wildlife habitat should be a land conservation priority for the Sanctuary in the next ten years. If property along the river comes on the market, purchase by Sanctuary or conservation partner should be considered.

Long-term health of the river and Sanctuary riparian zone will depend on the regional recovery of the river. The Sanctuary should continue to cooperate with the Schuylkill River conservation organizations and initiatives and advocate the avian and wildlife value of protecting the riparian habitat. Indirect support and encouragement for reducing the pollutants in the river should be offered where possible to groups working to improve the river health. Partnerships with local groups interested in river conservation can prove mutually beneficial as the sanctuary can provide wildlife information and assist in defining river conservation priorities to include wildlife needs.

Ecotourism based on bird migration at Hawk Mountain can be important for attracting support for river conservation. The Sanctuary might consider producing an annual report to the community on ecotourists attracted by the Sanctuary during the past year, particularly to municipal and business leaders. Wider knowledge of the economic impact of bird watchers can assist in recruiting support for river and land conservation. As recreational use of the river continues to increase, the Sanctuary should consider monitoring avian disturbance and seek to limit disturbance during fall migration period.

Structures on the Ridge. Continue to maintain a ridge top unobstructed above the tree canopy on the Sanctuary. Cellular telephone and other types of towers that extend above tree line and that have guy wires should be prohibited on Sanctuary grounds, except for an unlit weather or research instrument tower as needed. Structures protruding above the canopy layer, particularly on the ridge-top can be a hazard to low flying migrants. Night migrating songbirds may be most susceptible. The Sanctuary can set an example for other sites along the ridge by maintaining current unobtrusive design of its facilities. Where extension above the canopy layer is needed for research purposes, e.g. weather instruments, care should be taken to limit height of structure and guy wires will not be used. Any tower should extend no more than 50 feet above tree height and be tubular in design to enhance its detection by migrants and eliminate the need for guy wires. If a tower is constructed, it should be monitored by staff for bird impacts under a range of weather and seasonal conditions and taken down or redesigned if problems are found.

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2

Wintering & Nesting Birds

Goals

- Provide appropriate habitat for nesting and wintering birds, particularly forest species.
- Promote protection of continuous interior forest cover on and around the Sanctuary.

Management Objectives

1. **Preserve Unfragmented Forest.** Preserve and protect unbroken, unfragmented forest cover over a majority of the Sanctuary.
2. **Restrict Human Access.** Keep a large portion of the Sanctuary closed to public use, as defined in the Use Area Map.
3. **Protect Additional Low Elevation Forest.** Acquire, or protect through other means, additional contiguous low elevation forest and allow this forest to mature in order to increase densities of some birds.
4. **Riparian Forest.** Conserve forest cover along streams, improve and expand habitat protection along river, thus enhancing water quality and habitat for rare birds.
5. **Control Deer Population.** Reduce deer density to ecologically sustainable levels and maintain reduced levels to allow the recovery of the sub-canopy and other low vegetation, thereby improving habitat for birds impacted by extensive browsing, e.g., shrub-nesting birds such as the Wood Thrush.
6. **Hemlock Stands.** Protect and monitor intact Eastern Hemlock and evergreen stands and prohibit high impact activity in these areas.
7. **Limit Pesticide Applications.** Limit broadcast pesticide or herbicide applications on the Sanctuary except for critical resource protection.

Background

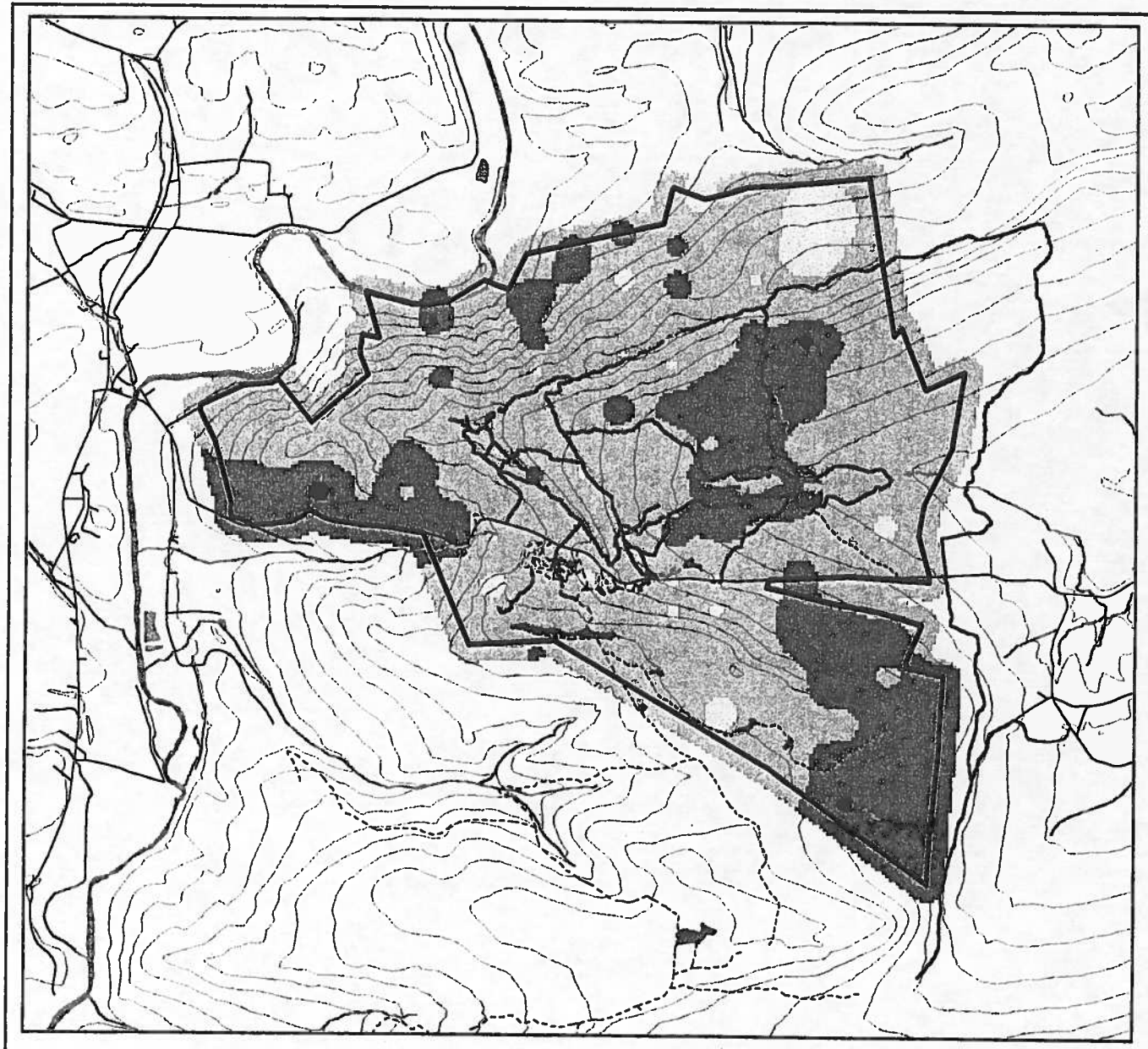
Hawk Mountain Sanctuary's 2,400 acres is located within one of the largest blocks of contiguous forest in southeastern Pennsylvania. Although the Sanctuary was logged and burned early in the century, since the founding of the Sanctuary it has been left relatively untouched. As shown in the table below, the Pennsylvania Game Commission, Pennsylvania Bureau of Forestry, and the Hamburg Borough Watershed own much of the surrounding forest; and, together the protected area comprises over 15,000 acres. This protected area is primarily forested, provides tremendous opportunity for wildlife conservation and acts as reservoir of biodiversity for much of Pennsylvania's southeastern region. In addition, the Conservation Science Forum process conducted by Natural Lands Trust has indicated HMS as a conservation resource area in the Schuylkill River Watershed.

PROTECTED LAND IN THE VICINITY
OF HAWK MOUNTAIN SANCTUARY

Owner	Approximate Acreage
PA Game Lands No. 106	9,470
PA Bureau of Forestry	1449
Hawk Mountain Sanctuary	2430
Hamburg Watershed	1501
National Park Service	257
Total	**15,107**

Straddling the Kittatinny Ridge at the southern edge of the Ridge and Valley Province, the Sanctuary is primarily upland Appalachian Oak Forest. Birds associated with upland, contiguous forest are found in abundance. Edge species are restricted to lookouts, roads and building areas. Pockets of Eastern Hemlock and wet ravines increase the diversity of the bird community.

Since 1934, the Sanctuary staff has documented the bird community present on site. Early in its history, the younger forest harbored a different mix of species associated with shrubs or young forest. Today, Sanctuary bird life is dominated by birds of mature forest-interior habitat. In 1982, the Sanctuary began monitoring the breeding and wintering bird communities on two permanent census plots, each approximately 50 acres. These data represent the longest continuously operating bird census plots in the state of Pennsylvania and represent an important resource for monitoring the health of bird communities in the region. Their small size (less than 50 acres each) however, has limited the Sanctuary's knowledge of bird abundance and distribution.



Abundance of Forest Interior Species

- Hawk Mountain Boundary
- Wet Area
- Field
- Boulder Field
- Stream
- Road (paved)
- Road (unpaved)
- Trail (public)
- Trail (non-public)
- Contour Line (100 ft.)
- Parking Lot
- Building

Number of Individuals per Point

- 0
- 1-5
- 6-10
- 11-15
- >15

N W E S

0 1000 2000 Meters

This map created by Hawk Mountain Sanctuary Association
Prepared by: David R. Barber, February 2000

HAWK MOUNTAIN

MAP 14

The Sanctuary's resource inventory conducted from 1996 through 1998 mapped the distribution of breeding and wintering birds and provided a comparison of the abundance of birds across the entire Sanctuary (Map 10). Some forest-interior species documented to be declining across their range, were abundant at Hawk Mountain, e.g. Eastern Wood-Pewee, Great-Crested Flycatcher. Several *Partners In Flight* Watch List Species, such as the Wood Thrush and Worm-eating Warbler, were found in greater numbers than in other regions of the state. Such species are of high conservation priority in the state of Pennsylvania and the Appalachian region.

Eight of the top ten most abundant nesting species on Hawk Mountain land are neotropical migrant, forest-interior species, six of which are significantly declining in Pennsylvania as nesting species (Maps 11, 14). These findings indicate that Hawk Mountain provides regionally important, critical habitat for forest-nesting species generally and provides important nesting habitat for some species that are declining in other parts of their range. The Sanctuary may play a pivotal role in long-term conservation of forest songbird populations in Pennsylvania and across their range. The location of Hawk Mountain on the Kittatinny Ridge, the southern-most ridge of the Appalachian chain, also situates the Sanctuary at or near the northern edge of the breeding range for some species (Worm-eating Warbler) and southern range limit for other species (Dark-eyed Junco). Thus, Sanctuary avian diversity is enhanced through the range overlap of southern and northern bird species.

Wintering birds detected during the Sanctuary inventory included an array of species that depend on large forests for survival, e.g. Brown Creeper, White-breasted Nuthatch (Map 15). Woodpecker populations including Pileated and Hairy woodpeckers were especially abundant in the lower River of Rocks. Non-breeding winter visitors included Brown Creeper and Golden-crowned Kinglets, and both species were most abundant in the lower River of Rocks region and other areas with hemlock stands (Maps 15, 17). Winter survey results strongly suggest that hemlock-evergreen forest may provide important cover for wintering birds on Hawk Mountain. Availability of running water from the Kettle Creek and Little Schuylkill River and their tributaries is also very important to winter survivorship of Sanctuary birds. Overall, the ridge-top forest is a harsh environment in winter and is less used by wintering wildlife than the lower elevations of the Sanctuary.

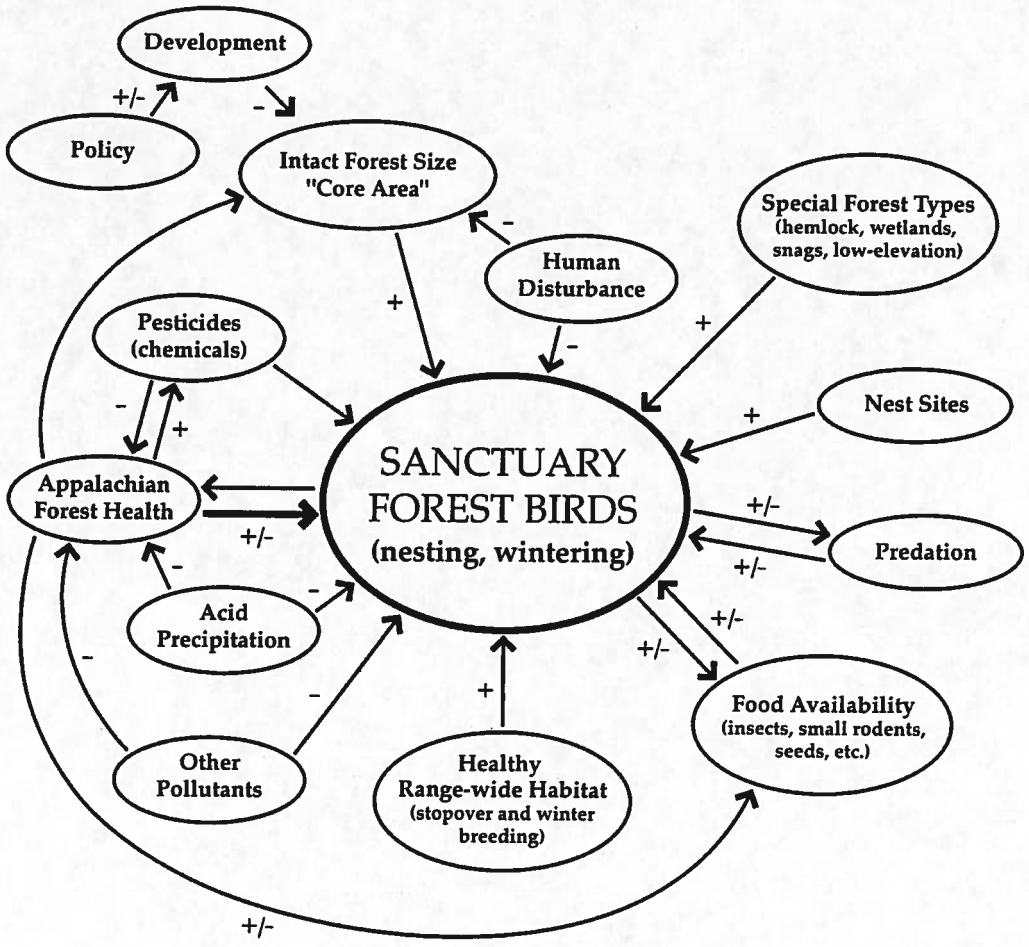
Sanctuary Nesting and Wintering Forest Bird Model

The Sanctuary forest bird model illustrates that many factors can impinge on nesting and wintering birds on-site. "Sanctuary Forest Birds" includes all bird species including raptors, nocturnal birds, etc. In some cases, the arrows indicate Sanctuary birds can impact other factors as well. Impacts can be positive, negative, or both, depending on the species in question. Heavier arrows, such as "Appalachian Forest

Health" indicate a stronger influence in one direction than the others. In general, the health of the forest ecosystem may have the most important long-term impact on forest bird populations. Factors that cause widespread severe impacts on forest integrity, such as acid precipitation or deer overabundance, can indirectly have profound impacts on bird populations. Some segments of the bird community can be more affected than others. For example, shrub-nesting birds may be affected by lack of shrub or sub-canopy layers of forest, a direct consequence of deer overabundance. In addition, heavy over-browsing by deer may change or decrease invertebrate populations in the ground or leaf layer and indirectly affect insectivorous bird populations and distribution.

External factors that may limit forest bird survivorship include pollution, acid precipitation, and pesticides. Such factors may act directly to limit reproduction or survivorship, or may act indirectly by impinging on forest health, forest productivity or the insect prey of avian populations. Thus, arrows connect directly and indirectly to forest bird populations indicating the impacts can be complex.

NESTING & WINTERING BIRD MODEL DIAGRAM



Special habitats or forest types increase habitat diversity and attract a variety of birds to nest and winter, e.g. hemlock stands attract and sustain certain rare nesting or wintering birds. Hemlock or other evergreen stands provide thermal cover for wintering birds and may increase survivorship overall. Low elevation riparian forest provides nesting opportunity for Red-shouldered Hawks, Great Blue Herons and Green Herons, birds not documented elsewhere on the Sanctuary. These special habitats are important to sustaining avian diversity on Hawk Mountain. The availability of nest sites within the Sanctuary forest can influence the number and diversity of birds on Hawk Mountain. For example, an abundance of cavities in River of Rocks valley provides for a variety of hole-nesting species such as woodpeckers, Black-capped Chickadee, and Tufted Titmouse. Lack of a natural shrub layer due to factors such as excessive deer browsing, or invasive plant competition can limit nesting sites for species that use shrubs for nesting or rely on dense ground cover such as the Worm-eating Warbler and Black-and-white Warbler. Overall breeding success can be limited by nest parasitism and predation. Some egg and chick loss is sustainable and 'normal' within any population of birds, but when rates of predation and nest parasitism increase disproportionately populations may decline. Predation and parasitism have been documented to increase near openings and human disturbed areas in the forest landscape.

Preserving Wintering And Nesting Birds: Issues, Rationale, And Action Steps

Preserve Continuous, Un-fragmented Forest. Preserve and protect continuous, un-fragmented forest cover over most of the Sanctuary. Hawk Mountain and nearby public and private forestlands form a large block of undeveloped forest (Map 18). The size and unbroken nature of the forest provides a critical refuge for wildlife that depends on large expanses of forest to survive. As human population and pressures increase in the Appalachian region, Hawk Mountain's 2,430 acres of contiguous forest will become increasingly important for birds and other wildlife that need large mature tracts of forest to survive. Some species showed higher densities on Hawk Mountain than elsewhere across the state or region. Hawk Mountain's 2,430 acres provides critical habitat for forest interior specialists such as Worm-eating Warbler, Ovenbird and Wood Thrush (Maps 13 and 14). However, because species such as the Worm-eating Warbler may need 3,000 acres or more of contiguous forest to reach maximum population densities, the Sanctuary also needs to work with adjacent landowners to preserve a healthy avian community on Hawk Mountain.

The Sanctuary's forest may act as a source for re-population of avian forest communities in the more fragmented southeastern region, e.g. birds may disperse from Hawk Mountain's forest to smaller tracts to the south, maintaining bird populations in

these regions (Map 18). Maintaining the contiguous forest of Hawk Mountain and surrounding area is important in maintaining regional forest bird abundance.

Maintaining the continuous forest canopy cover across the Sanctuary where possible is beneficial to forest-interior birds. Within Hawk Mountain, some species showed significant aversion to human-use areas including Sanctuary trails. Rose-breasted Grosbeak, Ovenbird, Eastern Wood-Pewee and Black-and-white Warbler were less abundant near areas used by people (Map 11, 12). Edge species associated with nest parasitism and predation, e.g. Brown-headed Cowbird and American Crow were more abundant near openings such as the Visitor Center and parking lots. Long-term research on Hawk Mountain has shown that openings the size of the Hawk Mountain facilities and parking complex (approximately ten acres) do have a detrimental impact on nesting success of Ovenbirds, a forest-interior ground-nesting species. Other species show similarly diminished nest success, e.g. Wood Thrush, which is usually attributed to an increased predation rate along edges. Nest success of Ovenbirds is lower near openings and individual annual return rates are lower than in forest away from edges. Research on impacts of roads on songbirds also indicates a negative influence from the road can extend over 600 meters from the forest edge. Heavily traveled roads have a greater impact as noise levels can impinge on territorial song detection. Another possible influence of openings and roads is the increased activity of white-tailed deer near edges which may lead to pockets of heavy browsing around openings and the trampling or alteration of the vegetation community which may reduce habitat quality for nesting birds.

Because of the importance of Hawk Mountain to forest-interior species (Map 14) and the opportunity the Sanctuary has to provide for birds of mature contiguous forest, Hawk Mountain will seek to maintain the contiguous forest canopy across the Sanctuary wherever possible. This may include limiting expansion of existing openings, where possible, and working with the township and local residents to limit canopy openings around Sanctuary boundaries or along Hawk Mountain Road, e.g. establishing a forested buffer for the Sanctuary. Particularly sensitive areas for rarer nesting birds such as the north slope and near the Little Schuylkill River (e.g. Worm-eating Warbler, Red-shouldered Hawk) and lower River of Rocks (Barred Owl, Winter Wren) might be designated for low human use or researcher only use to protect these populations for the long-term. Sanctuary trails should be designed to minimize disturbance to surrounding forest, e.g., minimize erosion and avoid canopy openings, and new trails should be carefully evaluated to minimize impacts on forest-interior species. Efforts should be made to maintain islands of trees in parking lots to minimize the disturbed area effect.

Restrict Human Access. Keep a large portion of the Sanctuary closed to public use, with current levels as defined in the Sanctuary Use-Management Area Map (Map 1A). Nesting and wintering birds expend additional energies when disturbed by people during these time periods. Human disturbance can also lead to increased nest

predation by attracting predators and nest parasites to the area. Even low-level researcher activity or low-use trails may have a negative impact on nesting birds. Thus, the Sanctuary should continue to maintain large areas of the Sanctuary grounds as off-limits to public visitation and allow only limited, staff-supervised activities in these areas. Because the lower River of Rocks area is heavily used by wintering birds, this area in particular should be considered for protection from winter disturbance when possible.

Birdfeeders can attract and support a variety of nest predators (Grey Squirrel, Eastern Chipmunk and Brown-headed Cowbird). Staff should evaluate and assess impacts of feeders and consider reducing feeding of birds or using feeders less attractive to mammals.

Restricted access can also benefit forest-nesting raptors. The most recent site of Northern Goshawk and Barred Owl nests on Hawk Mountain were in lower elevation forest. Both species are intolerant to human disturbance. Other raptors nesting on Hawk Mountain are found in areas of low human use, e.g. along River of Rocks Trail, or areas with no human use, such as the north slope. In accordance with the Sanctuary's mission in raptor conservation, the Sanctuary should continue to provide some undisturbed sites for sensitive raptor species to nest as per the Management Area Map (Map 1A).

Areas with trails open to the public will be kept as natural and undisturbed as possible to allow people to experience Hawk Mountain's birds and unique forest community. Low level use trails are important to maintain on-site as they provide a wild and natural experience and allow visitors to encounter Hawk Mountain's nesting and wintering birds with limited negative impacts. The Sanctuary should increase efforts to reduce trail erosion and runoff and limit impact of trails on surrounding forest. Trails should be inspected annually for impacts.

Protect Additional Low Elevation Forest. Acquire, or protect through other means, additional contiguous low elevation forest and allow this forest to mature in order to allow increased densities of low elevation forest birds. Sanctuary inventory results suggest a rich and unique diversity of bird-life can be found in the lower elevation, moist forest of the Sanctuary and neighboring properties (e.g. Red-shouldered Hawk, Blue-headed Vireo). In addition, some species sensitive to fragmentation are found here in greater number than at higher elevations (e.g. Wood Thrush). Other research has shown that low elevation forest, particularly riparian forest, is of rare supply in Pennsylvania and region-wide. State land often is found on dry ridge-tops and less along lower slopes. As such, the Sanctuary could benefit birds and other associated wildlife and plant communities by seeking to conserve low elevation forest on and outside its borders through direct acquisition with willing sellers, or by conservation easements or other conservation agreement.

Older or maturing forest has been shown to harbor greater densities of some species of birds including declining species of warblers, thrushes, or vireos. One species found on Hawk Mountain during inventory work that was not present as a nesting species 10 to 20 years prior, is the Winter Wren. Another species associated with mature forests that has become increasingly abundant is the Hermit Thrush. Older forest benefits a variety of mammal species as well. As the forest matures, the Sanctuary provides improved habitat for mature forest species. Because neighboring landowners, such as the Pennsylvania Game Commission and Bureau of Forestry, may continue to manage their forest on a 100–150 year rotation. Hawk Mountain can fill an important niche by providing habitat for species that rely on older, less disturbed forest. In concept, the public-private protected land will hold a diversity of species. The Sanctuary might seek to maintain current low elevation forest in low human access zones, and partner as possible with other conservation groups and neighbors to protect the contiguous and mature nature of low elevation forest on or near Hawk Mountain.

Riparian Forest. Conserve forest cover along streams, improve and expand habitat protection along river, thus enhancing water quality and habitat for rare birds and other wetland species. Some species may be found only along the Little Schuylkill River, including the Red-shouldered Hawk and Belted Kingfisher. To improve or expand the habitat available for birds along the river, Sanctuary staff and board may seek to acquire or protect by easement the natural forest cover present along Sanctuary boundaries near the river and in areas adjacent to Kettle Creek. Protection of a buffer zone of riparian vegetation along the Little Schuylkill River extending at least 100 feet from river edge should be encouraged among adjacent landowners. Tributaries to the river that run through the Sanctuary should be monitored for water quality and those data shared with regional river conservation groups. The Sanctuary might also partner with other groups to seek improvement in water quality and river health to provide abundant aquatic prey for nesting species in this unique Sanctuary zone. The Sanctuary might encourage public knowledge and appreciation of the river in coalition with other river conservation groups.

Control Deer Population. Reduce deer density to, and then maintain it at, an ecologically sustainable level to allow the recovery of the sub-canopy and other low vegetation, thereby improving habitat for birds impacted by over-browsing, e.g., shrub-nesting birds such as the Wood Thrush. Some species known to be declining across the eastern region may be detrimentally impacted by deer overabundance. Wood Thrush numbers have declined on Sanctuary long-term census plots and species associated with dense ground and shrub cover such as Worm-eating Warbler appear restricted to areas with Rhododendron or Mountain Laurel stands (Map 13). Both species are listed as a bird conservation priority for Pennsylvania and the Appalachian Region. The abundance of each may improve if forest shrub layer were to recover.

Concentrated deer browsing may aggravate the impacts of trails and other openings on Hawk Mountain. Control of deer populations may lessen the impact of these openings

on shrub-and ground-nesting birds. Deer density should be reduced (see forest stewardship section) to lower levels and maintained through culling program. Culling should be encouraged in areas of Sanctuary with particular importance to forest birds, such as the Sanctuary's north slope and lower River of Rocks. Deer culling also may improve forage for some species where over-browsing has limited fruit or seed production. Recovery of shrub-nesting birds can be monitored by using long-term census plots. An additional census plot could be implemented to increase the bird monitoring samples (possibly in lower elevation area). Hunters, Sanctuary staff and volunteers will be informed as to the impact of deer on songbird populations and subsequent monitoring results. Posters in the Visitor Center featuring results of research conducted on songbirds and deer in northern Pennsylvania are one possible avenue for visitor education as well as placing an additional deer exclosure in a visible location. HMS may also consider setting up long-term forest vegetation monitoring sites to monitor the impacts of culling on forest vegetation.

Hemlock Stands. Protect and monitor intact hemlock stands and prohibit high impact activities in these areas. Hawk Mountain's hemlock stands are important to both nesting and wintering birds. These stands provide thermal cover and food during winter, and provide a unique mixed forest habitat for nesting birds such as the Black-throated Green Warbler and Blue-headed Vireo. In winter, densities of winter visitors such as the Golden-crowned Kinglet and Brown Creeper, are higher in hemlock areas (Maps 15, 16, 17). Limiting human disturbance to hemlock stand areas will enhance the value to birds and other wildlife.

Hemlock survival is currently threatened by the introduced pest, the wooly adelgid. The Sanctuary should monitor the health of the hemlocks and the bird abundance associated with hemlock stands annually. If research suggests some effective control of the adelgid is possible and warranted, this can be considered on a limited basis as long as impacts on non-target organisms are minimal. White Pine stands, as they evolve in future years, should also be monitored for future potential benefit to wintering birds.

Limit Pesticide Applications. Limit broadcast pesticide or herbicide applications on the Sanctuary, except when necessary for critical resource protection. The impacts of many pesticides and herbicides are poorly understood. Non-target impacts of these chemicals may be unknown and unanticipated. Recognizing that many of the Sanctuary's forest birds are insectivorous species, and chemical application can have unintended non-target impacts, such applications should be considered only when no other options are available, all other options have been explored, and when critical resources are severely threatened.

Considerations to be evaluated in weighing chemical applications include the fact that each species may feed preferentially on different groups of insects. For example Ovenbirds feed heavily on *Carabidae* ground beetles but supplement their diet with caterpillars, spiders, etc; Scarlet Tanagers glean caterpillars from the canopy and sub-

canopy layers. Diets are varied and the interactions in nature highly complex. Caution and restraint should prevail where impacts are unknown. And, impacts on all forest communities should be considered. The Sanctuary is home to an array of nesting raptors that feed on Sanctuary songbirds and small mammals. If application is warranted, the agent should be the least toxic and least persistent possible to avoid unintended or long-term impacts. The potential for bioaccumulation and magnification must be evaluated before any application. Applications should be specific and in limited areas to avoid wide impacts, and conducted only by trained personnel.

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3
Forest Ecosystem Stewardship

Goals

- Promote and maintain the natural ecological integrity of the Central Appalachian Forest ecosystem on the Sanctuary.

- Increase monitoring of indicators of forest health and function. Several factors cause major negative impacts to Pennsylvania's forests. Deer abundance appears to be having a major deleterious effect on the HMS forest; however, other factors that may contribute to forest decline include invasive vegetation, pests, disease and acid precipitation.

Management Objectives

1. **Forest Steward.** Assign specific responsibility to staff for forest function and health.

2. **Deer Densities.** Reduce deer densities to sustainable level to enhance forest regeneration, i.e., continue and expand the Sanctuary's hunting program to improve culling of the deer herd with an emphasis on does.

3. **Deer Exclosures.** Consider installing additional deer exclosures in visible locations and in different forest management units as a research and educational tool, and to confirm and document the level of deer impact. Evaluate the need for deer fencing near the Visitors Center and remove if indicated.

4. **Monitor Impacts of Deer on Forest Habitats.** Monitor impacts of deer on forest. Monitor deer population effects on the environment in order to both improve the current culling program and to remediate other contributing factors.

5. **Invasive Species Control.** Control invasive species, e.g. Japanese Stiltgrass, now well established within the Sanctuary, particularly within forest gaps and along areas of human disturbance (trails, roads, parking lots) to prevent further spread, especially in the event of a major disturbance, i.e., insect defoliation, fire, or wind. Invasives are poised to quickly spread throughout the Sanctuary following any major disturbance (wind, fire, defoliation). Consider the following actions in the near-term to control and forestall the spread of invasives:

a. Minimize future soil disturbance

b. Undertake an assessment of invasive species levels within the Sanctuary, including mapping by species. Monitor on an annual basis to determine rate of spread.

c. Control existing species starting with those that impact the canopy and working down to the herbaceous layer. (e.g., see NLT's *"Controlling Invasives"* brochure.) Focus should be on those areas (such as the south-facing slope below Owl's Head in Management Unit 1) which have greater solar exposure, because such areas tend to be colonized more rapidly.

6. **Natural Forest Processes.** By minimizing forest-management activities, allow natural processes, cycles and disturbances to occur and the forest to mature naturally into old growth forest. Most of the forest surrounding the Sanctuary is under active timber management. Given that fact, the goals of the Sanctuary, and the forest function-health concerns expressed above, timber harvests should be restricted from the Sanctuary, except for the removal of invasive, diseased, or infested trees (e.g., Asian long-horned beetle) or for safety reasons.

7. **Understand Human Impacts.** Monitor and assess human impacts on the forest and respond appropriately, e.g., by moving trails, limiting access and other measures that may be necessary for long-term protection of forest communities.

8. **Protect Additional Low Elevation Forest.** Acquire or protect additional low-elevation forest as this type is currently in low proportion on HMS and allow this forest to mature naturally in order to increase densities of some birds.

9. **Acid Precipitation.** Acid precipitation affects forest function-health by modifying soil chemistry. This is a more pronounced problem on thin and highly weathered soils such as those at HMS. Long term, the Sanctuary should try to ascertain the level of impact on forest communities from acid precipitation.

10. **Role of HMS in Regional Forest Context.** Develop a working relationship with neighbors, especially adjoining public land owners (Bureau of Forestry and PA Game Commission) to coordinate management strategies, and to secure long-term protection of the large block of forest including Hawk Mountain. Consider bioreserve designation at state or regional level.

11. **Long-Term Research.** Consider a cooperative effort with neighboring public landowners to investigate the effects of different management regimes on fauna, particularly birds.

12. **Diverse Monitoring Strategy.** Develop a long term, comprehensive monitoring strategy that considers cost and other institutional constraints on the Sanctuary and that includes:

    a. Measurement of floral and faunal communities, and tracking of threats to the healthy functioning of the forest system from all sources.

    b. Coordination of monitoring efforts with other entities so HMSA data are comparable and consistent among agencies and conservation organizations, e.g., Pennsylvania Bureau of Forestry and Pennsylvania Game Commission, to enable better indications of forest function and health across the entire Commonwealth.

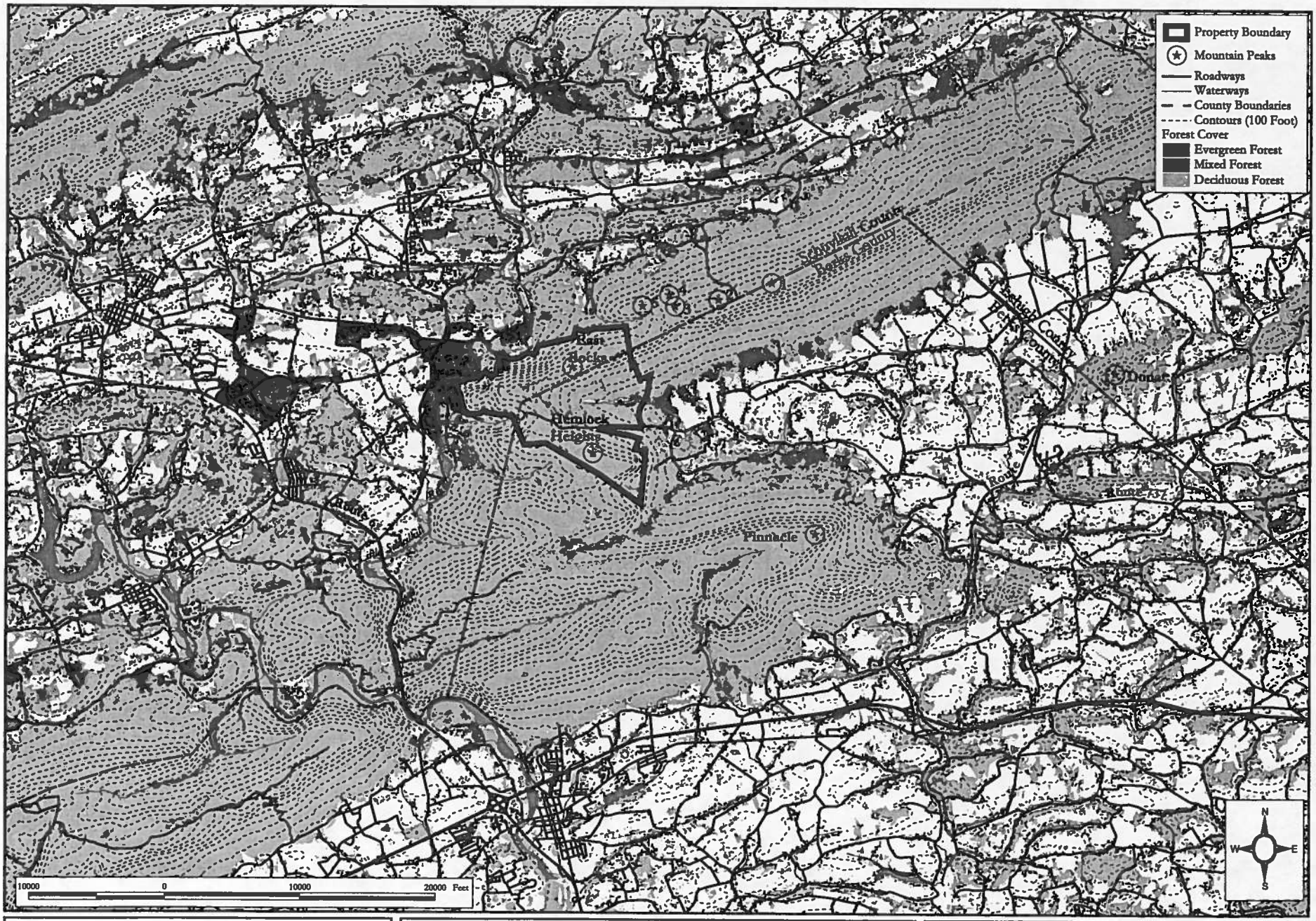
13. **Limit Scientific Collecting or Researcher Habitat Alteration.** Scientific collecting will be prohibited except as per Sanctuary Research Policy. Alteration of natural habitat and communities for research purposes should be limited to temporary, special cases as approved by senior staff.

14. **Culling of Nuisance Animals.** Culling will be limited to nuisance animals that disrupt the natural forest ecosystem, e.g. heavy deer browsing of understory vegetation, or where non-native wildlife are detrimentally impacting native wildlife or attempting to establish self sustaining populations, e.g. Norway rat.

Background

Hawk Mountain Sanctuary (HMS) straddles the southernmost (Kittatinny) ridge of the Ridge-and-Valley Physiographic Province. As such, it is a guiding landscape feature for migrating birds, for which the Sanctuary was founded. The ridge also provides the first break to the highly fragmented landscape to the south. Through its size and diversity of plant communities, the Sanctuary offers important ecological and environmental benefits. The Sanctuary's forest forms a critical link to over 12,000 acres of other protected forest lands including State Game Lands No. 106, Weiser State Forest, the Appalachian Trail, and the Hamburg Watershed. These protected lands are themselves in a larger landscape of contiguous forest covering at least 15,000 acres locally, but which also extends northeast and southwest along the ridge. This forest provides valuable habitat to species that require extensive interior forest habitats. In addition, the tree-covered slopes of Hawk Mountain Sanctuary prevent degradation of the water quality of the Little Schuylkill River and its associated tributaries and improve groundwater recharge for local valley communities.

The HMS forest was shaped by the inherent environmental conditions (topography, soils, hydrology, aspect) of the site and the biotic (human, insect pests and pathogens) and abiotic stresses (fire, wind, ice, drought) over the last 150 years. Like most of



Hawk Mountain Sanctuary
Schuylkill and Berks Counties, PA

MAP 18

Regional Forest Cover

DCR 3/29/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Martin, Kutztown University.

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Pennsylvania's forests, the forest within HMS was clearcut during the late 19th and early 20th centuries for lumber, charcoal, and tannin. Subsequent fires and the demise of the American Chestnut (which on average made up a third of the Eastern forest) in the early 20th century fostered the current dominance of oak species within the state and Sanctuary. Despite several infestations by the introduced Gypsy Moth over the last few decades, oak still dominates the forest canopy (Maps 21, 22). Without major disturbance (clearcutting, high wind events) dominance will likely shift to more shade tolerant species such as Red and Sugar Maple, White Pine, Eastern Hemlock, and Blackgum.

Forest System Model

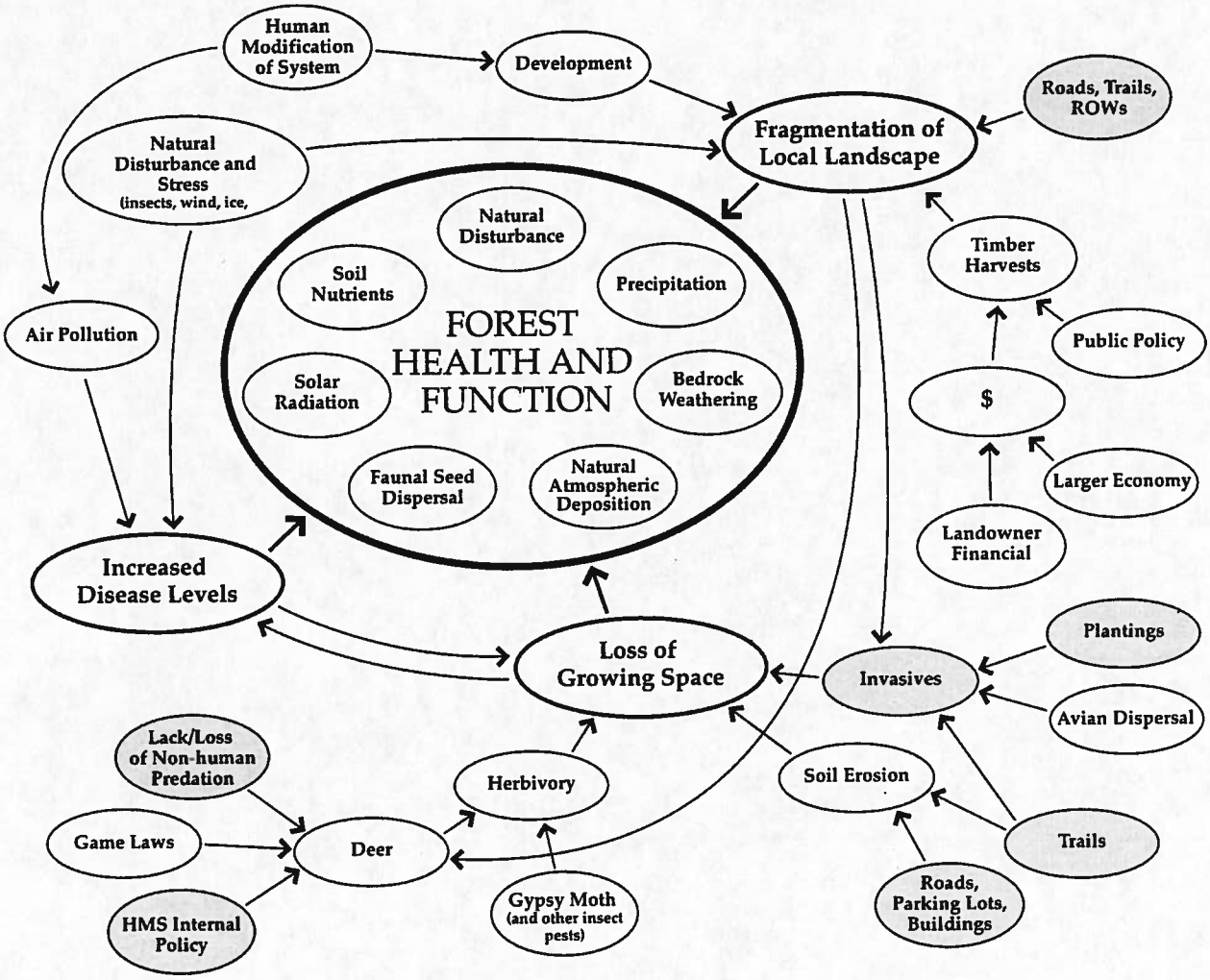
The Forest Model illustrates the various positive and negative factors that impact forest health within the Sanctuary. While positive factors are largely beyond the capabilities of HMS to influence significantly, some human activities on the Sanctuary can impact the magnitude of the negative effects.

Positive influences are within the large oval marked "forest function-health". These include factors that directly support plant growth (precipitation, solar radiation, soil nutrients), and contribute to the dispersal (faunal seed dispersal) and regeneration establishment (natural disturbance) of desirable species.

Outside the "Forest Health and Function" oval are those factors that adversely impact forest health. There are three major negative factors contained within the larger bold ovals - fragmentation of the local landscape, disease, and loss of growing space. The various components that contribute to each of these major factors are within the smaller circles connected to the appropriate negative factor by an arrow. These components in turn are influenced by other factors. Those factors that are more or less under the influence of HMS are within shaded ovals.

For example, forest function-health declines when relatively finite growing space (major factors supporting plant growth including light, water, nutrients, and atmospheric gases) is lost by desirable plant species. Growing space can decrease due to soil erosion removing nutrients, the growth of undesirable invasive species displacing native plants, or through direct removal of biomass by insects or deer herbivory. The Sanctuary can have a positive effect on forest health by reducing these impacts. Soil erosion can be minimized by limiting the extent of built structures (buildings, roads, parking lots, trails) and by properly handling runoff from these more or less impervious surfaces. Limiting disturbance will also help to prevent invasive plants from becoming further established. Modification of the HMS deer hunting program to increase culling rates and decrease herbivory in some heavily browsed areas could significantly improve forest function-health (Map 19A).

FOREST SYSTEM MODEL DIAGRAM



Vegetation Management Units

HMS is part of the Appalachian Oak Forest that covers most of Pennsylvania. This forest is dominated by various oaks in association with maple, hickory, tuliptree, birch, and pine. The specific oak dominant and associated species at any particular site is largely determined by elevation, hydrology, and aspect. Although most of the Sanctuary is dominated by hardwood forest, there are significant areas of conifer and mixed hardwood and conifer forest.

Hawk Mountain Sanctuary
Schuylkill and Berks Counties, PA

Vegetation Management Units

MAP 20

DCR 3/29/00
NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, and structures from Professor Robert Martin, Kutztown University.

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Vegetation management units consist of areas within the Sanctuary that harbor similar plant communities. There are seven general types of communities within the Sanctuary (Map 20). Plant community classification is based on *Terrestrial and Palustrine Plant Communities of Pennsylvania* by Jean Fike (1999) and is updated from *Natural Ecological Communities of Pennsylvania* by Thomas Smith (1991), which was used in the *Forest Stewardship Plan* for Hawk Mountain Sanctuary (1998) by Natural Lands Trust.

Management Unit 1 is a 75 -100 year old Dry Oak - Heath Forest (formerly Xeric Central Hardwood Forest) that covers most of the upper to mid-slope areas of the Sanctuary. Despite repeated defoliation (1971, 1973, 1981, 1982, 1989, 1990) (Maps 21, 22) by Gypsy Moths, oaks (Chestnut, Red, Scarlet, Black, White) continue to dominate this unit which constitutes over half (1,350 acres) of the Sanctuary. Other major canopy species include Red Maple, Black Birch, Blackgum, and Sassafras along with scattered Pitch Pine and White Pine on the upper slopes and Tuliptree, Aspen, and Black Cherry on the mid slopes. The relatively open character of much of the forest (particularly on the upper slopes) reflects the impact of the past Gypsy Moth infestations and the poor soil (very thin and stony) conditions throughout the unit.

The understory and groundcover vary widely in density from very sparse (the norm) to very dense patches of primarily striped maple. Blackgum, Red Maple, Striped Maple, and Witchhazel are the major components of the understory that also includes Mountain Laurel, Rhododendron, Japanese Barberry, White Pine, Sheep Laurel, Ailanthus, Sweetfern, Pignut Hickory, Shadbush, smilax, and American Chestnut sprouts (a fruiting individual was found to the east of North Lookout) make up most of the remainder of the understory trees and shrubs. Low-bush Blueberry and Huckleberry are the dominant ground cover species followed by Hay-scented Fern and Japanese Stiltgrass. Stiltgrass, Barberry, and Ailanthus are exotic invasives. Hay-scented Fern also can invade disturbed areas and dominate ground cover preventing regeneration of seedlings. The current distribution of the invasives is patchy - principally found along road, parking lot, and trail edges, and in woodland gaps, and stormwater channels, although some impacted areas are spreading.

Wildlife benefits within this management unit are compromised by the unnatural patchiness of the understory and ground cover and a lack of perennial water resources, but still are abundant due to its size, amount of oak mast, and the almost entirely contiguous forest cover. The few breaks (rock outcrops) in the forest cover are important sites for snakes and lizards and are the historical sites for the Allegheny Woodrat, a Pennsylvania Natural Diversity Inventory (PNDI) species of special concern. Most important, this management unit includes most of the Blue Mountain ridgetop which hosts the fall raptor migration, as well as the annual migration of over 150 songbird species and butterflies. Numerous types of cavities are available to mammals (Gray Squirrel, Raccoon) and birds, as well as upland songbird nesting sites, food, and water from two ephemeral pools and two intermittent streams. Some

evergreen cover is available from the scattered pines and hemlock. Hard mast is very abundant from the oaks, maple, pines, and hemlock. Soft mast is available from the Blackgum, barberry, blueberry, Huckleberry, Partridgeberry, and Shadbush. Dead woody material that supports insects and fungi is also fairly abundant. The forest supports a high deer population as evidenced by browse and a lack of native tree regeneration.

Management Unit 2 is a 75 - 100 year old Red Oak - Mixed Hardwood Forest (formerly Dry-Mesic Acidic Central Hardwood Forest) that is found on the mid-to-lower east-facing slopes. As in Unit 1, several species of oak dominate the canopy despite repeated defoliation (1971, 1973, 1981, 1982, 1989, 1990) by gypsy moths (Maps 21, 22). Other major canopy components include Tuliptree, Black Birch, and Blackgum. The sparse to somewhat dense understory consists mostly of Striped Maple, Witchhazel, Blackgum, Black Birch, and Red Maple. Mountain Laurel, Rhododendron, Japanese Barberry, White Pine, Ailanthus, Multiflora Rose, smilax, Spicebush, Shrub Honeysuckle, hemlock, Mountain Ash, Sassafras, Sugar Maple, hawthorne, Tuliptree, and American Chestnut sprouts make up most of the remaining understory trees and shrubs. Advanced regeneration is limited to patches of Black Birch near gap edges and scattered Sassafras, White Pine, and hemlock. Low-bush Blueberry and Huckleberry constitute most of the ground cover followed by ferns and Japanese Stiltgrass. Vines (grape, Virginia Creeper, Poison Ivy) are a concern as grape has invaded many existing gaps. The current distribution of the invasives is patchy and their impact isolated. However, moderately severe impacts are found principally along road and trail edges, woodland gaps, and stormwater channels.

Wildlife benefits within this management unit include food, cover, and water resources. Numerous natural cavities are available to mammals (squirrel, Raccoon) and birds (owls, Tufted Titmouse), as well as songbird stick nest sites. Evergreen cover occurs in scattered pines and hemlock groves which provide valuable cover for songbirds. Hard mast is very abundant from the oaks, Tuliptree, Maple, beech, pine, and hemlock. Soft mast is available from the Blackgum, barberry, blueberry, Huckleberry, and Partridgeberry. A manmade pond (Schaumboch's Pond) and several intermittent streams feed Kettle Creek and add water sources for wildlife.

Management Unit 3 is comprised of a greater than 100 years old Hemlock - White Pine - Northern Hardwood Forest (formerly called Northern Conifer Forest), covering two areas in the Sanctuary characterized by cooler north-facing upper slopes or ravines. Eastern Hemlock and birch (Yellow and Black) constitute most of the canopy followed by oak (chestnut and red), White and Pitch Pine, and Blackgum. In general, the understory is fairly dense, with very dense patches of Rhododendron, along with hemlock, Witchhazel, Black Birch, Mountain Laurel, Sassafras, Mountain Holly, Low-bush Blueberry, and Red Maple. Ground cover (ferns, grasses, and mosses) and vines (Virginia Creeper and grape) are sparse. Japanese Stiltgrass occurs in forest gaps.

There are many native wildlife benefits available in this management unit. The evergreen cover in both the understory and canopy layers provides excellent winter cover for grouse, turkey, and deer, and nest sites for native songbirds, including Blue-headed Vireo, Dark-eyed Junco, and numerous warblers. A variety of cavities exist for mammals (squirrel, Raccoon) and hole-nesting birds (owls, Black-capped Chickadee, Tufted Titmouse). There is a fair amount of hard mast from the hemlock, birch, maple, pine, Witchhazel, and oak. Soft mast is available from the grape, Mountain Holly, Sassafras, Blackgum, and blueberry. Dead and down woody material which supports fungi and insects is also fairly abundant. A major limiting factor is the lack of perennial water. There is a high deer population as evidenced by heavy browse on the understory trees and shrubs, particularly the Rhododendron. The hemlocks in this area are also stressed by woolly adelgid infestation and a series of droughts during 1990s.

Management Unit 4 is a 75 - 100 year old Tuliptree - Beech - Maple Forest (formerly Mesic Central Forest) that is found in scattered patches on protected middle to lower slope areas that contain the most fertile soils within the Sanctuary. Tuliptree, Red Maple, and Eastern Hemlock dominate the canopy followed by Red oak, Black Birch, Chestnut Oak, Aspen, White Pine, White Ash, Basswood, and Yellow Birch. The Rhododendron and hemlock understory is fairly dense, and also contains Witchhazel, Striped Maple, Sassafras, Sugar Maple, Low-bush Blueberry, Blackgum, Red Elderberry, and American Chestnut sprouts. Sparse ground cover includes ferns, grasses, mosses, and herbaceous perennials (White Baneberry, Horsebalm, Spotted Knapweed, Wild Sarsaparilla, Starflower, Solomon's Seal) and Partridgeberry. Vines (Poison Ivy, grape, Virginia Creeper) are sparse and currently not problematic (except in the small patch just north of Mountain Road) although the grape, along with Japanese Stiltgrass and Hay-scented Fern, is poised to colonize any future gaps.

Native wildlife benefits from the evergreen cover in both the understory and canopy layer which provides excellent winter cover for grouse, turkey, and deer, and nest sites for native songbirds, including Dark-eyed Junco and numerous warblers. It is also important winter cover for birds such as the Brown Creeper and Golden-crowned Kinglet. A variety of cavities are available to mammals (squirrel, Raccoon) and birds (owls, Black-capped Chickadee), There is an abundant hard mast from the maple, Tuliptree, Aspen, hemlock, pine, Witchhazel, birch, and ash. Soft mast is available from the grape, Red Elderberry, Sassafras, Blackgum, Partridgeberry, and blueberry. A perennial stream, Kettle Creek, runs through the section near the River of Rocks. Dead and down woody material which supports fungi and insects is also fairly abundant. A high deer population occurs here as evidenced by a lack of hardwood regeneration and heavy browse on the evergreen shrubs and understory trees.

Management Unit 5 is a 25 to 50 years old Sycamore - River Birch - Box Elder Floodplain Forest (formerly called "Floodplain Forest") which lies in a thin (25 to 50 feet) band along the Little Schuylkill River. Together Red Maple and River Birch dominate the unit with Sycamore, Grey Birch, Red Ash, and beech also present. There

are a variety of trees and shrubs in a fairly dense understory within this unit. Spicebush and Red Maple are most abundant followed by Witchhazel, oaks (scrub, red, and white), Mountain Laurel, White Pine, hemlock, Pignut Hickory, along with invasive shrubs (Multiflora Rose, Shrub Honeysuckle). Although spotty, this unit has the most tree regeneration in the Sanctuary, including most of the advanced (over 2' in height) hardwood regeneration. Species include White and Red Oak, Black Walnut, White Pine, and hemlock. Dense groundcover of ferns and forbs, including scattered patches of Japanese Knotweed (a serious invasive of riparian areas) and Japanese Stiltgrass.

Important native wildlife benefits include access to a dependable water source for terrestrial animals, deciduous and evergreen forest cover for waterfowl, piscivorous birds (herons, Belted Kingfisher) and songbirds, and feeding habitat for migrant raptors and songbirds. There is considerable hard mast from the maple, pine, and Witchhazel which will increase significantly as the forest matures. Soft mast is available from the Spicebush, Shrub Honeysuckle, Multiflora Rose, and sumac. Cavity sites and dead woody materials are limited due to the young age of the forest. The forest is the area least impacted by deer, because it is located between the river and the railroad tracks.

Management Unit 6 is a Dry Oak-Heath Woodland (formerly Mesic Scrub Oak-Heath Barrens (Shrub-Savannah) on the ridgetop south of Hawk Mountain Road which has remained open since it was cleared through logging and fires. Deer browse and competition from the dense heath shrub layer have helped to keep it open. This area is dominated by Low-bush Blueberry, Hay-scented Fern, and Sweetfern with scattered canopy trees. Chestnut Oak and Red Maple constitute the majority of the tree species, followed by White Oak and Blackgum. This woodland diversifies the wildlife habitat of the Sanctuary, providing herbaceous and deciduous shrub cover, nesting sites, and food for small mammals, butterflies, and birds (e.g. Eastern Towhee, Common Yellowthroat).

Management Unit 7 is Successional Land composed of six fields that were abandoned 10 to 15 years ago. The five fields on the ridge top to the south of the Visitor Center were created in 1968 as wildlife "food plots." These areas are dominated by forbs, Hay-scented Fern, Japanese Stiltgrass, and ericaceous shrubs (Sweetfern, Sheep's Laurel). Also present are invasive shrubs (Multiflora Rose, Barberry, Shrub Honeysuckle) and scattered trees (Pitch Pine, Blackgum, oak, Ailanthus). The deer population, exposed conditions, and poor soils combine to hinder native tree regeneration.

Issues & Rationale

Closed-canopy Old Growth Forest

Hawk Mountain Sanctuary is part of one of the largest blocks of contiguous forest in southeastern Pennsylvania. Even so, much of the surrounding forest is under threat of disturbance by timber harvest, development, and recreational activities. This

disturbance of the regional forest may continue due to high timber prices and the pressure to implement multiple use management regimes on public lands that include regular or increased timber harvests and increased access for recreation. Except for very steep or rocky areas, State Forest land is generally cut at a rate of one percent each year to encourage the regeneration of oak and other valuable early and mid-successional species. State Gamelands are managed to maintain the successional stages that are preferred by game species such as deer, grouse, and turkey.

The continual disturbance of the surrounding forest increases the importance of the Sanctuary's closed-canopy forest as habitat for forest interior birds, mammals and amphibians. Recent Sanctuary surveys have confirmed its importance for forest interior birds, especially neotropical migrants (birds that winter in the tropics). Eight of the ten most abundant species found within the Sanctuary are in this group which was not as highly ranked in forest surveys across the state. Likewise, bird species that prefer open and disturbed habitat (Common Yellowthroat, Indigo Bunting, Eastern Towhee, Eastern Phoebe, Gray Catbird, Mourning Dove, Northern Cardinal, Chipping Sparrow, and House Wren) were found in relatively smaller numbers on the Sanctuary than they are in other forest surveys within the state and were confined mostly to areas of disturbance or human use such as boulder and field openings, around buildings, and along roads. Brown-headed Cowbirds, a nest parasite, were significantly more abundant in areas of human disturbance, including along all trails.

The relatively hands-off compensatory management used by the Sanctuary will allow for the perpetuation of contiguous forest and the future development of old growth forest which will provide unique wildlife habitat to the region, particularly for forest interior species that require closed canopy forest habitat. Lack of cutting within the Sanctuary will result in canopy dominance by more shade tolerant species such as White Pine, Blackgum, and Eastern Hemlock as opposed to oak and ash which favor periodic disturbance. This offers the opportunity for joint research on the effects of different management regimes on wildlife populations.

This comparison, if undertaken, will also provide insight into ecological changes in the regional forest after other drastic changes (oak dominance, elimination of the American Chestnut, decline of beech and hemlock) brought about both directly (timber cutting) and indirectly (fire, introduced pests and diseases) by human activities over the past 150 years. The current land management goals of state agencies and the high economic value of oak will essentially limit forest succession on adjacent public lands to the mid-successional hardwood species that dominate today's forests.

Recommendations:

Because of the extent and significance of the lands under their control, the Sanctuary should continue to develop a close working relationship with the Pennsylvania Game Commission and Bureau of Forestry. Cooperative research could be pursued and

research results used to evaluate and guide future management decisions and activities within the agencies. Such changes might assist in protecting the Sanctuary forest integrity from the impacts caused by more intensive management along common borders (e.g. the 20-acre clearcut along the southwest border in 1998) the effects (increase in Brown-headed Cowbirds, proliferation of invasive plants) of which extend into the Sanctuary. In addition, cooperation among the three parties is essential to address effectively the forest issues that follow.

In general, further disturbance to the Sanctuary in the form of trails, roads and buildings outside of the areas designated for such uses should be minimized to protect the integrity of the interior forest habitat.

Forest Regeneration

The perpetuation of any woodland community depends upon the ongoing establishment of tree and shrub regeneration (seedlings and saplings) that are sufficient in number to occupy the gaps that are created by natural or human disturbance to the various structural layers (canopy, understory, shrub) within these plant communities. Within most of the Sanctuary forest there is a clear deficiency of native tree and shrub regeneration. Canopy tree regeneration needed to perpetuate a structurally diverse and species rich closed-canopy forest that will meet the wildlife goals of the Sanctuary is lacking. In order to perpetuate the existing woodlands it will be necessary to aggressively address the regeneration problem as soon as possible. If allowed to reach a crisis level (probably within the next few decades or after the next high wind event), the task of restoration will become formidable. And, valuable ecological and human benefits will be lost for many decades.

Deer Abundance:

Numerous factors contribute to regeneration failures. Evidence from throughout Pennsylvania indicates that the current high population of white-tailed deer is playing a major role in reducing the survival of native flora. Deer reduce tree and shrub regeneration through excessive browsing and by consuming tree seeds (particularly acorns) and other herbaceous plants. It is believed that over 100 species of native wildflowers have become extirpated in Pennsylvania as a result of deer browse. The resulting lack of cover, food, and structural diversity within our forests has undoubtedly reduced populations of small mammal and bird species.

Research suggests that our native forests evolved with deer densities of 10 deer per square mile. At the turn of the century, white-tailed deer were nearly extirpated from many of the eastern states through over-harvesting and deforestation. By instituting game laws, state agencies rebuilt the deer population. Statewide the deer population now exceeds 20 deer per forested square mile and in some southeastern counties may

exceed 30 deer per forested square mile. Twenty per square mile is considered the appropriate maximum level to allow tree and shrub regeneration.

The forest at HMS shows clear evidence of a high deer population including a distinct browse line on trees and shrubs, spotty (and browsed) wildflower populations, the proliferation of Hay-scented Fern, and sparse tree and shrub regeneration. In order to better understand the current deer population and its role in regeneration failure further monitoring and research may be necessary. Possible approaches to this challenging management issue are presented in the Appendix.

Recommendations:

Given that the forest management goal of HMS is focused on maintaining natural ecological function-health, the Sanctuary should maintain the deer population at a density close to the pre-European settlement level of 10 per forested square mile. To achieve that goal, the 2400-forested acres (4 square miles) within Sanctuary should be supporting only 40 deer.

1. **Consider a Survey of Deer.** The first step will be to gain a reasonable estimate of the current deer densities throughout the year. (See Appendix for details).

2. **Consider Additional Deer Exclosures.** It also will be helpful to visually demonstrate the extent of vegetation damage within the Sanctuary to reveal the need for reducing the deer density to members and the general public. Because deer damage is so widespread throughout the region it is often difficult to appreciate the level of impact, as there is so little healthy forest available for comparison. Consider installing one or more additional 8-foot high 10 x 10 meter deer exclosures at a few visible locations within the sanctuary which will provide at least a small area of untouched forest with which to calibrate their perspective. The staff should increase monitoring of exclosures and measure the difference in tree and shrub regeneration inside and outside to quantify deer impact.

3. **Reduce Deer Population.** In order to achieve its management goals, the Sanctuary will need to determine the appropriate manner to reduce deer impact. Control methods can be grouped into two categories, those that reduce the deer population of a property and those that restrict deer access. Non-control or letting nature take its course is employed on most properties because of economical and logistical constraints.

   The most frequently used and most effective reduction method is culling. Populations can also be reduced through contraception and trap and transfer. Contraception has proven effective in arresting population growth under limited circumstances. Trapping or darting deer, and then moving them to another location

are expensive and difficult to use and survival rates of transported deer have been discouraging.

Restriction methods which are viable and cost effective in certain situations include fencing and deer repellents. Fencing is effective for small areas. It should be remembered that the exclosure need not be deer free, but rather exclude enough deer to reduce damage. Repellents also can be effective in small areas where one only needs to reduce the browse damage to tolerable limits .

Most restrictive methods of control, while effective at hindering deer access to vegetation, are costly and simply move the problem to neighboring properties. Numerous studies have proven that removing deer through controlled hunts is the most practical and effective means for addressing the problem.

Given the size and ruggedness of the Sanctuary the only practical option for reducing deer impact is through a controlled culling program. The Sanctuary currently distributes approximately 250 hunting permits each year to local residents. Besides restricted access to certain areas there is minimal regulation of the hunt and coordination between hunters. A reduction in deer impact will be best achieved through an increase in the effectiveness of the existing hunting program (see Appendix for some possible options).

If the hunting program is effective in reducing deer numbers and alleviating the adverse effects on vegetation, adjustments will need to be made to culling rates in order to meet deer density goals. At that point consideration could be given to the reintroduction of plant species, particularly wildflowers that have been reduced or extirpated due to deer impact.

Invasive Exotic Vegetation

Another factor that reduces forest regeneration is competition from invasive plant species. If left unchecked, invasives can rapidly usurp growing space from desirable native species and compromise the integrity and ecological succession of natural areas. Through their displacement of native vegetation, exotic invasives homogenize the structure and food resources of a site, thereby reducing its habitat value for native fauna, particularly songbirds.

Historical land use dominated by agriculture and logging, coupled with recent sprawl development, has effectively disturbed native vegetation in the region and, through its division and clearing of land parcels, added countless miles of the edge habitat that is highly favorable to the proliferation of invasives. The misguided promotion of several exotic species for wildlife food, erosion and livestock control, and nearby horticultural

plantings have provided enough seed sources for regional dispersal of numerous invasive species.

Invasive vegetation is rapidly spreading through the Sanctuary along roads, trails, and storm water channels and within woodland gaps. The Relative Forest Health Map (19A) shows areas impacted by invasive plants, including tree, shrub, vine, and herbaceous species. Together with a lack of native regeneration from deer and other factors, invasive plants seriously decrease the ecological integrity of the forest and jeopardize the perpetuation of a diverse native forest. As gaps are created by wind throws, pests, and pathogens, invasive vegetation may colonize these areas to the detriment of native species. Invasives control will be needed to assure the perpetuation of native plant communities within the Sanctuary.

OCCURRENCE OF INVASIVE SPECIES BY MANAGEMENT UNIT

	Management Units						
Plants	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Japanese Barberry	♦	♦					♦
Ailanthus	♦	♦					♦
Hay-scented Fern*	♦	♦		♦		♦	
Japanese Stiltgrass	♦	♦	♦	♦	♦		♦
Multiflora Rose		♦			♦		♦
Shrub Honeysuckle		♦			♦		♦
Grape*		♦	♦	♦			
Japanese Knotweed					♦		

* Native Species

Recommendations:

There are many techniques available for controlling invasive vegetation (see Appendix). These options are not mutually exclusive, and other options may become available in the future. Usually the control of invasives on any given site requires a combination of two or more methods. The exact mixture and timing will be different among sites. What will be common to all sites is the fact that the prolific nature of invasive plants mandates periodic monitoring and control to prevent a major disruption to the aesthetics and ecology of the impacted site. The following actions should be instituted at Hawk Mountain as staff and resources permit.

1. **Establish an invasive plant monitoring and control program (See Appendix).** Given that exotic invasive plants will be a long-term problem within the region, it is critical that the Sanctuary initiates a monitoring and control program to identify and quickly address any infestation before it significantly impacts native plant

communities. The first task will be to complete an inventory of invasives currently within the Sanctuary, using GPS data to establish a baseline from which to monitor the spread or decrease of each species and to prioritize control projects.

2. **Minimize disturbance.** Because exotic invasives are primarily spreading from areas of human disturbance or severe deer browse, future disturbance should be minimized. This includes minimizing the expansion of the trail system and parking lots. The Sanctuary should terminate use of the open area (part of Unit 7) at the top of the ridge south of the Visitor's Center as a material storage and dumpsite. Needed materials should be located closer to the building complex (already developed areas); unwanted material should be dispersed close to its origin (down trees) or disposed of off-site (masonry).

3. **Minimize material inputs to Sanctuary.** Caution should be taken when importing bulk materials for construction and maintenance of the facilities and roads that it does not originate from an area known to harbor invasive species. Material such as fill soil and mulch can contain seeds and viable stems of invasive plants. If possible, design construction projects to minimize the need for imported materials and coordinate construction projects to use excess on-site materials from one project as material for another. Any area that receives imported material should be monitored to quickly identify (and address) the establishment of any invasive species.

4. **Monitor Hawk Mountain Road.** Special attention should be given to Hawk Mountain Road along which several species are established and from which a few have spread into the Sanctuary along storm water runoff channels. Work closely with the township road engineers to reduce the amount of impact from runoff into the Sanctuary.

5. **Set Priorities for Invasive Plant Management.** In general, the future rate of woodland degradation is inversely proportional to the current level of degradation. When a single tree within a healthy, closed canopy forest is toppled by invasive vines the resulting gap (loss of growing space to desirable species) has a major impact on the surrounding trees — providing ideal conditions for the rapid establishment and spread of invasives within the gap to adjacent trees. On the other hand, the loss of a single tree in a heavily degraded, open canopy area creates relatively little change in the amount of growing space controlled by invasives. The first goal of restoration should be to protect that portion of the community that controls the most growing space, which, in the case of a woodland, will be the canopy trees.

   The focus of initial restoration efforts, therefore, should be to halt the degradation within the healthiest areas, moving then to the moderately impacted areas, and so on to the most degraded areas. Detailed suggestions on priorities are available in the Appendix.

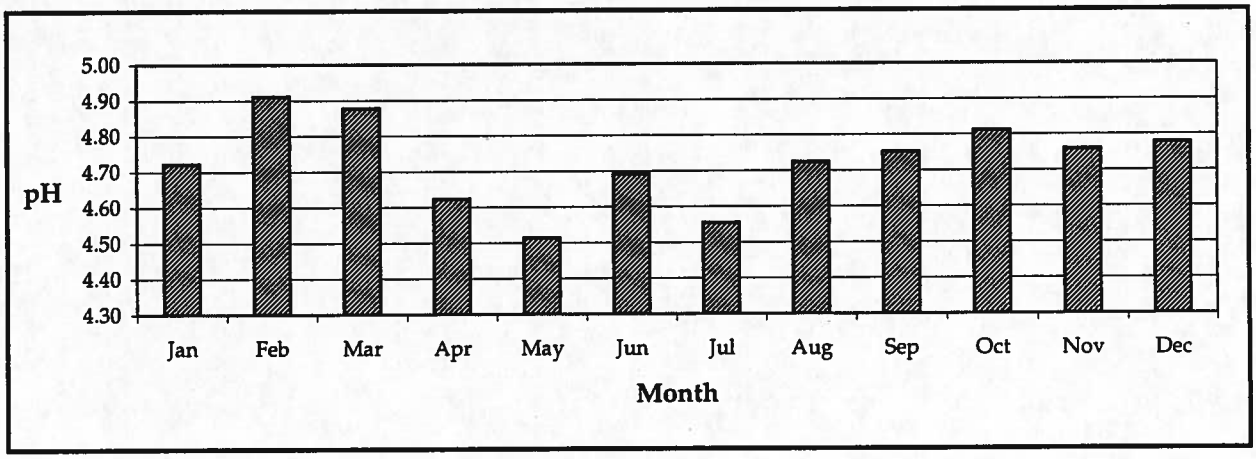
Acid Precipitation

Another major factor affecting regeneration in the region is acid precipitation. Although forest soils naturally acidify over time (centuries) through the uptake of base cations by trees it appears that atmospheric emissions from human activities over the past century have significantly accelerated that process. There is growing evidence that forest soils are significantly more acidic than at the turn of the century when existing forests were established and that high acidity has significant negative impacts on plant growth.

High acidity affects plant growth through its modification of soil chemistry. Acid precipitation increases the dissolution of aluminum from rocks which in turn both replaces calcium, magnesium, and potassium cations (critical for plant growth) and concentrates in the lower soil profile. Eventually, aluminum concentrations reach levels that are toxic to plant tissue. Soils that are high in organic matter can buffer the effects of aluminum, but highly weathered soils such as those over much of HMS are less effective.

In response to acidification, trees concentrate their roots closer to the surface, thereby making them more prone to wind throw and more susceptible to drought and frost. Acidity affects tree regeneration by restricting seedling root growth and limiting the availability of essential plant nutrients. This reduces their ability to respond with new growth after deer or insect herbivory.

1995 TO 1999 AVERAGE MONTHLY PH
HAWK MOUNTAIN SANCTUARY



Soil acidification also impacts forest communities by favoring species that are less sensitive to its effects. In the short term this means a shift in hardwoods from red oak and sugar maple that are highly susceptible to acidification to more tolerant species like

red and striped maple. Eventually it will result in a shift to conifer species which require fewer nutrients because they do not lose their leaves on an annual basis like broad-leaved deciduous trees.

Recommendation:

Because of the high elevation and thin, weathered soils over much of HMS, tree regeneration is probably impacted to some degree by acid precipitation. The Sanctuary should try to ascertain the level of impact on vegetation growth and regeneration from acid precipitation to better guide its restoration efforts. A review of current literature on such topics should be conducted. Long-term Sanctuary rainfall data on pH and volume (collected since 1985) should be used in conjunction with additional soil and water sampling to evaluate extent and trend in acidification. Rainfall should continue to be monitored for acidity volume and impacts on the forest should be assessed periodically. Lime applications used in conjunction with deer exclosures could be considered to determine how regeneration may be impacted by acid precipitation.

Hazard Trees

The Sanctuary has an obligation to make a reasonable effort to protect the safety of the general public, preserve users, and staff within the Sanctuary. Hazard trees in high use areas (public roads, parking lots, lookouts) pose a threat to that safety. While the goal of the Sanctuary is to promote biodiversity through the maintenance of a closed-canopy forest and snags and cavity trees add to biodiversity, the Sanctuary needs to compromise that goal to remove obvious hazards.

Recommendation:

The Sanctuary should develop a hazard tree policy and program which they believe is a reasonable effort to protect public, visitors, and staff safety, particularly in high-risk areas. The program should include training of the staff in the identification and safe removal of hazard trees.

4
Special Habitat Areas & Unique Fauna

Goals

- Special habitats, communities, and species add diversity and vigor to the forest ecosystem and should be protected.
- Protect and manage each site and species, as appropriate, and as an integral part of a diverse forest system.

Management Objectives

1. **Special Habitat Steward.** Assign responsibility to specific staff for special habitat stewardship, function and protection.

2. **Develop Protection Strategies.** Develop and design strategies to protect each special habitat and fauna area.

3. **Implement Protection Strategies.** Create a schedule for implementing protection strategies for each special habitat and fauna area within a one to ten year time frame, recognizing that in many cases the best strategy will be to do nothing or to simply avoid inadvertent damage.

4. **Trail Rerouting and Scheduling.** Reroute trails as needed and schedule use so that trail use does not negatively impact special habitat areas, communities, or species, such as:

   a. Consider closing the River of Rocks trail during bird nesting times within the low elevation forest, and monitor impacts of closure.

   b. Reroute Skyline Trail around selected rocky outcroppings along the top of the ridge northeast of North Lookout, which are important reptile basking and vulture nesting sites.

5. **Monitoring by Staff.** Set up a monitoring program using HMS staff to assess the natural function, health and trajectory of selected "special habitat" populations

and communities, including salamanders, vernal pools, the Little Schuylkill riparian zone and the hemlock groves.

6. **Monitoring by Others.** Develop monitoring strategies, using partners and/or outside experts, for other special habitats, communities or species possibly including Knothole Moss, New Jersey Tea Moth, lichens, and Timber Rattlesnakes.

7. **Woodrat Reintroduction.** Investigate reintroducing woodrats to some historically occupied sites by partnering with appropriate outside experts.

8. **Understand Human Impacts.** Assess human impacts on special habitat areas and respond appropriately, e.g., by moving trails, limiting access and other measures that may be necessary for long-term protection.

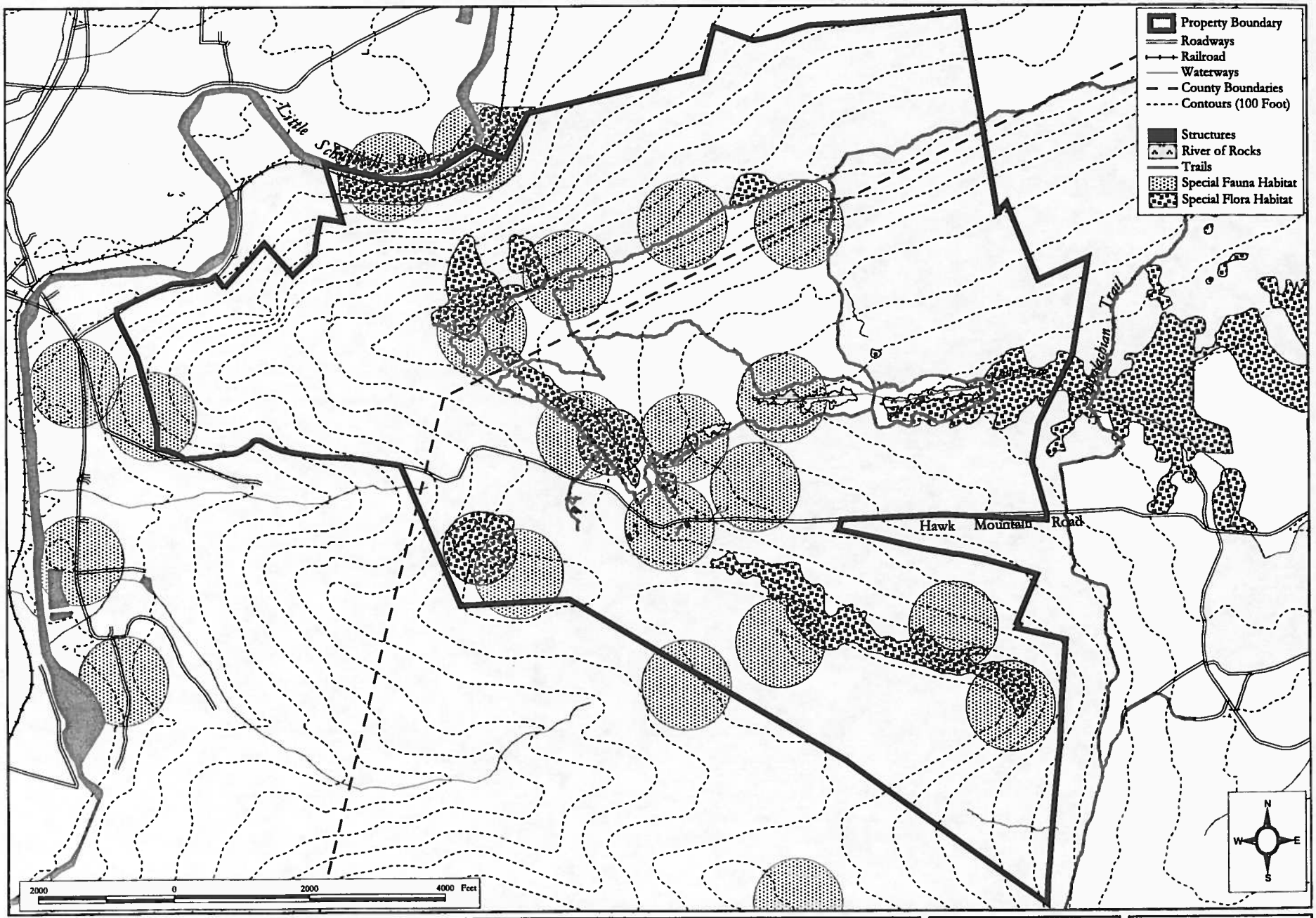
Background & Recommendations

The recent biological inventory of HMS and other long-term records revealed a number of special plant communities and unique animals. The Appendix contains a list of all biota found within the Sanctuary. Twenty-two new plant species were discovered during Management Plan follow-up surveys along with many new butterflies and moths.

The issues related to the protection and enhancement of plant communities, habitats, and species that should receive special consideration within the Sanctuary's land management plans are discussed below and specific action items bulleted. The Special Habitat Areas map (Map 23) shows the location of associated areas within the Sanctuary. Any activities or new uses within these areas should be cleared with the Sanctuary Naturalist to ensure that the species of concern is not adversely impacted. At the end of this Section Four is a list of additional areas or biota that should be receive attention in future biological surveys.

Conifer (Hemlock) Groves

Two of the vegetation management units (3 and 4) contain a significant conifer component (primarily hemlock with some white pine) in the canopy (Map 20). The two sections of conifer forest that make up Unit 3 are rugged and beautiful areas within the Sanctuary characterized by steep, rocky, north facing slopes which provide a cool, moist environment for the development of this more northern forest community. The hemlock canopy shades a dense understory of Rhododendron and a green carpet of ferns, mosses, and lichens. Within the low slope forest of Unit 4 hemlocks create periodic evergreen pockets.



Hawk Mountain Sanctuary
Schuylkill and Berks Counties, PA

MAP 23

Special Habitat Areas

DCR 3/29/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, contours, River of Rocks, structures, and habitat areas from Professor Robert Martin, Kutztown University

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Biological surveys within these areas reveal their importance to both plant and animals. They are particularly important as wintering and breeding areas for birds. In fact, data suggested that the presence of Eastern Hemlock was the single most important factor in winter bird distribution at HMS. The section of Unit 4 below the River of Rocks appears to be particularly crucial wintering habitat for Golden-crowned Kinglets, Brown Creeper, and other wintering birds. A breeding bird survey showed that Black-and-white Warbler and Black-throated Green Warbler were found predominately near hemlock stands across the Sanctuary.

Recommendations:

1. **Woolly Adelgid.** Introduced to this country 40 years ago this aphid-like insect is infesting hemlocks throughout eastern Pennsylvania and other northeastern states. Infestation is indicated by cottony white egg masses that are deposited in early summer on the underside of the needles. The nymphs hatch in the spring and stress the tree by sucking sap from the needles. While healthy trees can survive mild to moderate infestation, the hemlocks within the Sanctuary were already under stress from several droughts over the last decade the effects of which are exacerbated by shallow rooting resulting from the thin, rocky soils and potential effects of acid precipitation. This stress has no doubt reduced the ability of the hemlocks to tolerate the adelgid.

Infestation levels vary widely between the hemlock groves of the Sanctuary. Those within Unit 2 and 4 (which are on lower slopes impacted less by drought) show light to moderate impact; some trees on the high slopes of Unit 3 (particularly in the section to the north of North Lookout) appear to be dying from the effects of drought and adelgid.

Unfortunately, the only effective treatment for the adelgid is spraying with horticultural oil. This would be highly impractical within the Sanctuary due to poor accessibility of affected areas and the size of the canopy trees. In some cases public agencies are removing infected trees from forests; again this would be impractical and destructive to surrounding vegetation. Several biological solutions, both native and exotic insects and fungi, are being tested as future control measures.

- Monitor the distribution of infestation within the Sanctuary using GPS mapping
- Consider possible biological controls as they are developed

2. **Sparse Regeneration.** Like most of the Sanctuary the hemlock groves have sparse regeneration. This is of particular importance in these areas due to the effects of the adelgid on canopy trees.

- Determine deer density level and reduce to an appropriate level (see above) to allow for tree regeneration to replace dead canopy trees

3. **Human Disturbance.** Currently Unit 3 only is used for research. Unit 4 receives some use by hikers of the River of Rocks trail and from unpermitted ingress from the Appalachian Trail property, which abuts the Sanctuary to the east. While these areas are very attractive destinations, encouraging increased use would be to the detriment of both the plant and animal species association with this special forest community. Trampling of the ground cover, and the further introduction of invasives is likely. Negative impacts associated with the disturbance of various sensitive bird species include disruption in foraging patterns and alterations in normal social behavior. A number of studies have documented that disturbance of breeding birds by humans may result in flushing of parents from nests; abandonment of both eggs and chicks by parents; thermal stress on eggs and chicks; and flight of chicks from the nest. In addition, disturbance of wintering birds may increase the demand on scarce energy resources, thereby reducing the thermal value of the cover.

- Minimize human access. In general, these areas should only be used for research or limited education. In the section of Unit 4 where a portion of the River of Rocks Trail already exists, consideration should be given to closing that section during May and June (and possibly winter) to minimize human impact to songbird populations.
- Work with the Appalachian Trail managers (on whose property the Unit 4 forest continues) to make them aware of the significance of this forest and to agree upon a common management regime both to discourage unwarranted access to the Sanctuary and to protect and enhance this special community.

Ridgetop Communities

The ridgetop forest to the south of the Visitor Center is broken by a string of openings (Units 6 and 7) between Owl's Head and the Cobble. The largest opening near the Cobble is an Oak - Heath Woodland; the remaining openings are successional areas dominated by herbaceous and ericaceous shrub species.

The biological surveys drew attention to these areas as sites of high butterfly activity. The Berks County Natural Areas Inventory conducted by The Nature Conservancy found three rare moths within similar woodland on nearby game lands.

Recommendations:

1. **Need for Additional Information.** Survey results indicate that a more detailed study of moth and butterfly species is warranted in these areas. As these barrens comprise the majority of vegetated open area within the Sanctuary, it is important to know their ecological significance.

- Continue detailed invertebrate survey, particularly moths and butterflies.

Riparian Forest

A thin strip of riparian forest isolated along the Little Schuylkill River is probably the management unit with the best health and most diverse flora (particularly herbaceous species) within the Sanctuary. It's location on a relatively steep bank between the river and railroad tracks appear to deter frequent access by deer. To maintain its current condition and its benefits to wildlife and water quality (shading, nutrient input) particular attention should be given to the management of this area.

Recommendations:

1. Invasive plants. Several species of invasive plants are present and beginning to spread within this area including Japanese Knotweed, an aggressive colonizer of riparian areas.

- Remove invasive species, particularly the Japanese Knotweed, before they have a significant impact on the herbaceous flora. No herbicides or pesticides should be used in this riparian area (see Appendix).

2. Human disturbance. The railroad tracks that run parallel to the river create a barrier to turtles trying to access terrestrial habitat. During plant surveys of this unit, two turtles were observed unsuccessfully trying to cross the tracks. Currently, no studies exist regarding the effects of such barriers on turtles. Also, this area is used by the fishing public to access the Little Schuylkill. While this use has not seriously impacted the site, there is a worn trail. Such use can degrade the riparian forest through soil disturbance and compaction, the introduction of invasive species, and the trampling of herbaceous plants.

- Investigate the impact of railroad tracks on turtle migration and other wildlife.
- Consider tunnels or other means of turtle crossing.
- Monitor use and impacts by the fishing public (although this will be difficult given the remoteness of the site) if it becomes more problematic.

Wetlands

There are several wetland sites within the Sanctuary. They include ephemeral pools in Management Units 1 and 4, and areas adjacent to seeps and springs in Unit 2. Wetlands increase biodiversity both by supporting different plant species and communities, and by providing important wildlife benefits (water source for all wildlife, breeding sites for insects and amphibians).

Recommendations:

1. Identification of wetlands. Although most of the wetlands have been mapped during the inventory, smaller more remote sites may have been missed. Because of their importance efforts should be made to survey for additional wetlands as well as springs within the Sanctuary and map any new ones found.

- Locate all springs and ephemeral pools using GPS and as possible annually monitor water levels and wildlife activity.

2. Disturbance. Given their relatively small size and saturated soils, Sanctuary wetlands are particularly sensitive to disturbance, both from human and wildlife trampling. Disturbance can cause mortality of amphibians directly through crushing or indirectly through siltation of the water (which affects egg hatching). Disturbance of leaf litter around wetlands creates hot and dry areas that interrupt amphibian migration routes. It is important to avoid disturbance of these areas even when they are dry. Currently, the River of Rocks Trail passes close to a seep wetlands within Management Unit 2.

- Create a buffer of 50 feet or more designated as a no disturbance zone around all wetlands.
- Reroute existing trails outside the buffer zone.
- Monitor wetlands for disturbance; consider enlarging the buffer zone and modifying trail layout if disturbance continues.
- Minimize human access. In general, current HMS wetland areas should only be accessed for research, monitoring, or limited education purposes.

Mosses & Liverworts

A total of 66 bryophytes were identified on Hawk Mountain including 48 moss species and 18 liverworts. Six moss species are listed as being rare or infrequently collected in Pennsylvania. Most were found only in areas which have restricted public access.

The Knothole Moss, is also of uncommon occurrence throughout eastern North America. As its common name denotes it is typically found on moist, rotten bark in the knotholes of trees. Two small populations of this moss were located within the Sanctuary during the inventory. One was on a fallen log along the River of Rocks Trail, and the second was in the knothole of a live tree growing on non-public rocky outcropping.

Recommendations:

1. Human Disturbance. Human access increases the trampling of ground vegetation in an area. Studies to date have shown a negative correlation between human activity and the distribution of rare mosses and liverworts within the Sanctuary.

- Minimize human access. Access to restricted areas should continue to be minimized to prevent disturbance of these rare species. Some rocky areas should always be kept undisturbed to allow healthy populations to thrive.

2. Knothole Moss. The occurrence of the Knothole Moss in a living tree on rocky outcropping suggests that this non-public outcropping should not be pruned as per the recommendation given below under "Rattlesnake Basking Sites." It also mandates that before older trees are pruned or cut at outcroppings or other sites, that staff should survey each tree for this rare species. The occurrence of a rare moss needs to temper that recommendation.

- Keep older trees on lookouts where possible. Train staff to identify the Knothole Moss and require them to survey any potential host tree before it is removed for any reason.

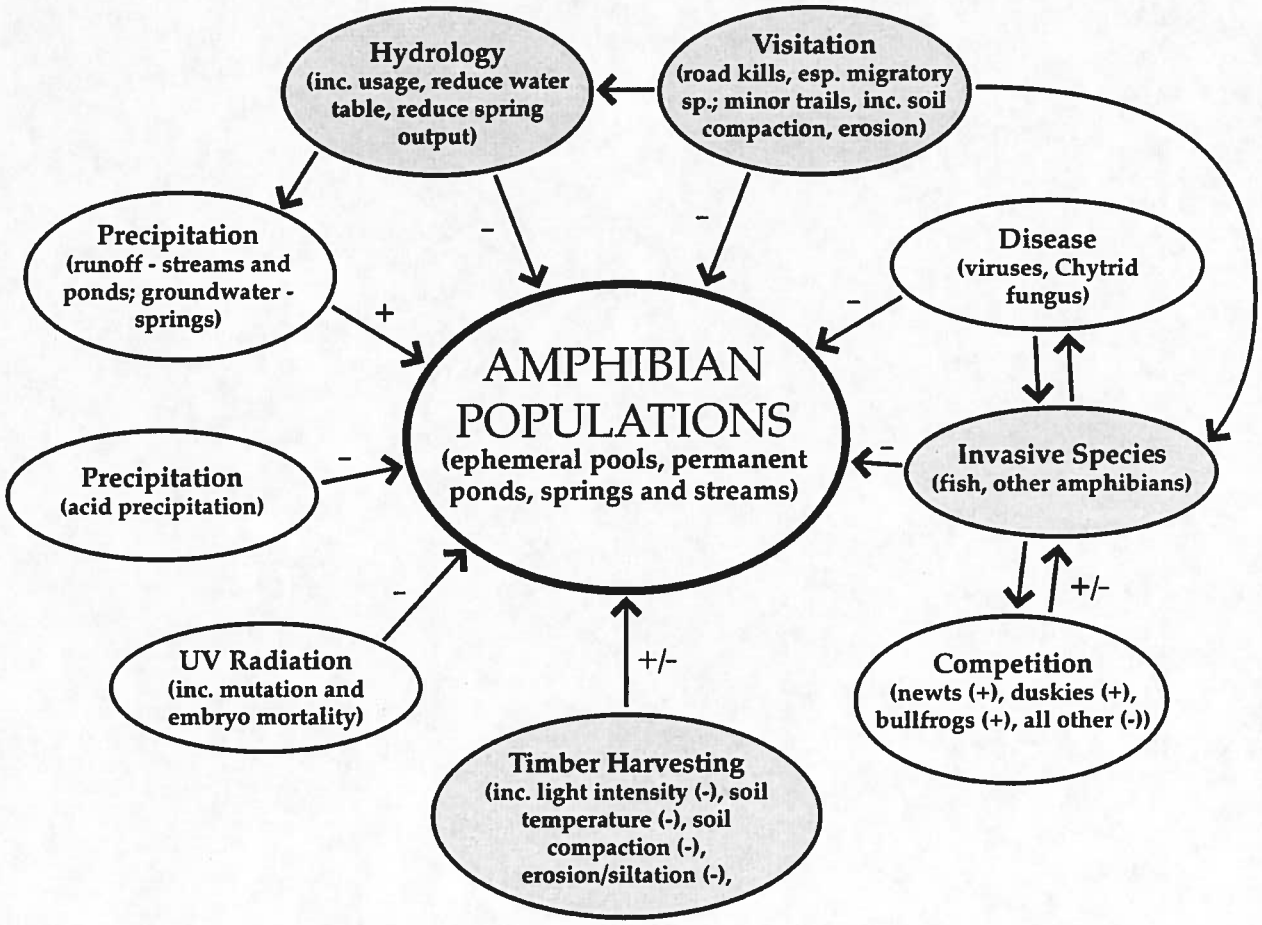
Herpetofauna

The diversity of species and densities of amphibians found at Hawk Mountain Sanctuary is high and recent surveys demonstrated substantial populations of some species within the site. Nearly half of the species known from southeastern Pennsylvania occur here. A total of seventeen amphibian species (ten salamanders, seven frogs) were cataloged during recent surveys. A large population of the Marbled Salamander, which is of infrequent occurrence throughout Pennsylvania and not previously known in Schuylkill County, was located. Critical habitat for amphibians includes Schaumboch Pond (all of the frogs and most of the salamanders found within the Sanctuary are found in or around it), the ephemeral pools between the Cobble and Owl's Head, the Visitor Center two ponds, the lower stretch of Kettle Creek within Unit 4, and wetlands along the Little Schuylkill

Although aquatic habitats are limited on the Sanctuary, where there is sufficient water, amphibian communities are as rich and diverse as anywhere in the region. The high populations of some species (Red-spotted Newts, Green Frogs, Pickerel Frogs) suggests that the Sanctuary may act as a source for dispersal of some species into the surrounding farmlands. Lack of calling activity at the farm ponds, marshes, and streams in the valley east of the Sanctuary during the time of the survey by Dr. George Cline indicates that the Sanctuary may indeed be a refuge for many species.

Amphibian Model

The Amphibian Model illustrates the positive and negative factors that impact amphibians within the Sanctuary. Factors that could be managed by the Sanctuary are shaded.



Reptiles are represented by five turtles, 12 species of snakes, and one lizard, the Five-lined Skink. Two of the snakes, the Timber Rattlesnake and Eastern Hognose Snake are listed as Pennsylvania Species of Special Concern (S3, PC) - species which could become endangered or threatened in the future because of their special habitat requirements and susceptibility to human disturbance. Rattlesnakes utilize the rock outcrops and natural caves within the Sanctuary as basking and over wintering (hibernaculum) sites. Some of these sites are located near current public use areas (Skyline Trail).

Recommendations:

1. Monitoring. The richness and abundance of amphibian species within the Sanctuary and their possible importance to regional populations suggests that monitoring of these populations is needed to identify and address any negative impacts.

- Establish a long-term amphibian monitoring program.

2. Road Mortality: Roads can have significant impacts on amphibians either from direct contact with moving vehicles or from pollutants (tire dust, metals associated with steel-belted tires, brake dust, oil) in storm water runoff. Road survey results in 1998 suggest that mortality on individual nights can be high as many as 92.5% of total amphibians sighted were killed by cars. In spring 1997 and 1998, the numbers killed in a two-kilometer length of road numbered over 100 frogs or salamanders per night. The two areas showing concentrations of amphibians killed by cars were the section of Hawk Mountain Road near Schaumboch's Pond and the section of Hawk Mountain Road and Rockland Road that lies between the western end of the Sanctuary and breeding sites on the floodplain of the Little Schuylkill River. Mortality occurs mainly during rainy nights in spring (March and April) and late summer (August & September). Species (all frogs, Marbled, Spotted, Red-backed Salamanders, and Red-spotted Newts) that travel widely to breeding sites or have a highly terrestrial life cycle are more likely to meet this fate.

- Inform neighbors, particularly those along Rockland Road of the amphibian road kill issue and seek their cooperation in driving with caution during spring and late summer wet weather.
- Identify migratory pathways or patterns, if any, and determine their width. Consider construction of amphibian underpasses (or other crossing systems) in areas of high concentration that are less than 50 meters wide.
- Consider installing signs indicating areas and times of high amphibian activity along the roads.

3. Exposure to Ultraviolet Radiation: An increase in UV radiation caused by decreases in the ozone layer has been linked to increased mortality rates (UV-b is able to penetrate water and egg masses and increase mutation rates in developing embryos) in some amphibian populations.

- Consult with researchers studying UV-b radiation levels or possible effects on amphibians; consider monitoring, if needed, to provide a correlation between inputs and changes in amphibian populations.

4. Acid Precipitation: The effects of acid precipitation vary between amphibian species due to differences in physiology and time of breeding. Species such as Wood Frogs, Spring Peepers, and Spotted Salamanders that breed early in vernal pools fed by snowmelt are more susceptible.

- Monitor individual species populations and changes in soil and water acidity at breeding sites.

5. Breeding Site Availability. Because amphibians breed in water any changes in hydrology will significantly impact local amphibian populations. Although water resources are not abundant, all three types of amphibian breeding sites (permanent ponds, ephemeral pools, and springs and streams) occur in and around the site. Ephemeral (vernal) pools and springs are highly beneficial because they do not support fish and other aquatic predators that feed on amphibians and their eggs. The relative sparsity of breeding sites on the Sanctuary itself, however, concentrates large numbers of amphibians in a few breeding sites both on and off the Sanctuary, often necessitating migration over public roads (see Roads above).

Increased water usage by the Sanctuary or the development of private lands adjacent to the Sanctuary could potentially impact amphibian populations by lowering the ground water table, thereby lowering or eliminating springs and associated pools and ponds.

- Undertake a study of the hydrology of Hawk Mountain prior to any increase in water use to assess the potential impacts of increased use. If possible, determine which adjacent, off-site parcels, if developed, would have the greatest effect on Sanctuary water resources.
- Protect on-site ponds and groundwater levels.
- Seek to protect off-site pools when possible.
- Investigate the potential for developing ephemeral pools within the Sanctuary. This would not only increase local breeding sites, but also hopefully lower amphibian road mortality.
- Possibly regrade the interior road that leads to Owl's Head to eliminate deep ruts (which can trap amphibians); create ephemeral pools adjacent to the road. Consider closing the road during spring to prevent siltation of these pools.
- Locate all unmapped springs and ephemeral pools using GPS and monitor all wetlands for water levels, acidity, and amphibian activity.

6. Forest Management. Timber harvests generally have a negative impact on amphibians by increasing siltation of water bodies, increasing light intensity to the forest floor resulting in temperature increase and moisture loss, and by increasing soil compaction.

- Meet with the Pennsylvania Game Commission to share results of recent herpetological studies and to discuss their management of lands adjacent to HMS, particularly their lands on the northwest side of the Sanctuary.
- Promote protection of amphibian migration corridors.
- Maintain a closed-canopy forest by minimizing human disturbance, particularly around ephemeral pools.

7. Predators. Some species, including raccoons, opossum, and skunks, that are supported by human food and shelter can be effective predators of amphibians and reptiles and their eggs. Likewise, fish significantly reduce the value of permanent ponds to amphibians, as can certain amphibians. Within the Sanctuary, for example, there is a high population of Red-spotted Newts which will consume Wood Frog eggs and tadpoles.

- Discourage unnatural populations of "subsidized" mammalian predators by continuing to properly disposing of trash and preventing access to structures.
- Eliminate predator fish (Bluegills, bass) in permanent ponds through periodic seining.
- Continue to monitor Red-spotted Newt population and their effects on other amphibians; Monitor Wood Frogs and other amphibians and consider providing additional ephemeral pools to promote Wood Frogs.

8. Disease. Diseases caused by introduced viruses and fungi can seriously impact native amphibians and reptiles. Potential sources of these pathogens include release of captive animals and use of contaminated collecting equipment by researchers.

- Prohibit the release of any animals into the Sanctuary to assure that only appropriate native wildlife species in good health and similar genetic stock are released to protect both the safety of the animal and the health of the Sanctuary biota.
- Establish a policy and protocol for researchers to include sterilizing collecting equipment before use within the Sanctuary.
- Continue to prohibit visitors from bringing pets onto Sanctuary grounds (except for parking lot area when restrained on a leash).

9. Rattlesnake Basking Sites. Given that the Sanctuary forest will be managed to maintain a closed canopy, potential basking sites for snakes will be limited to natural openings (rock outcrops, boulder fields) and ephemeral openings created by wind events. It is, therefore, important to protect the habitat value of the relatively few permanently open, rocky sites within the Sanctuary.

- Minimize human disturbance (trails, outlook) to currently undeveloped rocky outcroppings, and reroute the Skyline Trail away from known basking sites where possible.
- The open rocky sites may be preserved and enhanced through the selective removal or judicious pruning of trees within or around the opening. Because of the discovery of the rare Knothole Moss (see Knothole Moss above) on a tree at the Cobble, however, appropriate examination of all trees needs to occur prior to removal. Care should also be taken not to remove any American Chestnut trees.

10. Disturbance of Hibernacula. Traditional hibernacula are always located in forested areas and may be used for decades or more. Even minor cutting around these sites can have drastic effects on their usefulness to snakes as over-wintering sites.

- Prohibit cutting, disturbance and trails within 100 meters or more of any hibernaculum.

Invertebrates

Two insect surveys have been conducted within the Sanctuary. A general survey by Rawlins et al. in 1998 reported 412 species of insects. Of these, 347 species were Lepidoptera (butterflies and moths). One New Jersey Tea Moth, *Apodrepanulatrix liberaria*, Pennsylvania Species of Special Concern, was found in the forest below Schaumboch Pond. A butterfly survey by Monroe in 1997 and 1998 cataloged 58 species of butterflies. A new species (Common Buckeye, *Junonia coenia)* was found in 2000, making a total of 59 species of butterflies.

Although Hawk Mountain consists almost entirely of mixed oak forest there is sufficient diversity of habitat (occasional openings from rock outcrops, past cutting or burning, road and building construction) and elevation range to support a variety of butterfly species. Rawlins found high diversity of Lepidoptera and non-Lepidoptera in the low elevation forest (Management Unit 4) below the River of Rocks, and Monroe discovered the highest diversity of butterflies within open, disturbed areas, although some species were found only in wooded areas. Rawlin's surveys focused on night-flying insects including moths, the diversity of which may have been enhanced by the habitat diversity in the lower elevation area. Monroe surveyed only butterflies, which feed heavily on nectar plants, thus higher diversity is expected in openings.

Recommendations:

1. Need for Additional Information. A more detailed study of moth and butterfly species is warranted for Hawk Mountain. Additional moth surveys are needed to fully understand the distribution, diversity, and abundance on the Sanctuary. Butterfly

surveys in a variety of Sanctuary forest types and areas should continue to determine if different species are dependent on different habitats or sites within the sanctuary.

- Continue to conduct detailed invertebrate surveys, particularly moths and butterflies, and other groups as possible.

2. Invasive Plants. Many butterfly species are restricted to one or two plant species that their larva can use as food. Invasive plants can impact butterfly populations by crowding out these food plants.

- Monitor and control invasive plants as needed (see Appendix).

3. Forest Disturbance. Several rare species (i.e. anglewings such as Compton's Tortoiseshell) require heavily wooded areas as territories and for hostplants. Human disturbance to the canopy and overabundance of deer can negatively impact these species.

- Maintain a closed-canopy forest.
- Reduce current deer populations (See Forest Stewardship).

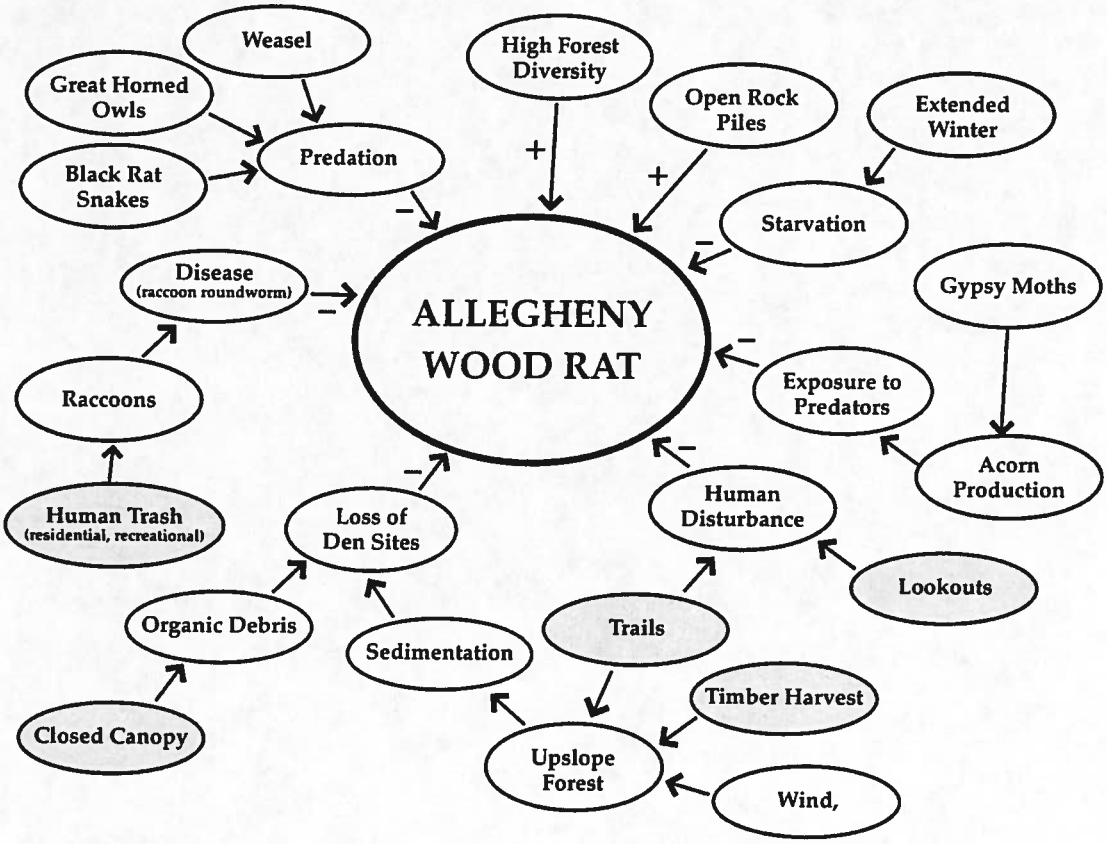
Mammals

Twenty-nine species of mammals have been found within the Sanctuary. Two new species, the Pygmy Shrew and Pine Vole, were found during the biological inventory survey in 1996 and 1997. The presence of the dime-sized Pygmy Shrew (the smallest mammal in North America) is of particular interest as the record extended the known range of this secretive species. Many large mammals, e.g. Black Bear, Gray and Red Fox, Coyote, and Porcupine, are found in relatively high number within the Sanctuary due to the abundant forest cover created by Hawk Mountain and adjacent public lands. The Bobcat, a Pennsylvania Species of Special Concern, also occurs on site (see Appendix).

Hawk Mountain offers promise for increasing the population of the Allegheny Woodrat, another Pennsylvania Species of Special Concern. Although it has not been found within the Sanctuary since 1975, there are several favorable reintroduction sites within the Sanctuary, including Owl's Head, Cobble, and River of Rocks and nearby Game Lands to the south.

Woodrat Model

The Woodrat Model (see diagram below) illustrates the positive and negative factors that can impact woodrats within the Sanctuary. (Factors that can be managed by Hawk Mountain are shaded.) Although no woodrats currently reside on the Sanctuary, it is a species that occurred here in the recent past. Providing positive factors and reducing negative factors where possible would be critical to the success of any reintroduction or recolonization effort.



Any reintroduction effort should be preceded by a detailed habitat suitability study locally. The positive factors that support woodrat populations are suitable habitat (open rock piles with large crevices) and a forest with high plant diversity to satisfy its varied diet. HMS has numerous rock piles and the potential to sustain a diverse forest. Woodrats are negatively impacted by disease (particularly Raccoon Roundworm), predation, starvation following severe winters, loss of appropriate den sites (specifically the filling rock crevices), and direct human disturbance.

On-site management can reduce several of these negative factors. First, discouraging Raccoons by properly disposing of refuge from residential structures and visitors will limit woodrat expose to Raccoon Roundworm. Maintaining forest function-health (see

Forest Function-Health Model) will provide a diverse plant diet. Selective cutting of trees around rock piles and proper trail layout will prevent organic debris and sedimentation from clogging up the rock crevices needed for den sites. Finally, limiting human use of prime den sites will minimize direct disturbance.

Recommendations:

1. Forest disturbance. Most of the uncommon mammals noted above use the Sanctuary because of its large contiguous forest and the relatively low human impact over much of the site.

- Minimize human disturbance to the forest to protect the viability of these species.

2. Allegheny Woodrat. This species prefers open rock piles with large crevices. Canopy closure over these sites could impact the success of any reintroduction effort. In addition, human activity around den sites can discourage use by woodrats.

- Selectively remove intruding trees around potential reintroduction sites to prevent accumulation of organic matter in crevices (see *Rattlesnake Basking Sites* and *Knothole Moss* above for cutting guidelines).
- Any reintroduction site should remain undisturbed by human activities (trail, lookout).

Tardigrades and Others

Many groups of organisms are poorly inventoried at Hawk Mountain, in Pennsylvania and beyond. For example, we may know exactly how many pairs of a certain bird species occurs on Hawk Mountain annually, but for many groups, particularly invertebrates, we do not even know how many species occur on-site, much less where and when they may occur. In this plan, we recognize the importance of continuing to inventory and map the biodiversity of Hawk Mountain and adapt our management as new information is collected. One uncommonly studied group was surveyed during the Sanctuary's resource inventory, the *Tardigrades*.

Tardigrades, commonly called water bears, are considered one of the "lesser-known phyla." Information about these organisms, including their distribution in Pennsylvania, is limited because of the difficulty in collecting and culturing them. Regardless of their specific habitat (marine, freshwater, terrestrial), all tardigrades are aquatic, since they require a film of water surrounding the body to be active. They feed by piercing the cells of bacteria, algae, plants (mosses, liverworts, and lichens) or animals (protozoans, rotifers, nematodes, and small invertebrates) and sucking out their contents. Some species feed on detritus. A survey of tardigrade populations within the

Sanctuary was conducted during two summers (1996 & 1997). A total of 38 tardigrades representing five species and four genera were found. The low numbers were probably the result of hot and dry conditions during the survey.

Recommendations:

1. Lack of Information. There is a general lack of information regarding many groups of organisms and their ecological role and significance.

- Continue surveys of tardigrades within the Sanctuary.
- Encourage additional surveys by outside experts for other forest communities, including worms and nematodes, spiders, beetles, lichens, copepods, etc.

2. Forest Management. The canopy trees support tardigrade populations in several ways. First, they are home to mosses and lichens on which some species feed. Their shade provides shade for the growth of other tartigrade host plants. Finally, the moist leaf litter of the forest floor provide critical habitat requirements (moisture and food) for the tardigrades. Disturbance to the canopy would reduce significantly impact tartigrade populations.

- Maintain a closed-canopy forest.

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5

Balancing Monitoring, Research & Education Programs with Resource Protection

Goals

- Minimize adverse impacts of monitoring, research and education programs and projects on the Sanctuary's natural resources and balance programmatic benefits with resource needs.

- As new research on the Central Appalachian Forest ecosystem provides new knowledge relevant to sanctuary conservation and management, incorporate this new knowledge into Sanctuary management practices.

Management Objectives

1. **Project Review.** Projects should be reviewed by senior staff considering Land Management Plan objectives, and seeking to limit impacts on the natural communities of the Sanctuary.

2. **Limit Impacts of Facilities and Programs.** Continuously evaluate and limit adverse impacts of current facilities and infrastructure needed to accommodate HMS programs.

3. **Integrate Latest Research.** Incorporate latest research into sanctuary management where needed to conserve Appalachian forest communities.

Background

Hawk Mountain Sanctuary has been a leader in raptor research and monitoring since 1934, when the migration-monitoring program began. In the past two decades the Sanctuary has broadened its data collection to include breeding and wintering birds (1982), rainfall (1985), butterflies (1995), and amphibians (1996). The Sanctuary's Long-Range Plan of 1997 envisions continued growth of research. HMS staff, associates and

visiting scientists have contributed over 200 publications to technical and professional literature. Today HMS research work includes:

- Patterns and processes of avian migration
- The first global atlas of important raptor migration sites
- Appalachian forest ecology
- Neotropical migrant songbird nesting ecology
- Long-term ecological studies of raptor populations in nearby open habitats (From PHMC grant text)

For purposes of the Land Management Plan, research and education activities can be divided into two general categories; those that directly use the sanctuary's land and those that do not. The former include assessments of animal and plant populations on the Sanctuary. The latter include the Sanctuary's role as a clearinghouse for raptor migration and population data. The latter may require larger facilities and more staff as it grows.

With respect to protecting the Sanctuary's natural resources, the on-site category of research carries slightly more risk, simply because it involves working on the land. Monitoring stations, transects, sampling and surveying, etc. can impact sensitive habitats. This research and monitoring, however, also provide data directly relevant to conserving and improving the management of habitat at both the Sanctuary and elsewhere. The challenge is to balance risk to the resource with the benefits inherent in increased understanding. Providing areas undisturbed by any research will help (Map 24, 25).

The activity that carries the least risk and, potentially, provides the greatest benefits to HMS is the creation, compilation and analysis of raptor population data from the entire Western Hemisphere. This will implement the HMS goal to become "the recognized leader in monitoring North American raptor populations" (1997 Long Range Plan). It will require sophisticated facilities and equipment for HMS scientists and visiting researchers to collect and process data from throughout the Americas.

The Sanctuary is an excellent site for long-term ecological research for a number of reasons. It possesses facilities for scientists. Its natural habitats have been inventoried, establishing essential baseline information for future studies. Its size (in combination with abutting protected acreage) ensures healthy populations of many species. For these reasons it is likely to remain an attractive site for outside investigators on a range of ecological research topics. HMS is now working with researchers at 15 academic institutions, including five Commonwealth universities. Graduate students from Pennsylvania State University and SUNY-Syracuse complete advanced degrees at HMS. HMS has a Memorandum Of Understanding with Kutztown University and is affiliated with Cedar Crest College, through which it offers four college courses.

HMS welcomes exchanges with other biological research stations and nature centers. Its greatest training impact on the conservation profession has been through the 185 graduates of its International Internship Program, 55 of whom are from Pennsylvania. HMS is regularly called upon to mentor other hawk watch sites and has formalized this role through a technical assistance network called *Hawks Aloft Worldwide.* HMS annually hosts a Kittatinny Roundtable of regional migration observers and is the repository for the Hawk Migration Association of North America archives. The Sanctuary's *Adopt-A-Kestrel-Nestbox Program* developed in cooperation and with the support of the PA Game Commission's Nongame Program and The Wild Resource Conservation Fund is helping state residents practice real wildlife management. Staff provide leadership and expertise as board and committee members with national and state organizations, including the PA Biological Survey, PA Bureau of Forestry, PA Environmental Council, Berks County Conservancy, and, nationally, with the American Bird Conservancy, Raptor Research Foundation, and World Working Group for Birds of Prey and Owls. HMS has formed a coalition of local land conservancies, Appalachian Trail Commission and the Natural Lands Trust to advance land conservation in the Hawk Mountain region.

Sanctuary organized education programs span pre-school to post-graduate levels, and include teacher workshops, college courses, internships, school programs, public programs on-site and outreach. HMS believes learning is best accomplished through hands-on experiential activity, and that it has a responsibility to provide learning opportunities for all ages and levels of knowledge.

Fulfilling the needs of visiting school groups is the focal point of the HMS education program. A new curriculum, *The Acorn Project*, meets National Science Education Standards for grades K-4. Under development is *The Raptor Challenge* for Grades 9-12. A 70-page supplement, *Raptor Bites*, was added to the Hawk Mountain Teacher Guide last year. On the basis of a Berks County pilot of the *Adopt-a-Nestbox Program for Pennsylvania School Children* (an outreach program for rural and suburban middle schools) a videotape and poster have been produced to take the program statewide. Recently a new *Birding with Binoculars* program, complete with life-size photo-realistic raptor silhouettes and 100 pairs of new binoculars, has been developed and offered to visiting school groups and visitors.

Program evaluation by participants is standard practice for HMS education programs. Programs are developed by education staff, interns, and local educators in response to: public need and interest; a desire to reach underserved audiences; relevance to the Sanctuary's living collections and mission; and a need to enhance science and math education. A Teacher Internship, first sponsored by a PHMC grant in 1997, facilitates curriculum development. Despite the distance from urban centers (25 to 40 miles), off-site programs reached 4,000 people in 1998.

Also of importance are the Sanctuary's informal education programs, including placing personnel at lookouts on fall weekends to interpret the raptor migration and allowing visitors to experience this natural, wild phenomenon themselves. The positive impact these opportunities may have on visitors is difficult to measure, but given the large numbers of fall visitors, it must be substantial.

Discussion of Issues

Research and education activities affect and interact with the Sanctuary's land resource in at least five ways:

(1) education and research activities directly, if subtly, affect habitat and animal behavior;
(2) facilities (buildings, parking lots, trails, etc.) needed to accommodate these programs consume land, consume water and energy, increase storm water runoff, and attract people and automobiles which in turn may cause erosion, be sources of invasive plants, attract nest predators, and cause other impacts;
(3) results of these activities provide new knowledge to the Sanctuary enabling it to better manage the Sanctuary's resources;
(4) publication of research results and education spreads knowledge to the world beyond Hawk Mountain so that the local community and society at large become more receptive and supportive of natural resource conservation and the HMS mission; and
(5) unlike a public park, Hawk Mountain provides the increasingly rare opportunity to experience wild nature, to send the message that wild nature is good, to raise conservation awareness, to learn about nature in a more wild state than most people can easily experience, and to attract people who want these opportunities.

The challenge to HMS is to balance risk to the resource with benefits from increased understanding.

Project Review. Consider a formal set of protocols designed to minimize/limit and/or justify interference with natural systems. These protocols would guide a review by senior staff for proposed on-site research and education projects. The review will include, but not be limited to, consideration of Land Management Plan objectives and the results of the Inventory.

Minimize/Limit Impacts of Facilities and Programs. While recognizing the many other constraints under which the Sanctuary operates — financial, political, regulatory — HMS will attempt to keep new facilities close to existing ones and/or locate new facilities in the less sensitive areas of the Sanctuary and not spread the facilities out simply to provide privacy, better views, etc. New facilities should adhere to the most

appropriate environmental standards that are feasible within financial and programmatic constraints. Unavoidable impacts will be minimized and mitigated.

Integrate Latest Research. The Sanctuary will continue, and as feasible, expand research by HMS staff and visiting scientists that enhances understanding of migrant birds, forest fragmentation, knowledge of the Central Appalachian forest ecosystem, and a broad range of ecological topics or issues that can aid in better understanding and management of the land and water resources of the Sanctuary. When new knowledge is relevant, HMS will adapt management policies and activities to better the natural communities of the Sanctuary and surrounding areas.

6
Balancing Visitor Programs With Resource Protection

Goals

- "Continue to encourage and accommodate visitors to HMS ... Maintain the loyalty of serious hawk watchers (*Hawk Mountain Long Range Plan*, 1997)."

- Educate visitors to build conservation awareness — provide opportunities for visitors to interact with Sanctuary wild resources; to view raptors; to appreciate the Hawk Mountain global mission; to have a high quality, primary experience in a native forest environment; and to increase their understanding of migratory birds, the Appalachian forest ecology and other important aspects of the natural environment, locally and globally.

- Ensure that visitors do not create unacceptable negative effects to the resources that HMS seeks to protect by "balanc[ing] the desire to reach a large audience with the desire to maintain a memorable and pleasant visitor experience (*Hawk Mountain Long Range Plan*, 1997, p. 8)" and ensuring that migrant birds, the forest and other natural resources of the Sanctuary are not unnecessarily impacted by visitor activities.

- Accommodate the different needs of individual visitors and groups.

- Continue to encourage and accommodate visitors from the scientific community.

Management Objectives

1. **Encourage Off-Peak Visitation.** Continue to encourage visitation during off-peak times and seasons by increased programming, press releases and other marketing that will make the public more aware of off-peak opportunities, and "incentives (e.g., two-tier admission fee) that encourage greater visitation during non-peak time (Monday - Friday, December through August) (*Hawk Mountain Long Range Plan*, 1997, p. 8)."

2. **Enhance Interpretation.** Continue and enhance interpretation of the Appalachian forest for the general public using guided hikes and other techniques, in accordance with the general philosophy that some areas of the Sanctuary should not be open to the general public.

3. **Use Resource Inventory Results.** Use resource inventory results to increase opportunities for visitor and member appreciation and knowledge of Central Appalachian Forest, e.g., provide sanctuary checklists and interpretation guides for specific taxa such as mosses, butterflies and moths, mushrooms, flowers. Be careful however to not encourage activities that would endanger populations of rare species.

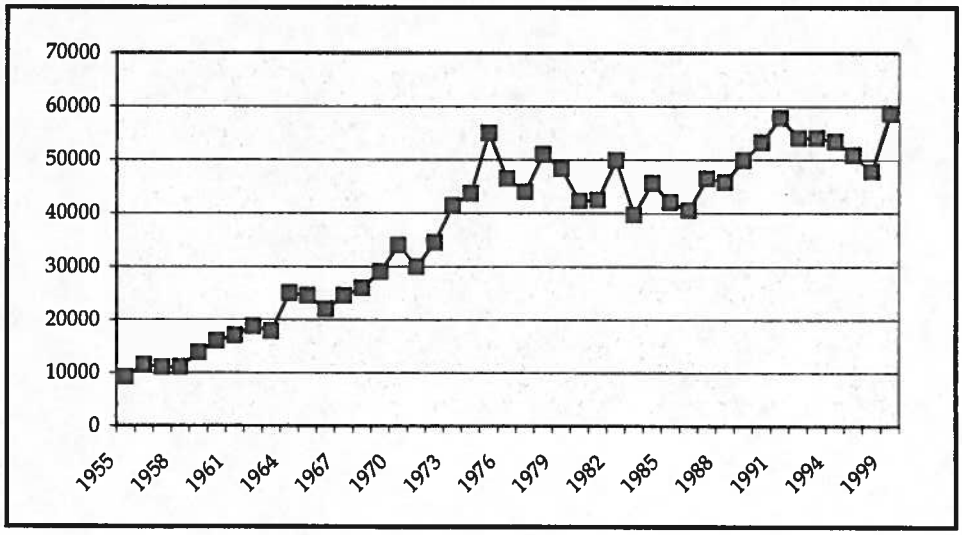
4. **Monitor Visitation Impacts.** Monitor effects of visitors and adapt management to mitigate, minimize/limit or eliminate negative effects.

5. **Visitation Data.** Institute better programs for tracking and displaying data on visitation.

Background & Discussion of Issues

As shown in the accompanying tables, visitation (excluding school groups) at Hawk Mountain increased steadily from 9,205 in 1955 to 55,000 in 1975, then leveled off to numbers varying between roughly 40,000 and 50,000 per year until about 1989. At that time use increased to a new range between roughly 50,000 and 60,000 (note that data are not available for 1996 and 1997).

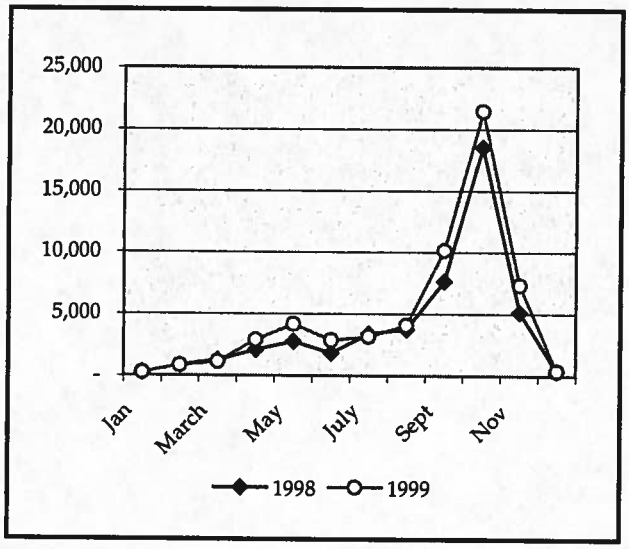
ALL VISITORS EXCEPT SCHOOL GROUPS BY YEAR

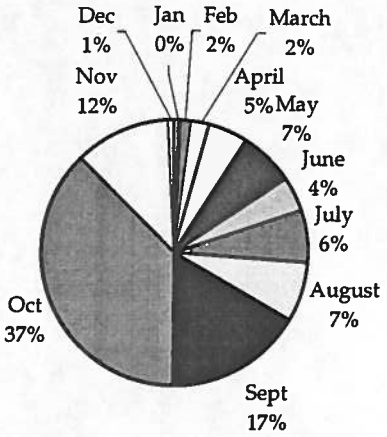


Year	Visitation	Year	Visitation	Year	Visitation	Year	Visitation
1955	9,205	1966	22,000	1977	44,000	1988	45,815
1956	11,500	1967	24,500	1978	51,000	1989	49,921
1957	11,000	1968	26,000	1979	48,300	1990	53,243
1958	11,100	1969	29,000	1980	42,303	1991	57,842
1959	13,800	1970	34,000	1981	42,534	1992	54,100
1960	16,000	1971	30,000	1982	49,908	1993	54,100
1961	17,000	1972	34,500	1983	39,753	1994	53,379
1962	18,700	1973	41,400	1984	45,672	1995	50,842
1963	17,800	1974	43,700	1985	42,089	1998	47,866
1964	25,000	1975	55,000	1986	40,553	1999	58,682
1965	24,500	1976	46,500	1987	46,520		

Not surprisingly, there are wide variations in annual use patterns, with the highest use occurring in the fall at times of peak southward hawk migrations. Using 1998 and 1999 as examples, the month of October alone accounted for 37% of total annual use, the months of September and November together another 29% and the remainder of the year 34%. This seasonal use pattern results in high numbers of trail users on peak fall weekends on the Scenic Overlook Trail with lower use at other times, including weekdays in the fall.

NONGROUP VISITATION BY MONTH



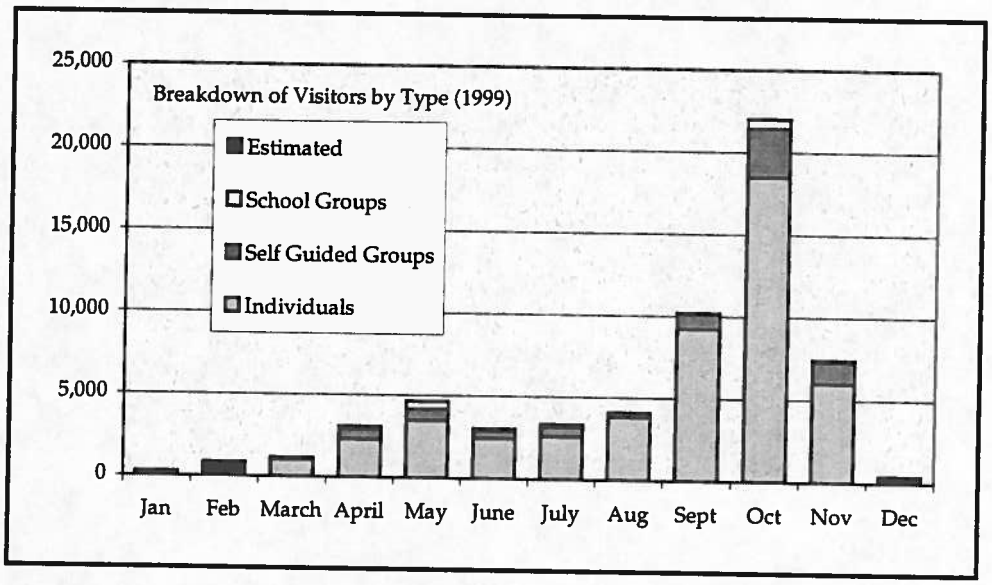


Year	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Totals
1998	255	839	1,242	2,079	2,770	1,826	3,393	3,747	7,639	18,532	5,144	400	47,866
1999	255	839	1,125	2,886	4,160	2,877	3,142	4,072	10,131	21,459	7,336	400	58,682

January, February and December, 1998, figures are estimates. All other figures are from gate or Visitor Center records.

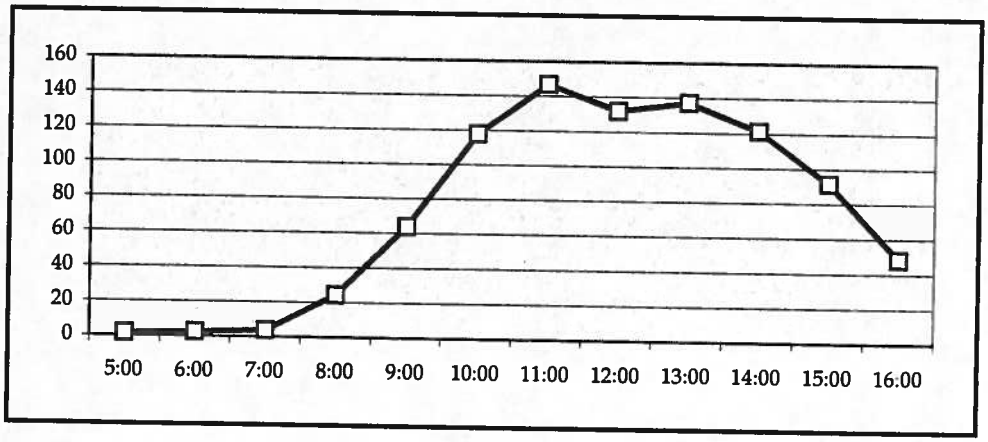
One way HMS has attempted to balance use is by encouraging group visits at nonpeak times. The accompanying Monthly Visitor Use Composition table shows group and nongroup visits by month for 1999.

MONTHLY VISITOR USE AND COMPOSITION



Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Individuals			1,023	2,277	3,449	2,417	2,571	3,801	9,225	18,484	5,992		49,239
Self Guided Groups			102	609	711	460	571	271	906	2,975	1,344		7,949
School Groups				171	463	126	171	10	73	562	75		1,651
Estimated	255	839										400	1,494

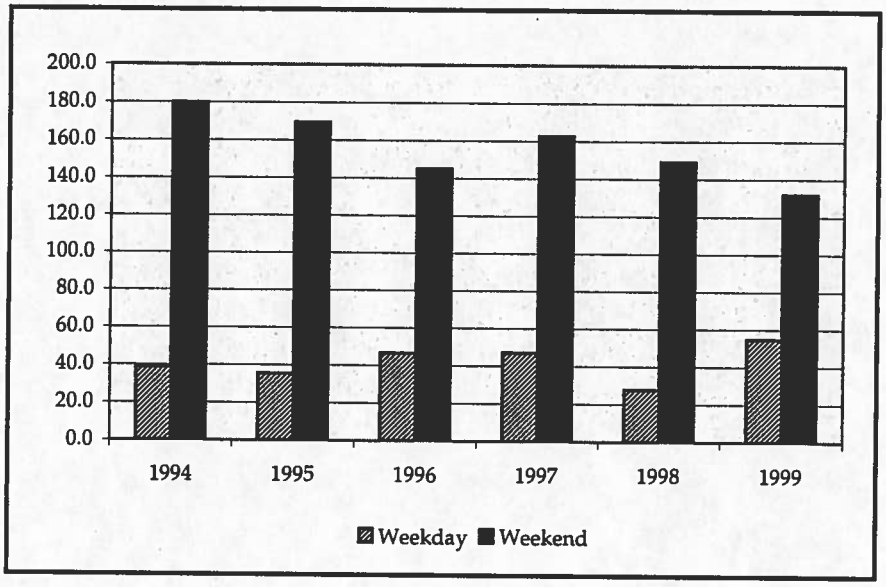
AVERAGE OCTOBER WEEKEND USE BY HOUR



As shown in the above chart, visitation varies widely within the course of an October weekend day, peaking late morning, then dropping off toward evening.

Large numbers of autumn visitors and the uneven annual pattern of annual, weekly, daily and hourly visitation are major managerial challenges to the Sanctuary. Because recent efforts to even out use by a tiered fee structure and nonpeak programming have succeeded, these efforts will be continued. Impacts of visitation, whether it be heavy trail use or water consumption, will be monitored and impacts addressed. This might include counts of trail use on the less traveled parts of the system.

HOURLY WEEKEND VS. WEEKDAY VISITATION



	Weekday	Weekend
1994	38.6	179.8
1995	35.5	169.5
1996	46.5	144.9
1997	47.0	162.6
1998	27.7	149.1
1999	54.7	132.0

Education of its many visitors is a priority for the Sanctuary, and to the degree that visitors gain more knowledge of local ecology, the results of the biological inventory, and greater conservation awareness, the Sanctuary's mission and programs will benefit. The Sanctuary's educational efforts have been enhanced by recent improvements that include: increased interpretive staff; better identification of staff, interns, and volunteers (staff and interns wear HMS vests, volunteers wear armbands and nametags); increased one-on-one interaction between visitors and HMS staff/volunteers/interns; and roving staff and interns on trails, at the information booth and at lookouts. Adding the results of the inventory to the mix of interpretive subject matter will further enhance the educational program.

Since most visitors come to birdwatch, walk a trail, use a facility or participate in a program, for the purposes of this study, the recommendations of sections 5, 7 and 8 will be treated as if they were a part of this section.

Future Considerations

The Kittatinny Ridge or Blue Mountain offers other locations in Pennsylvania for observing raptor migration, including Waggoners Gap and Second Mountain to the west and Bake Oven Knob to the east. By cooperating with other organizations or taking direct action on its own, Hawk Mountain may be able to encourage visitation to these sites and relieve visitor pressure on the Sanctuary itself, while achieving many similar benefits, including visitor education and enhanced conservation awareness.

7
Trails & Lookouts

Goals

- Trails and lookouts are to provide a means for visitors to have a direct, *primary experience* in a mostly natural, and authentically rugged, environment and are an integral part of increasing *conservation awareness*.

- Trails and lookouts allow visitors access to areas that are determined by HMS to be appropriate for visitation, including new and enhanced lookouts like East Rocks and the Slide.

- Design and maintain trails and lookouts to the appropriate standard — trails and lookouts will vary in design, maintenance and accessibility standards from handicapped accessible to extremely rugged, depending on terrain, resource, program and numbers of visitors. For example, the Scenic Lookout Trail is highly improved and maintained between the Visitor Center and South Lookout so that nearly any visitor, including wheelchair users, can get to at least one lookout and because the terrain permits this level of accessibility.

- Modify and maintain lookouts and trails in Area 8 on the Use Area Map (the area around the lookout trails) to accommodate growth in visitation.

- Design and maintain trails and lookouts to be compatible with the resources that HMS seeks to protect, e.g., water quality, including measures to keep people on the trails, e.g., physical barriers.

Management Objectives

1. **New or Reopened Lookouts.** Evaluate the use of new lookouts (those reopened in 1997) by visitors. Assess need for new or reopened lookouts, particularly at the Slide and East Rocks, based on the quality of visitor experience and effects of crowding.

2. **Trail Improvements and Modifications.** Before considering new trails, HMS will improve, reroute and modify trails so that they do not negatively impact special

habitat areas, other sensitive natural areas on the sanctuary, or have other unintended negative consequences. This will be a continual effort as problem areas are identified.

3. **New Trails.** Assess need for new trails based on the quality of visitor experience, the effects of crowding and maintenance capacity of HMS staff. Include trail use counts and interviews or input from trail users. Evaluate visitor wishes for additional hiking opportunities.

4. **Maintain Views from Lookouts.** Maintain views from public lookouts by judicious pruning of trees and other vegetation that would otherwise block views. Develop and document a standard approach with staff and board input, based on historical monitoring, and with sensitivity to ecological priorities (see recommendation for protecting Knothole Moss in Section 4). Use photographs, drawings and narrative to document approach so that the acceptable maintenance standard is clear to staff, volunteers, and the public.

5. **Group Use of Lookouts and Trails.** Consider use of specific lookouts, e.g., East Rocks and 3/4 Lookout, and certain trails exclusively for groups to reduce conflicts with other users.

6. **Prohibit Public Access to Use Area 1.** Continue to prohibit public access to Use Area 1 (see Use Area Map in Introduction), excepting occasional guided groups, to prevent human interference with research and monitoring activities, to reduce wildlife disturbance, and to maintain this area in the most natural condition possible.

7. **Informal Visitor Learning.** Maintain opportunities for visitor learning from natural resources on the site, as well as educational resources within the Visitor Center.

8. **Trail Facilities.** Ensure that the design of signs, benches, and other facilities along the trail system appear to be and are consistent with the natural environment and the mission of HMS, and that they enhance the visitor experience.

9. **Monitor Trail Impacts.** Continue to investigate the impact of trails and trail use on populations of native fauna and flora. Institute better methods for tracking trail and lookout use.

10. **Trail and Lookout Accessibility.** Continue to search for ways to improve accessibility to disabled visitors, especially to South Lookout, within the constraints of the rough terrain of the Sanctuary. This may include measures such as smooth trail surfacing and providing staff assistance to wheelchair users.

Background

Trails and lookouts at Hawk Mountain Sanctuary have several purposes. First and foremost, they provide access to hawk watchers who need a way to get from the Sanctuary parking areas to the lookouts. Second, they provide an opportunity for staff and others to interpret the environment. Third, while the Sanctuary is not a public park, they provide a recreational experience for visitors and opportunities to view an unspoiled landscape. Fourth, they provide access to the property for management, monitoring and research purposes.

Currently, the Sanctuary has six discrete, named trails with a total length of 7.92 miles (Map 26). Nine lookouts (excluding the Slide and East Rocks) are maintained for public viewing. The level of improvement of the trails varies greatly. The trail between the Visitor Center and South Lookout is the most improved, is accessible by wheelchairs and can be traversed by a small truck for maintenance and emergency access purposes. On the other hand, many other trails are narrow, rough, rocky and primitive.

Variation in use and degree of improvement of trails is illustrated by the following table (Map 27).

Trail	Length (Miles)	Level of Use	Level of Improvement
Scenic Lookout Trail: Visitors Center to Hawk Mt. Rd.	0.16	High	High - Brick pavers & groomed shale/woodchips; wheelchair traversable*
Scenic Lookout Trail: Hawk Mt. Rd. to South Lookout	0.11	High	High - Groomed shale & soil; wheelchair traversable*
Scenic Lookout Trail: South Lookout to Escarpment Trail (+)	0.23	Moderately High	High - Groomed shale & soil
Scenic Lookout Trail: Escarpment Trail (+) to North Lookout	0.55	Moderately High	Moderate - Rocky, well trodden
Slide & Sunset Overlook Trail	0.13	Moderate	Mixed - Moderate/Primitive
Escarpment Trail	0.31	Moderate	Primitive
Express Trail	0.07	Moderate	Mixed, somewhat improved
River of Rocks Trail	3.54	Low	Primitive
Skyline Trail	1.63	Low	Primitive
Golden Eagle Trail	0.99**	Low	Primitive
Education Trail (closed to public)	0.19	Low	Primitive
Total	7.92	As per recent GPS measurements	

* Does not meet ADA standards because slope exceeds recommended grade due to natural terrain.

** Golden Eagle Trail length measurement excludes common length with Skyline Trail

List of Lookouts. HMS has eleven lookouts as follows, listed in rough order of distance from the Visitor Center:

1. South Lookout
2. Appalachian Overlook
3. River of Rocks Overlook
4. Ridge Overlook
5. Bald Lookout
6. 3/4 Lookout
7. Kettle View
8. North Lookout
9. Sunset Lookout
10. The Slide (restricted view - trees not pruned)
11. East Rocks (not currently maintained)

Level of Trail and Lookout Use. As shown in the tables in the previous section on visitor programs, the number of nongroup visitors at Hawk Mountain increased steadily from 9,205 in 1955 to 55,000 in 1975, then leveled off to numbers varying between roughly 40,000 and 50,000 per year until about 1989. At that time use increased to a new range of roughly 50,000 to 60,000.

The wide variations in annual use patterns, with the highest use occurring in the autumn at times of peak hawk migration, result in high numbers of trail users on peak fall weekends on the Scenic Lookout Trail with relatively low use at other times and on other trails. This puts additional wear and tear on the trail system that would not occur if the use were spread out over longer time periods, because, for example, the number of people using the trail at peak times forces people off the maintained trail surface leading to a wider compacted and disturbed area, which in turn may lead to more erosion, and so forth.

Discussion of Issues

New Trails & Lookouts. New trails may be considered to relieve crowding, or the perception of crowding, at peak use periods.

Crowding can be a concern on the Scenic Overlook Trail during peak fall weekends, primarily six weekends from late September through early November, when both hawk watchers and foliage observers come. Using 1998 and 1999 figures, it is likely that 2,000 to 3,000 people use this trail on an average October weekend day. This can result in a steady stream of humans along trails, and sizable numbers of people at lookouts, particularly North Lookout, the destination of most visitors. When they occur, these large numbers make a "wilderness" experience along this trail impossible and detract

from a visitor's ability to commune with nature. Although long time hawk watchers may be most distressed by this crowding (this requires verification), this group would also know to schedule their time at the Sanctuary to avoid crowds. In any case, at peak times, human interactions, both positive and negative, increase and can dominate the experience, rather than nature.

There are also benefits to larger numbers of people. During the walk to the lookouts, there are many opportunities for conversation about birds and the Hawk Mountain environment among visitors. More people provide extraordinary opportunities for interpretation by HMS staff. Visitors may educate each other. At the lookouts, hawk watching among the larger numbers of people becomes a shared experience in which newcomers are able to learn from old-timers (without revealing their ignorance). Everyone focuses outward watching for raptors and seeing them soar over the wild and rural landscape spread below. For someone who is new to the Mountain or to the migratory phenomenon, the crowds may not be an issue, or may be a positive factor. The Sanctuary will gain greater understanding of visitor's perspectives by conducting surveys on crowding among visitors.

Although trails are not commonly thought of as a source of forest fragmentation, considerable research in recent years shows that trails and roads do have significant impacts on an array of flora and fauna. Some impacts may last long after the trails are closed. On Hawk Mountain, limited work showed some songbird and small mammals would avoid even lightly used trails, and that even trails which had been closed for over twenty years were avoided by small mammals.

Other negative impacts of trails include erosion, especially on steep slopes, and spreading of invasive plants by soil disturbance and seed distribution on boots and clothing. Currently this is evidenced by the spread of invasive plants along trails and storm water channels. Heavy use of the trails on fall weekends can lead to trail widening, compaction and related impacts that might not otherwise occur if trail use were more spread out over the year.

Lastly, new trails require maintenance, patrolling and staff resources, when the Sanctuary is challenged to properly maintain the current trail network.

Total trail and lookout use is constrained by a number of factors, including terrain, trail condition, rest rooms and parking. The current number of parking spaces available on site is probably the most critical limiting factor, although a decision to use remote parking and provide shuttles would remove that constraint.

The Sanctuary recently has expanded the number of maintained lookouts, many of which are now staffed on peak weekends. The result has been a reduction in number of people on trails and at North Lookout and expanded interpretive contacts. These results suggest that a further evaluation of the need for new or reopened lookouts, particularly

at the Slide and East Rocks is in order, based on the quality of visitor experience and effects of crowding. Groups in particular historically used East Rocks in order to minimize noise and disturbance to visitors at North Lookout. Use by groups of East Rocks deserves new consideration.

Planning new trails and lookouts requires a thoughtful balance between ecological and operational costs on the one hand, and programmatic and human benefits on the other. The Sanctuary will assess the need for new trails based on the quality of visitor experience, the effects of crowding and the maintenance capacity of HMS staff. Using trail counters or other means for obtaining accurate trail use measures, careful capital and operational cost estimates and interviews with trail and lookout users will provide better data for HMS to make decisions on modification or expansion of the trail/lookout network.

Prohibit Public Access from Use Areas 1 and 2. There has been an unofficial policy to keep public trails out of the areas shown on the Use Areas Map as Area 1 and sensitive communities there, e.g., vernal pools, in order to maintain these lands for wildlife and research purposes. One operational consideration has been the difficulty of collecting admissions to these areas and managing human use and safety in remote areas. This policy ought to be formalized and extended to the Area shown as Area 2. Area 2 is distinguished by extremely steep slopes and the Little Schuylkill riparian zone. Trails here would create higher levels of impacts than in less steep areas. An important exception from this general rule is to permit occasional staff-guided groups to enter these areas for programmatic purposes, especially Area 1 which is served with an existing service road. By limiting access HMS will prevent human interference with ongoing research and monitoring activities and reduce wildlife disturbance. By maintaining these areas in relatively natural conditions, HMS will secure baseline study areas that are relatively undisturbed and unfragmented which can be compared with other more disturbed areas in the future.

Trail Standards and Maintenance. Trail systems require constant monitoring, maintenance and improvement, especially in rugged terrain. The trampling effects of many feet, erosional effects of precipitation and runoff, and gravity's effects on steep slopes all conspire to cause soil erosion and potential off-trail effects like stream sedimentation and changes in plant communities. In addition, changing societal concepts of what constitute adequate standards for access, and legal considerations like liability cause land managers to constantly upgrade their notions of "acceptable" levels of construction and maintenance. Programmatic needs, like access to a new interpretive site, may also require trail changes. In the course of this study, previously unknown sites of habitat sensitivity were discovered. It can be expected that this pattern of discovery will continue. Therefore HMS should expect that the trail system might not be static, that improvement, maintenance and modification will be a constant process.

During this study several specific sensitive areas and problems were discovered that will be addressed as soon as possible:

- Consider closing the lower loop of the River of Rocks Trail during bird nesting (May 15 through early July) within the low elevation forest. This is now a nesting site for rarer warblers and historically for both Northern Goshawk and Barred Owl. Also see recommendations for conifer groves in Section 4 for a rationale for winter closings.
- Reroute the Skyline Trail around reptile habitat sites along top of ridge northeast of North Lookout, by moving the trail laterally (up to 50 feet).
- Correct trail erosion in several areas, especially the Golden Eagle, Express and River of Rocks Trails.
- Install boardwalks to bridge streams and wet areas on the River of Rocks Trail.

HMS staff should continue to monitor and investigate the impact of trails and trail use on populations of native fauna and flora and will make changes to the trail system, such as those indicated above, to mitigate any negative impacts. Staff also needs to investigate the best design standards for trails and keep apprised of trail design innovations. To assist in these efforts better methods of counting trail and lookout use is essential.

Current levels of trail improvement enable a high level of access to South Lookout. This represents a good balance between the access needs of the visitor and the Sanctuary's desire to keep an authentic natural setting (although some object to the wire gabions and related improvements at South Lookout). The Sanctuary will continue to search for ways to improve accessibility to disabled visitors, especially to South Lookout, within the constraints of the rough terrain of the Sanctuary. This may include measures such as smooth trail surfacing and providing staff assistance to wheelchair users.

Trail related facilities, including signs, benches and the trail gate, aesthetically complement and reinforce the natural image of the Sanctuary. The Sanctuary should use rustic (but safe) materials in the design and construction of trail facilities. HMS should consider hiring a consultant in image creation to review signage and other site facilities for their consistence with the Sanctuary mission and image. The consultant also will look at the diversity of surface materials — pavers, woodchips and a shale/soil mix used on the Scenic Lookout Trail to see whether it would be feasible to simplify and naturalize the look and feel of this important visitor route and still achieve functional requirements. All consultant recommendations will be subject to careful review and approval by HMS staff and board.

Informal Visitor Learning. Hawk Mountain offers the general public unparalleled opportunities to learn about the natural world. The magnificence of the site inspires

awe and opens the mind of the sensitive person to new impressions. The authenticity of the natural surroundings allows for the careful observer to see and learn new things. The effort to walk to the more distant lookouts makes the arrival there more rewarding. The presence of other knowledgeable people — visitors, staff and volunteers — means that deeper knowledge is almost always available for the inquiring mind. Keeping the feel of a wild place is integral to this experience. Possibilities to build on these opportunities will be kept in mind when making decisions regarding trail placement, lookout maintenance and related activities.

Maintain Views from Lookouts. Maintenance of views from the lookouts requires periodic pruning to keep views open. This activity can be problematic, if an eager but overly aggressive person removes too much or does not follow recommended practices. Damaged vegetation, such as sprouting stumps, may be evident for many years. Ideally, pruning and cutting will not be evident to any but the most sophisticated visitor.

To overcome this problem, and maintain the lookouts in as natural and as naturally appearing a state as possible, the Sanctuary will develop and document a standard approach, based on historical monitoring, following industry standards and with sensitivity to other ecological priorities. The approach will include photographs, drawings and narrative to clarify the acceptable maintenance standard to staff, volunteers, and the public. Sanctuary personnel will be trained in appropriate pruning techniques. Training will include identification of Knothole Moss (see Section 4) and other species or conditions needing special handling.

8
Facilities & Historic Sites

Goals

- "Maintain the Sanctuary heritage as a first class facility (*Hawk Mountain Long Range Plan*, 1997)."
- Assure HMS facilities meet health and safety standards and adapt as needed in the future.
- Use "green" architectural and "sustainable landscape" design standards in any new construction, in a fiscally responsible manner.
- Gradually incorporate green architectural and sustainable landscape standards, e.g., sustainability of water supply, maintenance of groundwater quality, energy conservation, into existing HMS operations and existing facilities, in a fiscally responsible manner.
- Manage and maintain historic and archeological sites on the Sanctuary according to appropriate standards and provide interpretation when consistent with HMS's conservation and educational mission.

Management Objectives

1. **Adequate Facilities.** Provide facilities to accommodate those people and functions necessary for an "expanded leadership role" by HMS, i.e., visiting researchers, HMS staff, and interns, including international interns (*Hawk Mountain Long Range Plan*, 1997). This would include the proposed Center for Conservation Learning.
2. **Minimize Facility Impacts.** Construct any new or expanded facilities in an environmentally sensitive manner with minimal impact on natural resources, including limits on ground disturbance and use of fill from offsite.
3. **Stormwater Management.** As soon as possible, modify drainage for roads, parking lots, buildings, and other facilities to recharge storm water to ground water in accordance with best management practices, thereby preventing erosion, groundwater depletion and other impacts. Limit ground disturbance and use of fill

from offsite. Work with townships as needed to address problems along Hawk Mountain Road.

4. **Archeological & Historic Resources.** Properly protect the "Middle to Late Archaic" archeological site documented by Pennsylvania Historical and Museum Commission, as well as Slide and other nearby areas having "potential for additional archeological resources" for future archeological research (letter from Pennsylvania Historical and Museum Commission, July 6, 1998). Consider consulting with an archeologist and historian to further investigate this site and other potential resources at HMS.

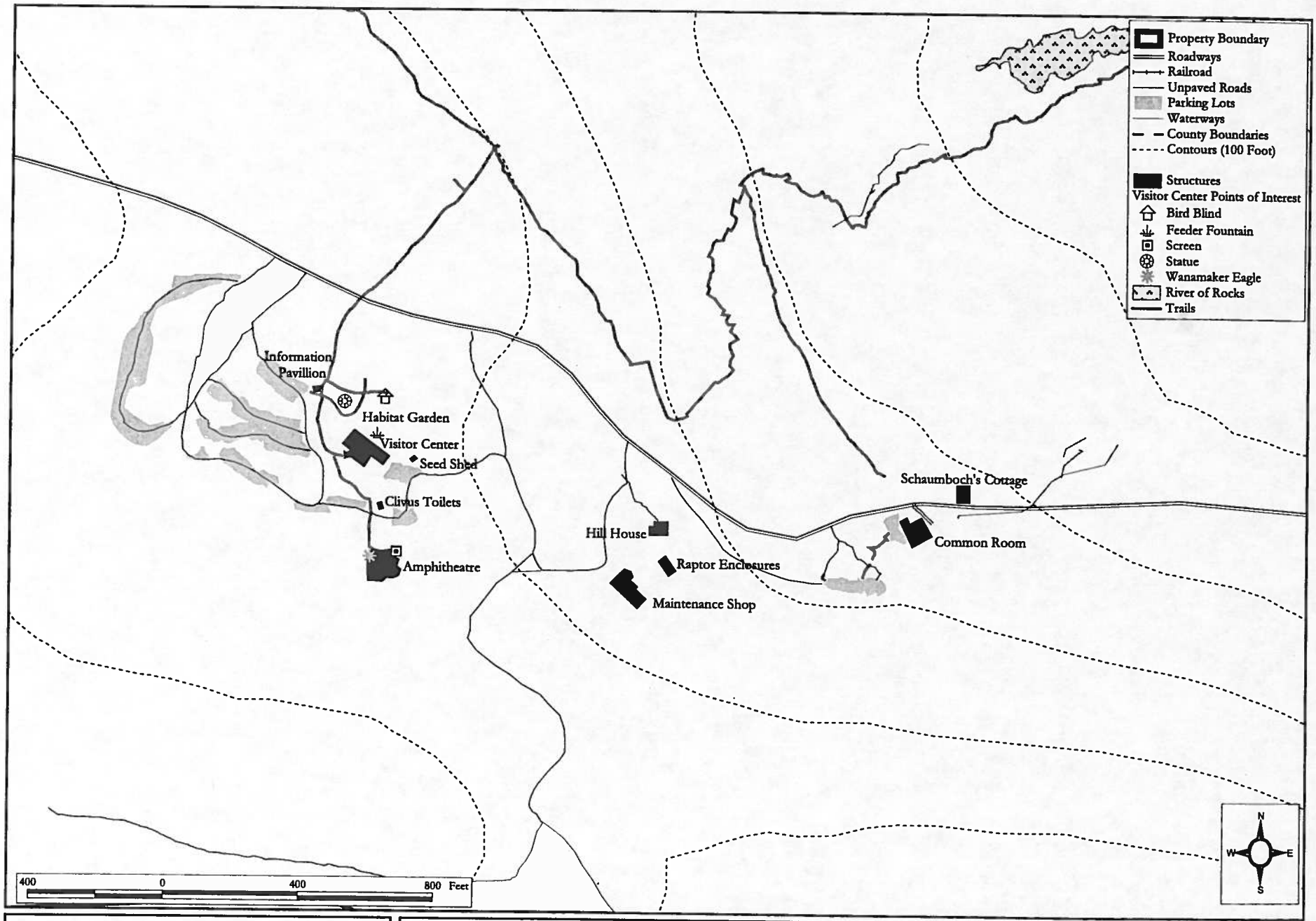
5. **Practice Water Conservation On-site.** Continue to evaluate water use and conserve. Recycle wherever and whenever possible.

Background

Hawk Mountain has an extensive inventory of buildings and other facilities, which tend to be concentrated on top of the mountain in the vicinity of the Visitor Center (Maps 28, 29).

Enclosed Buildings. The following table summarizes the existing enclosed buildings.

Building	Built	Renovations	Additions	Current Purpose	Square Footage
Visitor Center	1974		1987, 1991	Museum, art gallery, bookstore, storage, offices, custodial	7,000
Common Room	1953	1987, 1998		Intern residence, meeting room	3,955
Hill House	1968	1997		Staff residence	1,670
Maintenance Shop	1978			Workshop, garage	1,440 - enclosed area only
Schaumboch's Cottage	1793	1861, 1938, 1966, 1993, 1998		Staff residence	1,280
				Total	15,345 enclosed



Hawk Mountain Sanctuary
Schuylkill and Berks Counties, PA

Visitor Area

MAP 29

DCR 3/29/00

NOTES:
1. Waterways, roads, and county boundaries from Pennsylvania Spatial Data Access (PASDA).
2. Property boundary, railroad, trails, easements, River of Rocks, and structures from Professor Robert Martin, Kutztown University.

Natural Lands Trust
Hildacy Farm, Palmers Mill Road, Media, PA 19063
610-353-5587 www.natlands.org

Kutztown University, Dept. of Geography
Dr. Robert N. Martin, Department Chair
610-683-4364 www.kutztown.edu

These buildings have a variety of needs as summarized below.

Building	Needs (as of 5/1/00)				
	Expansion	Upgrades, Renovations	Historic Restoration	Septic Upgrade*	Special Items
Visitor Center	•	•		•	
Common Room		•		•	Correct trail erosion, plant native grass
Hill House				•	
Maintenance Shop	•	•			
Schaumboch's Cottage			•	•	Conversion to museum, housing for visiting scientists

* to be completed by 12/31/00

Other Facilities. Other facilities include smaller structures like outdoor toilets and site improvements like river ways and parking lots as per the following list:

1. **Miscellaneous Small Structures**
   a. Outdoor Toilets
   b. Clivus Multrum Toilet in the Campground
   c. Three Shelters
   d. Trail Check-In Station (a.k.a. "gate")
   e. Information Booth
   f. Maintenance garage, open structure by enclosed garage
   g. Tool/recycling shed
   h. Raptor mews
   i. Shed behind Visitor Center
   j. Bird blind at pond

2. **Site Improvements**
   a. Vehicle Circulation and Parking
      - Main Parking Lots at Visitor Center
      - Parking Lots at Common Room
   b. Amphitheaters
   c. Campground with seven campsites
   d. Native Plant Garden, Fence, Pond, Trail, Observation Deck and Blind

3. **Historic and Archeological Sites**
   a. Old Logging Roads
   b. Charcoal Burn Sites
   c. Old Trails

d. Slide
e. River of Rocks Prehistoric Sites

Parking. Parking is a key factor in that the total number of parking spaces places a limit on the total number of visitors the Sanctuary can accommodate at any one time.

Parking Facility	Number of Parking Spaces
Visitor Center	350
Common Room	30
Shoulders along Hawk Mountain Road	60
Total	440

If we assume an average of about 2.5 people per car at peak times, that yields an approximate maximum of 1100 visitors on site at any one time.

Adequate Facilities. People and functions required for the ambitious research and education programs and "expanded leadership role" recommended in the 1997 Hawk Mountain Long Range Plan would require additional facilities, as current facilities are not adequate. In particular the need for expanded housing and workspace for 1) professional visitors (researchers, scientists, teachers), 2) interns, including international interns, and 3) staff was described in the Long Range Plan.

Other facility needs may include:

- Grass playfield in the upper Common Room parking lot for guided activities with groups of children.
- Additional program, staff office and storage space.
- Meeting space.
- Space for concessionaires (food vendors, etc.) for special events
- Additional parking

Minimize Facility Impacts. Construct any new or expanded facilities in an environmentally sensitive manner to limit impact on Sanctuary resources. To accomplish this, HMS ought to attempt to keep new facilities close to existing ones and/or locate new facilities in less sensitive areas of the Sanctuary. New inventory data can be used to help identify such sites. New facilities will adhere to the best environmental standards that are feasible within financial and programmatic constraints. Fill from offsite, which may contain invasive plant seeds, ought not to be used. Clearing and other unavoidable impacts will be minimized and mitigated. Within the parking areas in particular, maintaining islands of trees will reduce the disturbed area effect, detrimental to interior forest birds, as discussed in Section 2.

Stormwater Management. As soon as possible, ideally within two years, modify drainage for roads, parking lots, buildings, and other facilities to recharge storm water to ground water in accordance with best management practices, thereby preventing erosion, reducing groundwater depletion and related impacts. This may require redesign and reengineering of roads, parking lots and trails to minimize environmental impacts and maximize groundwater recharge. In the course of these improvements, HMS will limit ground disturbance and use of fill from offsite. DEP's new Growing Greener program may provide opportunities for funding to address these issue using innovative on-site techniques, such as bioremediation. The Sanctuary also will work with local townships to address erosion and storm water problems along Hawk Mountain Road. These improvements will not only remediate an existing problem, but could become an educational "display" to demonstrate the "right" way to handle storm water with opportunities for educating many audiences. For this reason, the Sanctuary may want to consider using multiple storm water remediation techniques with some accompanying interpretive materials.

Archeological and Historic Resources. Properly protect the "Middle to Late Archaic" archeological site documented by PHMC, as well as Slide and other nearby areas having "potential for additional archeological resources" for future archeological research (letter from Pennsylvania Historical and Museum Commission, July 6, 1998). Consider partnering with an archeologist and historian to further investigate this site and other potential resources on the Sanctuary. Address negative impacts of visitor use, such as climbing on foundations at the Slide.

Practice Water Conservation On-site. Continue to evaluate water use, conserve and recycle wherever and whenever possible, so as to minimize impacts of groundwater withdrawals.

Future Considerations

Evaluate the need for concessionaire's space, kitchen facilities and similar improvements needed for special events.

References:

Interviews with Hawk Mountain Sanctuary staff and board members. January 1, 2000 through June 1, 2000.

Pennsylvania Historical and Museum Commission. July 6, 1998. Correspondence.

Appendix A
Master List of Biota

1. Plants

Ferns and Fern Allies

Wolf's Claw Clubmoss (*Lycopodium clavatum*)
Running Pine (*Lycopodium complanatum*)
Bog Clubmoss (*Lycopodium inundatum*)
Shining Clubmoss (*Lycopodium lucidulum*)
Ground Pine (*Lycopodium obscurum*)
Field Horsetail (*Equisetum arvense*)
Cut-leaved Grape Fern (*Botrychium dissectum*)
Daisy-leaf Grape Fern (*Botrychium matricariifolium*)
Rattlesnake Fern (*Botrychium virginianum*)
Cinnamon Fern (*Osmunda cinnamomea*)
Interrupted Fern (*Osmunda claytoniana*)
Royal Fern (*Osmunda regalis*)
Maidenhair Fern (*Adiantum pedatum*)
Ebony Spleenwort (*Asplenium platyneuron*)
Maidenhair Spleenwort (*Asplenium trichomanes*)
Lady Fern (*Athyrium filix-femina*)
Silvery Spleenwort (*Athyrium thelypteroides*)
Walking Fern (*Camptosorus rhizophyllus*)
Fragile Fern (*Cystopteris fragilis*)
Hay-scented Fern (*Dennstaedtia punctilobula*)
Spinulose Woodfern (*Dryopteris spinulosa*)
Marginal Shield Fern (*Dryopteris marginalis*)
American Shield Fern (*Dryopteris intermedia*)
Ostrich Fern (*Matteuccia struthiopteris*)
Sensitive Fern (*Onoclea sensibilis*)
Purple-stemmed Cliffbrake (*Pellaea atropurpurea*)
Common Polypody (*Polypodium vulgare*)
Christmas Fern (*Polystrichum acrostrichoides*)
Bracken Fern (*Pteridium aquilinum*)
New York Fern (*Thelypteris noveboracensis*)
Broad Beech Fern (*Thelypteris hexagonoptera*)
Blunt-lobed Woodsia (*Woodsia obtusa*)
Virginia Chain Fern (*Woodwardia virginica*)

Trees

Pitch Pine (*Pinus rigida*)
White Pine (*Pinus strobus*)
Eastern Hemlock (*Tsuga canadensis*)
Long-beaked Willow (*Salix bebbiana*)
Pussy Willow (*Salix discolor*)
Trembling Aspen (*Populus tremuloides*)
Large-toothed Aspen (*Populus grandidentata*)
Shag-bark Hickory (*Carya ovata*)
Mockernut Hickory (*Carya tomentosa*)
Bitternut Hickory (*Carya cordiformis*)
Pignut Hickory (*Carya glabra*)
Mockernut (*Carya alba*)
Black Walnut (*Juglans nigra*)
Butternut (*Juglans cinerea*)
Smooth Alder (*Alnus rugosa*)
Sweet Birch (*Betula lenta*)
Yellow Birch (*Betula alleghaniensis*)
River Birch (*Betula nigra*)
Gray Birch (*Betula populifolia*)
American Hazelnut (*Corylus americana*)
Beaked Hazelnut (*Corylus cornuta*)
American Chestnut (*Castanea dentata*)
Beech (*Fagus grandifolia*)
White Oak (*Quercus alba*)
Scarlet Oak (*Quercus coccinea*)
Scrub Oak (*Quercus ilicifolia*)
Chestnut Oak (*Quercus prinus*)
Red Oak (*Quercus rubra*)
Blackjack Oak (*Quercus marilandica*)
Black Oak (*Quercus velutina*)
Tulip Tree (*Liriodendron tulipifera*)
Sassafras (*Sassafras aldidum*)
Witch Hazel (*Hammelis virginiana*)
American Mountain Ash (*Sorbus americana*)
Shadbush (*Amelanchier intermedia arborea*)
Fire Cherry (*Prunus pensylvanica*)
Black Cherry (*Prunus serotina*)
Choke Cherry (*Prunus virginiana*)
Staghorn Sumac (*Rhus typhina*)
Dwarf Sumac (*Rhus copallina*)
Red Maple (*Acer rubrum*)
Striped Maple (*Acer pensylvanicum*)
Black Gum (*Nyssa sylvatica*)
Alternate-leaved Dogwood (*Cornus alternifolia*)
Flowering Dogwood (*Cornus florida*)
Red-osier Dogwood (*Cornus stolonifera*)
Persimmon (*Diospyros virginiana*)
White Ash (*Fraxinus americana*)
Northern Catalpa (*Catalpa speciosa*)

Shrubs

Sweet Fern (*Comptonia peregrina*)
Multiflora Rose (*Rosa multiflora*)
Black Raspberry (*Rubus occidentalis*)

Spice Bush (*Lindera benzoin*)
Wild Gooseberry (*Ribes cynosbati*)
Frostweed (*Helianthenum canadense*)
Poison Ivy (*Rhus radicans*)
Red Chokeberry (*Aronia arbutifolia*)
Juneberry (*Amelanchier canadensis*)
Mountain Holly (*Ilex montana*)
American Holly (*Ilex opaca*)
Winterberry (*Ilex verticillata*)
Mountain Holly (*Nemopanthus mucronata*)
Bittersweet (*Celastrus scandens*)
Virginia Creeper (*Parthenocissus quinquefolia*)
Fox Grape (*Vitis labrusca*)
Summer Grape (*Vitis aestivalis*)
Frost Grape (*Vitis vulpina*)
Autumn Olive (*Elaeagnus umbellata*)
Huckleberry (*Gaylussacia baccata*)
Lambkill (*Kalmia angustifolia*)
Mountain Laurel (*Kalmia latifolia*)
Rhododendron (*Rhododendron maximum*)
Pinkster Flower (*Rhododendron nudiflorum*)
High-bush Blueberry (*Vaccinium corymbosum*)
Low-bush Blueberry (*Vaccinium angustifolium*)
Partridge Berry (*Mitchella repens*)
Tartarian Honeysuckle (*Lonicera tatarica*)
Common Elderberry (*Sambucus canadensis*)
Red Elderberry (*Sambucus racemosa*)
Maple-leaved Viburnum (*Vibernum acerifolium*)
Checkerberry (*Gaultheria procumbrens*)

Flowers of the Forest and Forest Edge

Jack-in-the-Pulpit (*Arisaerna triphyllum*)
Lily-of-the-Valley (*Convallaria majalis*)
Day Lily (*Hemerocallis fulva*)
Trout Lily (*Erythronium americanum*)
Wild Lily-of-the-Valley (*Maianthemum canadense*)
Indian Cucumber (*Medeola virginiana*)
False Soloman's Seal (*Smilacina racemosa*)
Great Soloman's Seal (*Polygonatum canaliculatum*)
Greenbrier (*Smilax rotundifolia*)
Cat-Brier (*Smilax glauca*)
Carrion-flower (*Smilax herbacea*)
Painted Trillium (*Trillium undulatum*)
Pink Lady's Slipper (*Cypripedium acaule*)
Yellow-fringed Orchis (*Habenaria ciliaris*)
Ragged-fringed Orchis (*Habenaria lacera*)
Showy Orchis (*Orchis spectabilis*)
Downy Rattlesnake Plantain (*Goodyera pubscens*)
Whorled Pogonia (*Isotria verticillata*)
Lamb's Quarters (*Chenopodium album*)
Pokeweed (*Phytolacca americana*)
Spring Beauty (*Claytonia virginica*)
Deptford Pink (*Dianthus armeria*)
Starry Campion (*Silene stellata*)
Bladder Campion (*Silene cacubalus*)
Fire Pink (*Silene virginica*)
Bugbane (*Cimicifuga racemosa*)
Wild Columbine (*Aquilegia canadensis*)
Hepatica (*Hepatica americana*)
May Apple (*Podophyllum peltatum*)
Bloodroot (*Sanguinaria canadensis*)
Celandine (*Chelidonium majus*)
Common Wintercress (*Barbarea vulgaris*)
Round-leaved Sundew (*Drosera rotundifolia*)
Common Cinquefoil (*Potentilla simplex*)
Crown Vetch (*Coronilla varia*)
Rabbit's-foot Clover (*Trifolium arvense*)
Red Clover (*Trifolium pratense*)
White Clover (*Trifolium repens*)
Common Wood Sorrel (*Oxalis montana*)
Yellow Wood Sorrel (*Oxalis europaea*)
Erect Wood Sorrel (*Oxalis stricta*)
Fringed Polygala (*Polygala paucifolia*)
Spotted Touch-Me-Not (*Impatiens capensis*)
Pale Touch-Me-Not (*Impatiens pallida*)
Northern Blue Violet (*Viola septentrionalis*)
Sweet White Violet (*Viola blanda*)
Downy Yellow Violet (*Viola pubescens*)
Bristly Sarsaparilla (*Aralia hispida*)
Dwarf Ginseng (*Panax trifolium*)
Round-leaved Pyrola (*Pyrola rotundifolia*)
Pipsissewa (*Chimaphila umbellata*)
Spotted Wintergreen (*Chimaphila maculata*)
Trailing Arbutus (*Epigaea repens*)
Indian-Pipe (*Monotropa uniflora*)
Pine-Sap (*Monotropa hypopithys*)
Pimpernel (*Anagallis arvensis*)
Whorled Loosetrife (*Lysimachia quadrifolia*)
Starflower (*Trientalis borealis*)
Butterfly-weed (*Asclepias tuberosa*)
Common Milkweed (*Asclepias syriaca*)
Swamp Milkweed (*Asclepias incarnata*)
Viper's Bugloss (*Echium vulgare*)
Gill-over-the-Ground (*Glechoma hederacea*)
Basil Balm (*Monarda clinopodia*)
Wild Bergamot (*Monarda fistulosa*)
Selfheal (*Prunella vulgaris*)
Common Mullein (*Verbascum thapsus*)
Common Speedwell (*Veronica officinalis*)
Squawroot (*Conopholis americana*)
Venus' Looking-glass (*Specularia perfoliata*)
Cardinal Flower (*Lobelia cardinalis*)
Pearly Everlasting (*Anaphalis margaritacea*)
Common Ragweed (*Ambrosia artemisiifolia*)

Common Burdock (*Arctium minus*)
Spotted Knapweed (*Centaurea maculosa*)
Wild Lettuce (*Lactuca canadensis*)
Wavy-leaved Aster (*Aster undulatus*)
Large-leaved Aster (*Aster macrophyllus*)
Sweet Joe-Pye Weed (*Eupatorium purpureum*)
Trumpetweed (*Eupatorium fistulosum*)
White Snakeroot (*Eupatorium rugosum*)
Daisy Fleabane (*Erigeron annuus*)
Woodland Sunflower (*Helianthus strumosus*)
Bull Thistle (*Cirsium vulgare*)
Canada Thistle (*Cirsium arvense*)
Common Chicory (*Cichorium intybus*)
Orange Hawkweed (*Hieracium aurantiacum*)
Mouse-ear Hawkweed (*Hieracium pilosella*)
Rattlesnake Weed (*Hieracium venosum*)
Two-flowered Cynthia (*Krigia biflora*)
Downy Goldenrod (*Solidago puberula*)

New Plants from Followup Inventory

Beaver-poison (*Cicuta maculata* L.var. *maculata*)
Honewort (*Crytotaenia canadensis* (L.)DC.)
Thin-leaved sunflower (*Helianthus decapetalus* L.)
Cutleaf coneflower (*Rudbeckia laciniata* L.)
Heath aster (*Aster pilosus* Willd. var.)
Canada goldenrod (*Solidago canadensis* L. var.)
Marsh watercress (*Rorippa palustris* (L.) Bess. ssp.)
Cardinal-flower (*Lobelia cardinalis* L.)
Meadow bottle gentian (*Gentiana clausa* Raf.)
Purple loosestrife (*Lythrum salicaria* L.)
Meadow-rue (*Thalictrum revolutum*)
False nettle (*Boehmeria cylindrica* (L.)Swartz var.)
Wood-nettle (*Laportea canadensis* (L.) Weddell)
Sedge (*Carex sp.*)
Sedge (*Carex debilis* Michx. var. debilis)
Sedge (*Carex pensylvanica* Lam.)
Common wood-rush (*Luzula echinata* (Small)F.J. Herm.)
Cutgrass (*Leersia virginica* Willd.)
Creeping (muhly *Muhlenbergia sobolifera* (Muhl.)Trin.)
Virginia wild-rye (*Elymus virginicus* L.)
Large Twayblade (*Liparis lilliifolia*)

2. Fungi

Slime molds (Myxomycetes)

Fuligo septica
Lycogala epidendrum
Stemonites splendens
Tubifera ferruginosa

Family Ceratiomyxaceae

Ceratiomyxa fruticulosa

(Family Unknown)

Apiosporina morbosa
Phaeocalicum polyporaeum
Massospora

Family Morchellaceae - Morels

Morchella conica
Morchella esculenta

Family Helvellaceae - Saddles

Helvella crispa (Fluted White Helvella)

Family Sarcosomataceae - Cup fungi on wood

Galiella rufa (Hairy Rubber Cup)

Family Pezizaceae

Peziza succosa

Family Pyronemataceae

Otidia grandis
Scutellinia scutellatus (Eyelash Cup)

Family Geoglossaceae

Geoglossum difforme
Triglossum hirsutum (Velvety Earth Tongue)

Family Dermatiaceae

Chlorociboria aeruginescens (Green Stain)

Family Leotiaceae

Bisporella citrina (Yellow Fairy Cups)
Leotia lubrica (Ochre Jelly Cup)
Cudonia lutea

Family Hypocreaceae

Hypomyces chrysospermus (Golden Hypomyces)
Hypomyces hyalinus (Amanita Mold)
Hypomyces lactifluorum (Lobster Mushroom)
Hypomyces luteovirens (Yellow-green Hypomyces)

Family Xylariaceae

Daldinia concentrica (Carbon Balls)

Family Tremellaceae
Pseudohydnum gelatinosum (Jelly Tooth)
Tremella foliacea (Jelly Leaf)
Tremella mesenterica (Witches' Butter)
Tremellodendron pallidum (Jellied False Coral)

Family Auriculariaceae
Auricularia auricula (Tree-Ear)

Family Dacrymycetaceae
Dacrymyces palmatus (Orange Jelly)

Family Cantharellaceae - chanterelles
Cantharellus cibarius (Chanterelle)
Cantharellus cinnabarinus (Cinnabar-red Chanterelle)
Cantharellus lateritius (Smooth Chanterelle)
Cantharellus minor (Small Chanterelle)
Cantharellus xanthopus (Yellow-footed Chanterelle)
Craterellus cornucopioides (Horn-o-Plenty)

Family Clavariaceae - Coral fungi
Clavaria amethystina (Violet-branched Coral)
Clavicorona pyxidata (Crown-tipped Coral)
Clavulina cristata (Crested Coral)
Clavulinopsis fusiformis (Spindle-shaped Yellow Coral)
Clavulinopsis helvola
Clavulinopsis pulchra
Ramaria testaceo-flava

Family Hydnaceae - Toothed fungi
Hericium erinaceus
Hydnellum scrobiculatum
Phellodon confluens

Family Hymenochaetaceae
Hydnochaete olivaceum (Brown-toothed Crust)

Family Polyporaceae - Polypores
Albatrellus cristatus (Crested Polypore)
Coltricia cinnamomea (Shiny Cinnamon Polypore)
Daedalia quercina (Thick-maze Oak Polypore)
Daedaleopsis confragosa (Thin-maze Flat Polypore)
Ganoderma applanatum (Artist's Conk)
Ganoderma tsugae (Hemlock Varnish Shelf)
Irpex lacteus (Milk-white Toothed Polypore)
Laetiporus sulphureus (Chicken Mushrooms)
Lenzites betulina (Multicolor Gill Polypore)
Phellinus gilvas (Mustard-yellow Polypore)
Phellinus igniarius (Flecked-flesh Polypore)
Phellinus radiatus
Polyporus varius (Elegant Polypore)
Polyporus mori
Polyporus melanopus
Porodisculus pendulus (Pendulous-disc Polypore)
Spongipellus pachyodon (Spongy Toothed Polypore)
Trametes versicolor
Trichaptum biform (Violet Toothed Polypore)
Tyromyces chioneus (White Cheese Polypore)

Family Schizophyllaceae
Schizophyllum commune (Common Split Gill)

Family Stereaceae
Stereum complicatum (Crowded Parchment)
Stereum ochraceo-flavus
Stereum ostrea (False Turkey-tail)

Family Thelephoracea
Thelephora terrestris
Thelephora vialis

Family Agaricaceae
Agaricus pocillator
Lepiota procera (Parasol Mushroom)

Family Amanitaceae
Amanita albocreata
Amanita banningiana
Amanita brunnescens brunnescens (Cleft-foot Amanita)
Amanita brunnescens pallida
Amanita ceciliae
Amanita cothurnata (Booted Amanita)
Amanita crenulata
Amanita daucipes
Amanita dolichopus
Amanita farinosa (Powder-cap Amanita)
Amanita flavoconia (Yellow Patches)
Amanita flavorubescens (Yellow Blusher)
Amanita franchetii
Amanita fulva (Tawny Grisette)
Amanita gemmata (Gemmed Amanita)
Amanita muscaria formosa (Yellow-orange Fly Agaric)
Amanita pachycolea
Amanita psuedovolvata
Amanita ropalopus

Amanita rubescens (Blusher)
Amanita vaginata (Grisette)
Amanita virosa (Destroying Angel)
Amanita volvata (Volvate Amanita)

Family Boletaceae

Boletinellus merulioides
Boletus affinis maculosus (Spotted Bolete)
Boletus auripes
Boletus auriporus
Boletus badius
Boletus bicolor (Two-color Bolete)
Boletus chrysenteron (Red-cracked Bolete)
Boletus fulvus
Boletus innixus
Boletus ornatipes (Ornate-stalked Bolete)
Boletus pallidus
Boletus parasiticus (Parasitic Bolete)
Boletus separans
Boletus subtomentosus
Boletus variipes
Gyroporus castanea (Chestnut Bolete)
Leccinum aurantiacum (Red-capped Scaber Stalk)
Leccinum insigne
Leccinum scabrum (Common Scaber Stalk)
Strobilomyces floccupus (Old Man of the Woods)
Suillus americanus (American Suillus)
Suillus pictus (Painted Suillus)
Suilles tomentosus (Tomentose Suillus)
Tylopilus alboater (Black Velvet Bolete)
Tylopilus eximius (Lilac-brown Bolete)
Tylopilus felleus (Bitter Bolete)
Tylopilus plumboviolaceus (Violet-gray Bolete)
Tylopilus rubrobrunneus

Family Coprinaceae

Coprinus silvaticus
Panaeolus retirugis
Panaeolus semiovatus (Semi-ovate Panaeolus)
Psathyrella candolleana (Common Psanthyrella)
Psathyrella conissans
Psathyrella delineata
Psathyrella hirta
Psathyrella rugocephala (Corrugated-cap Psanthyrella)

Family Cortinariaceae

Cortinarius alboviolaceous (Silvery-violet Cort)
Cortinarius anomalus
Cortinarius armillatus
Cortinarius decipiens
Cortinarius glaucopus (Bulbous Cort)
Cortinarius iodes (Viscid Violet Cort)
Cortinarius traganus
Gymnopilus penetrans
Inocybe calamistrata
Inocybe calospora
Inocybe fastigiata (Straw-colored Fiber Head)
ocybe fuscodisca (Black-nipple Fiber Head)
Inocybe lanuginosa (Woolly Fiber Head)
Inocybe pyriodora

Family Crepidotaceae

Crepidotus applanatus (Flat Crep)
Crepidotus mollis
Crepidotus nephrodes

Family Entolomataceae

Entoloma alboumbonatum
Entoloma griseum
Entoloma murii (Yellow Unicorn Entoloma)
Entoloma salmoneum (Salmon Unicorn Entoloma)
Entoloma sinuatum
Entoloma strictius (Straight-stalked Entoloma)
Entoloma violaceum

Family Hygrophoraceae

Camarophyllus pratensis
Camarophyllus pudorinus
Hygrocybe cantharellus (Chanterelle Waxy Cap)
Hygrocybe marginatus (Orange-gilled Waxy Cap)

Family Paxillaceae

Paxillus atrotomentosus (Velvet-footed Pax)
Paxillus involutus (Poison Paxillus)
Paxillus panuoides
Phylloporus rhodoxanthus (Gilled Bolete)

Family Plutaceae

Pluteus aurnatiorugosus (Golden Granular Pluteus)
Pluteus cervinus (Fawn Mushroom)
Pluteus leoninus

Family Russulaceae

Lactarius affinis
Lactarius allardii
Lactarius aquifluus (Burnt-sugar Milky)
Lactarius camphoratus (Aromatic Milky)
Lactarius chrysorrheus
Lactarius corrugis (Corrugated-cap Milky)

Lactarius croceus
Lactarius deceptivus (Deceptive Milky)
Lactarius fumosus
Lactarius gerardii (Gerard's Milky)
Lactarius luteolus (Buff Fishy Milky)
Lactarius peckii
Lactarius piperatus (Peppery Milky)
Lactarius rufus (Red-hot Milky)
Lactarius subgerardii
Lactarius subvellereus
Lactarius uvidus (Common Violet-latex Milky)
Lactarius vinaceorufescens (Yellow-latex Milky)
Russula abietina
Russula aeruginea (Tacky Green Russula)
Russula albella
Russula amygdaloides
Russula appalachiensis
Russula brevipes
Russula brunneoviolacea
Russula cicatricata
Russula claroflava (Graying Yellow Russula)
Russula compacta (Firm Russula)
Russula corallina
Russula corinthiirubra
Russula crustosa
Russula cyanoxantha
Russula decolorans
Russula decora
Russula earlei
Russula elaeodes
Russula emetica
Russula faginea
Russula fragiloides
Russula fulvescens
Russula heterophylla
Russula inopina
Russula integra
Russula krombholtzii (Blackish-red Russula)
Russula levyana
Russula lutea
Russula magna
Russula mariae (Purple-bloom Russula)
Russula melliolens
Russula modesta
Russula ochroleucoides
Russula ornaticeps
Russula perplexa
Russula praeumbonata
Russula pulchra
Russula pusilla
Russula redeolens
Russula rosea
Russula rubriceps
Russula silvicola
Russula subfoetens
Russula subfragilis
Russula subsericeonitens
Russula subvelutina
Russula vinacea
Russula virescens
Russula xerampalina

Family Strophariaceae

Naematoloma capnoides
Naematoloma sublateritium
Pholiota aurivella

Family Tricholomataceae

Armillariella mellea
Cantharellula umbonata (Grayling)
Clitocybe dilatata (Crowded White Clitocybe)
Clitocybe gibba (Funnel Clitocybe)
Clitocybe intermedia
Clitocybe odora (Anise-scented Clitocybe)
Clitocybe suaveolens (Fragrant Clitocybe)
Clitocybe subbulbipes
Collybia acervata (Clustered Collybia)
Collybia dryophila (Oak-loving Collybia)
Collybia maculata (Spotted Collybia)
Cyptotrama chrysopeplum
Laccaria amethystina
Laccaria laccata (Common Laccaria)
Laccaria ochropurpurea (Purple-gilled Laccaria)
Lentinellus ursinus
Marasmius androsaceus
Marasmius cohaerens (Fused Marasmius)
Marasmius delectans
Marasmius olidus
Marasmius peronatus
Marasmius plicatulus (Velvet-cap Marasmius)
Marasmius rotula (Pinwheel Marasmius)
Marasmius scorodonius (Garlic Marasmius)
Marasmius siccus (Orange Pinwheel Marasmius)
Melanoleuca alboflavida (Yellow-white Melanoleuca)
Mycena fusco-occula
Mycena galericulata (Common Mycena)
Omphalina ectypoides
Omphalina wynniae
Omphalotus illudens (Jack O' Lantern)
Oudemansiella platyphylla
Oudemansiella radicata (Rooted Oudemansiella)
Panellus stipticus (Luminescent Panellus)

Phyllotopsis nidulans (Orange Mock Oyster)
Pleurocybella porrigens (Angel's Wings)
Pleurotus ostreatus (Oyster Mushroom)
Rickenella fibula
Tricholoma flavovirens (Canary Trich)
Tricholomopsis rutilans (Variegated Mop)
Xeromphalina campanella (Fuzzy Foot)
Xerula furfuracea

Family Lycoperdaceae
Lycoperdon echinatum (Spiny Puffball)
Lycoperdon perlatum (Gem-studded Puffball)
Lycoperdon pyriforme (Pear-shaped Puffball)

Family Nidulariaceae
Crucibulum laeve (White-egg Bird's Nest)
Cyathus stercoreus

Family Phallaceae
Dictyophora duplicata
Mutinus elegans (Elegant Stinkhorn)

Family Sclerodermataceae
Scleroderma aurantium

Family Calostomataceae
Calostoma cinnabarinus (Sheep's Eyes)

3. Mammals

Virginia Opossum *(Didelphis marsupialis)*
Masked Shrew *(Sorex cinereus)*
Smoky Shrew *(Sorex fumeus)*
Pygmy Shrew *(Microsorex hoyi)*
Northern Short-tailed Shrew *(Blarina brevicauda)*
Little Brown Myotis *(Myotis lucifugus)*
Big Brown Bat *(Eptesicus fuscus)*
Red Bat *(Lasiurus borealis)*
Eastern Pipistrel *(Pipistrellus subflavus)*
Black Bear *(Ursus americanus)*
Raccoon *(Procyon lotor)*
Long-tailed Weasel *(Mustela frenata)*
Mink *(Mustela vison)*
Striped Skunk *(Mephitis mephitis)*
Coyote *(Canis latrans)*
Gray Fox *(Urocyon cinereoargenteus)*
Red Fox *(Vulpes fulva)*
Bobcat *(Lynx rufus)*
Woodchuck *(Marmota monax)*
Eastern Chipmunk *(Tamias striatus)*
Eastern Gray Squirrel *(Sciurus carolinensis)*
Eastern Fox Squirrel (Extirpated) *(Sciurus niger)*
Red Squirrel *(Tamiasciurus hudsonicus)*
Southern Flying Squirrel *(Glaucomys volans)*
Beaver *(Castor canadensis)*
Allegheny Woodrat (Extirpated) *(Neotoma magister)*
Norway Rat (Extirpated) *(Rattus norvegicus)*
House Mouse (Introduced) *(Mus musculus)*
White-footed Mouse *(Peromyscus leucopus)*
Boreal Redback Vole *(Clethrionomys gapperi)*
Meadow Vole *(Microtus pennsylvanicus)*
Pine Vole *(Pitymis pinetorum)*
Eastern Mole *(Scalopus aquaticus)*
Woodland Jumping Mouse *(Napaeozapus insignis)*
Porcupine *(Erethiszon dorsatum)*
Eastern Cottontail *(Sylvilagus floridanus)*
Virginia Whitetail Deer *(Odocoileus virginanus)*

4. Reptiles

Snapping Turtle *(Chelydra serpentina)*
Spotted Turtle *(Clemmys guttata)*
Wood Turtle *(Clemmys insculpta)*
Eastern Box Turtle *(Terrapene carolina carolina)*
Midland Painted Turtle *(Chrysemys picta marginata)*
Northern Water Snake *(Natrix sipedon)*
Northern Brown Snake *(Storeria dekayi)*
Northern Redbelly Snake *(Storeria occipitomaculata)*
Eastern Garter Snake *(Thamnophis sirtalis)*
Eastern Hognose Snake *(Heterodon platyrhinos)*
Northern Ringneck Snake *(Diadophis punctatus)*
Northern Black Racer *(Coluber constrictor)*
Smooth Green Snake *(Opheodrys vernalis)*
Black Rat Snake *(Elaphe obsoleta)*
Eastern Milk Snake *(Lampropeltis triangulum)*
Northern Copperhead *(Agkistrodon contortrix)*
Timber Rattlesnake *(Crotalus horridus)*
Five-lined Skink *(Eumeces fasciatus)*

5. Amphibians

Spotted Salamander *(Ambystoma maculatum)*
Marbled Salamander *(Ambystoma opacum)*
Red-spotted Newt *(Notophthalmus viridescens)*
Northern Dusky Salamander *(Desmognathus fuscus)*
Red-backed Salamander *(Plethodon cinereus cinereus)*
Slimy Salamander *(Plethodon glutinosis)*
Spring Salamander *(Gyrinophilus porphyriticus)*
Northern Red Salamander *(Pseudotriton ruber)*

Northern Two-lined Salamander (*Eurycea bislineata*)
Long-tailed Salamander (*Eurycea longicauda*)
American Toad (*Bufo americanus*)
Spring Peeper (*Hyla crucifer*)
Gray Treefrog (*Hyla versicolor*)
Bullfrog (*Rana catesbiana*)
Green Frog (*Rana clamitans melanota*)
Pickerel Frog (*Rana palustris*)
Wood Frog (*Rana sylvatica*)

6. Fish

(Species found by PA Fish and Boat Commission on Little Schuylkill River, Kettle Creek and other Pine Creek Tributaries)

Fallfish (*Semotilus corporalis*)
Creek Chub (*Semotilus atromaculatus*)
Rainbow Trout (*Oncorhynchus mykiss*)
Creek Chubsucker (*Erimyzon oblongus*)
White Sucker (*Catostomus commersoni*)
Margined Madtom (*Notorus insignis*)
Pumpkinseed (*Lepomis gibbosus*)
Bluegill (*Lepomis macroshirus*)
Largemouth Bass (*Micropterus salmoides*)
Smallmouth Bass (*Micropterus dolomieui*)
Brook Trout (*Salvelinus fontinalis*)
Rock Bass (*Ambloplites rupestris*)
Cutlips Minnow (*Exoglossum maxillingua*)
Blacknose Dace (*Rhinichthys atratulus*)
Longnose Dace (*Rhinichthys cataractae*)
Common Shiner (*Luxilus cornatus*)
Tessellated Darter (*Etheostoma olmstedi*)

7. Birds

Red-throated Loon (*Gavia stellata*)
Common Loon (*Gavia immer*)
Horned Grebe (*Podiceps auritus*)
Red-necked Grebe (*Podiceps grisegena*)
Double-crested Cormorant (*Phalacrocorax auritus*)
American Bittern (*Botaurus lentiginosus*)
Great Blue Heron (*Ardea herodias*)
Great Egret (*Casmerodius albus*)
Snowy Egret (*Egretta thula*)
Tricolored Heron (*Egretta tricolor*)
Green-backed Heron (*Butorides striatus*)
Black-crowned Night-Heron (*Nycticorax nycticorax*)
Yellow-crowned Night-Heron (*Nycticorax violaceus*)
White Ibis (*Eudocimus albus*)
Glossy Ibis (*Plegadis falcinellus*)
Tundra Swan (*Cygnus columbianus*)
Mute Swan (*Cygnus olor*)
Snow Goose (*Chen caerulescens*)
Brant (*Branta bernicla*)
Canada Goose (*Branta canadensis*)
Wood Duck (*Aix sponsa*)
Green-winged Teal (*Anas crecca*)
American Black Duck (*Anas rubripes*)
Mallard (*Anas platyrhynchos*)
Northern Pintail (*Anas acuta*)
Blue-winged Teal (*Anas discors*)
American Widgeon (*Anas americana*)
Canvasback (*Aythya valisineria*)
Redhead (*Aythya americana*)
Lesser Scaup (*Aythya affinis*)
Oldsquaw (*Clangula hyemalis*)
Black Scoter (*Melanitta nigra*)
White-winged Scoter (*Melanitta fusca*)
Bufflehead (*Bucephala albeola*)
Common Merganser (*Mergus merganser*)
Red-breasted Merganser (*Mergus serrator*)
Black Vulture (*Coragyps atratus*)
Turkey Vulture (*Cathartes aura*)
Osprey (*Pandion haliaetus*)
Bald Eagle (*Haliaeetus leucocephalus*)
Northern Harrier (*Circus cyaneus*)
Sharp-shinned Hawk (*Accipiter striatus*)
Cooper's Hawk (*Accipiter cooperii*)
Northern Goshawk (*Accipiter gentilis*)
Red-shouldered Hawk (*Buteo lineatus*)
Broad-winged Hawk (*Buteo platypterus*)
Swainson's Hawk (*Buteo swainsoni*)
Red-tailed Hawk (*Buteo jamaicensis*)
Rough-legged Hawk (*Buteo lagopus*)
Golden Eagle (*Aquila chrysaetos*)
American Kestrel (*Falco sparverius*)
Merlin (*Falco columbarius*)
Peregrine Falcon (*Falco peregrinus*)
Gyrfalcon (*Falco rusticolus*)
Ring-necked Pheasant (*Phasianus colchicus*)
Ruffed Grouse (*Bonasa umbellus*)
Wild Turkey (*Meleagris gallopavo*)
Northern Bobwhite (*Colinus virginianus*)
Virginia Rail (*Rallus limicola*)
Sora (*Porzana carolina*)
American Coot (*Fulica americana*)
Sandhill Crane (*Grus canadensis*)
Black-bellied Plover (*Pluvialis squatarola*)
Lesser Golden Plover (*Pluvialis dominica*)
Killdeer (*Charadrius vociferus*)
American Avocet (*Recurvirostra americana*)
Greater Yellowlegs (*Tringa melanoleuca*)
Lesser Yellowlegs (*Tringa flavipes*)

Solitary Sandpiper *(Tringa solitaria)*
Willet (*Catoptrophorus semipalmatus*)
Spotted Sandpiper *(Actitis macularia)*
Upland Sandpiper (*Bartramia longicauda*)
Ruddy Turnstone *(Arenaria interpres)*
Semipalmated Sandpiper (*Calidris pusilla)*
Least Sandpiper *(Calidris minutilla*)
Pectoral Sandpiper) *(Calidris melanotos)*
Dunlin (*Calidris alpina)*
Long-billed Dowitcher *(Limnodromus scolopaceus*)
Common Snipe (*Gallinago gallinago*)
American Woodcock *(Scolopax minor*)
Bonaparte's Gull (*Larus philadelphia)*
Ring-billed Gull *(Larus delawarensis)*
Herring Gull (*Larus argentatus)*
Lesser Black-backed Gull *(Larus fuscus)*
Great Black-backed Gull (*Larus marinus)*
Sabine's Gull (*Xema sabini)*
Common Tern *(Sterna hirundo)*
Rock Dove *(Columba livia*)
Mourning Dove (*Zenaida macroura)*
Black-billed Cuckoo *(Coccyzus erythropthalmus*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Common Barn Owl (*Tyto alba)*
Eastern Screech-Owl *(Otus asio)*
Great Horned Owl (*Bubo virginianus*)
Barred Owl *(Strix varia)*
Long-eared Owl *(Asio otus)*
Short-eared Owl (*Asio flammeus)*
Northern Saw-whet Owl *(Aegolius acadicus*)
Common Nighthawk (*Chordeiles minor)*
Chuck-will's-widow *(Caprimulgus carolinensis*)
Whip-poor-will *(Caprimulgus vociferus*)
Chimney Swift *(Chaetura pelagica)*
Ruby-throated Hummingbird (*Archilochus colubris)*
Belted Kingfisher *(Ceryle alcyon*)
Red-headed Woodpecker (*Melanerpes erythrocephalus)*
Red-bellied Woodpecker (*Melanerpes carolinus*)
Yellow-bellied Sapsucker *(Sphyrapicus varius)*
Downy Woodpecker *(Picoides pubescens*)
Hairy Woodpecker *(Picoides villosus)*
Black-backed Woodpecker (*Picoides arcticus)*
Northern Flicker *(Colaptes auratus)*
Pileated Woodpecker (*Dryocopus pileatus)*
Olive-sided Flycatcher *(Contopus borealis)*
Eastern Wood-Pewee (*Contopus virens)*
Yellow-bellied Flycatcher *(Empidonax flaviventris*)
Acadian Flycatcher (*Empidonax virescens)*
Alder Flycatcher *(Empidonax alnorum)*
Least Flycatcher *(Empidonax minimus)*
Eastern Phoebe (*Sayornis phoebe*)
Great-crested Flycatcher *(Myiarchus crinitus*)
Eastern Kingbird *(Tyrannus tyrannus*)
Horned Lark (*Eremophila alpestris)*
Purple Martin *(Progne subis)*
Tree Swallow (*Tachycineta bicolor)*
Northern Rough-winged Swallow (*Stelgidopteryx serripennis)*
Bank Swallow (*Riparia riparia)*
Cliff Swallow (*Hirundo pyrrhonota*)
Barn Swallow *(Hirundo rustica)*
Blue Jay (*Cyanocitta cristata*)
American Crow (*Corvus brachyrhynchos*)
Fish Crow *(Corvus ossifragus*)
Common Raven (*Corvus corax)*
Carolina Chickadee (*Poecile carolinensis*)
Black-capped Chickadee (*Poecile atricapillus*)
Boreal Chickadee *(Poecile hudsonicus*)
Tufted Titmouse *(Baeolophus bicolor)*
Red-breasted Nuthatch *(Sitta canadensis)*
White-breasted Nuthatch (*Sitta carolinensis*)
Brown Creeper *(Certhia americana)*
Carolina Wren (*Thryothorus ludovicianus)*
Bewick's Wren (*Thryomanes bewickii*)
House Wren (*Troglodytes aedon)*
Winter Wren (*Troglodytes troglodytes*)
Marsh Wren (*Cistothorus palustris*)
Golden-crowned Kinglet *(Regulus satrapa)*
Ruby-crowned Kinglet *(Regulus calendula*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Eastern Bluebird (*Sialia sialis)*
Townsend's Solitaire (*Myadestes townsendi)*
Veery (*Catharus fuscescens*)
Gray-cheeked Thrush *(Catharus minimus*)
Swainson's Thrush (*Catharus ustulatus)*
Hermit Thrush (*Catharus guttatus)*
Wood Thrush (*Hylocichla mustelina*)
American Robin (*Turdus migratorius*)
Gray Catbird (*Dumetella carolinensis*)
Northern Mockingbird (*Mimus polyglottos*)
Brown Thrasher *(Toxostoma rufum*)
Water Pipit *(Anthus spinoletta*)
Bohemian Waxwing (*Bombycilla garrulus*)
Cedar Waxwing (*Bombycilla cedrorum*)
Northern Shrike (*Lanius excubitor*)
European Starling *(Sturnus vulgaris)*
White-eyed Vireo (*Vireo griseus*)
Blue-headed Vireo *(Vireo solitaruis*)
Yellow-throated Vireo (*Vireo flavifrons)*
Warbling Vireo (*Vireo gilvus)*
Philadelphia Vireo (*Vireo philadelphicus*)
Red-eyed Vireo (*Vireo olivaceus*)
Blue-winged Warbler *(Vermivora pinus)*

"Brewster's" Warbler (*Vermivora pinus x Vermivora chrysoptera)*
Golden-winged Warbler *(Vermivora chrysoptera)*
Tennessee Warbler *(Verivora peregrina)*
Orange-crowned Warbler *(Vermivora celata)*
Nashville Warbler (*Vermivora ruficapilla)*
Northern Parula (*Parula americana)*
Yellow Warbler *(Dendroica petechia)*
Chestnut-sided Warbler (*Dendroica pensylvanica)*
Magnolia Warbler (*Dendroica magnolia)*
Cape May Warbler (*Dendroica tigrina)*
Black-throated Blue Warbler (*Dendroica caerulescens)*
Yellow-rumped Warbler (*Dendroica coronata)*
Black-throated Green Warbler (*Dendroica virens)*
Blackburnian Warbler (*Dendroica fusca)*
Yellow-throated Warbler (*Dendroica dominica)*
Pine Warbler (*Dendroica pinus)*
Prairie Warbler *(Dendroica discolor)*
Palm Warbler (*Dendroica palmarum)*
Bay-breasted Warbler (*Dendroica castanea)*
Blackpoll Warbler *(Dendroica striata)*
Cerulean Warbler (*Dendroica cerulea)*
Black-and-white Warbler (*Mniotilta varia)*
American Redstart (*Setophaga ruticilla)*
Prothonotary Warbler (*Protonotaria citrea)*
Worm-eating Warbler *(Helmitheros vermivorus)*
Ovenbird *(Seiurus aurocapillus)*
Northern Waterthrush (*Seiurus noveboracensis)*
Louisiana Waterthrush *(Seiurus motacilla)*
Kentucky Warbler (*Oporornis formosus)*
Connecticut Warbler *(Oporornis agilis)*
Mourning Warbler (*Oporornis philadelphia)*
Common Yellowthroat *(Geothlypis trichas)*
Hooded Warbler *(Wilsonia citrina)*
Wilson's Warbler *(Wilsonia pusilla)*
Canada Warbler *(Wilsonia canadensis)*
Yellow-breasted Chat *(Icteria virens)*
Summer Tanager *(Piranga rubra)*
Scarlet Tanager *(Piranga olivacea)*
Northern Cardinal *(Cardinalis cardinalis)*
Rose-breasted Grosbeak *(Pheucticus ludovicianus)*
Blue Grosbeak (*Guiraca caerulea)*
Indigo Bunting (*Passerina cyanea)*
Dickcissel *(Spiza americana)*
Eastern Towhee *(Pipilo erythrophthalmus)*
American Tree Sparrow *(Spizella arborea)*
Chipping Sparrow *(Spizella passerina)*
Field Sparrow *(Spizella pusilla)*
Vesper Sparrow (*Pooecetes gramineus)*
Savannah Sparrow (*Passerculus sandwichensis)*
Grasshopper Sparrow (*Ammodramus savannarum)*
Henslow's Sparrow (*Ammodramus henslowii)*
Fox Sparrow *(Passerella iliaca)*
Song Sparrow *(Melospiza melodia)*
Lincoln's Sparrow *(Melospiza lincolnii)*
Swamp Sparrow (*Melospiza georgiana)*
White-throated Sparrow (*Zonotrichia albicollis)*
White-crowned Sparrow (*Zonotrichia leucophrys)*
Dark-eyed Junco *(Junco hyemalis)*
Lapland Longspur *(Calcarius lapponicus)*
Snow Bunting (*Plectrophenax nivalis)*
Bobolink *(Dolichonyx oryzivorus)*
Red-winged Blackbird (*Agelaius phoeniceus)*
Eastern Meadowlark (*Sturnella magna)*
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus)*
Rusty Blackbird (*Euphagus carolinus)*
Brewer's Blackbird *(Euphagus cyanocephalus)*
Common Grackle (*Quiscalus quiscula)*
Brown-headed Cowbird *(Molothrus ater)*
Orchard Oriole (*Icterus spurius)*
Baltimore Oriole *(Icterus galbula)*
Pine Grosbeak (*Pinicola enucleator)*
Purple Finch *(Carpodacus purpureus)*
House Finch *(Carpodacus mexicanus)*
Red Crossbill (*Loxia curvirostra)*
White-winged Crossbill (*Loxia leucoptera)*
Common Redpoll (*Carduelis flammea)*
Hoary Redpoll *(Carduelis hornemanni)*
Pine Siskin (*Carduelis pinus)*
American Goldfinch (*Carduelis tristis)*
Evening Grosbeak *(Coccothraustes vespertinus)*
House Sparrow (*Passer domesticus)*

8. Dragonflies

Common Whitetail Skimmer *(Libellula lydia)*
Slaty Skimmer *(Libellula incesta)*
Blue Dasher *(Pachydiplax longipennis)*
Ruby Meadowhawk *(Sympetrum rubicundulum)*
Powdered Dancer *(Argia moesta)*
Northern Bluet *(Enallagma cyathegerum)*
Ebony Jewelwing *(Calopteryx maculata)*
Stream Bluet *(Enallagma exulans)*
Eastern Forktail *(Ischnura verticalis)*
Royal River Cruiser *(Macromia taeniolata)*

9. Beetles

Family Carabidae (Ground Beetles)

Bradycellus tantillus
Notiobia (Anisotarsus) terminata
Selenophorus opalinus

Stenolophus (Agonoderus) comma
Stenolophus (Agonoderus) lecontei
Stenolophus (Stenolophus) ochropezus
Cymindis (Pinacodera) limbatus
Dromius piceus
Lebia fuscata
Lebia ornate
Lebia viridipennis
Lebia viridis
Pentagonica parmarginatus
Bembidion (Furcacampa) affine
Bembidion (Furcacampa) impotens
Paratachys oblitus
Paratachys proximus
Paratachys scitulus
Clivina bipustulata
Clivina impressefrons

Family Cerambycidae (Long-horned Beetles)

Urographis fasciatus
Phymatodes testaceus
Xylotrechus colonus
Xylotrechus sagittatus sagittatus
Anelaphus parallelus
Astylopsis sexguttatus
Monochamus notatus
Ecyrus dasycerus
Centrodera decolorata
Leptorhabidium pictum
Metacmaeops vittata
Strangalepta abbreviata
Strangalia luteicornis
Orthosoma brunneum

Family Silphidae (Carrion Beetles)

Nicrophorus orbicollis
Nicrophorus pustulatus
Nicrophorus sayi
Necrodes surinamensis

10. Flies

Family Tipulidae (Crane Flies)

Neocladura delicatula
Elephantomyia (Elephantomyia) westwoodi
Epiphragma (Epiphragma) fasciapennis
Limonia (Dicranomyia) liberta
Limonia (Limonia) indigena
Limonia (Metalimnobia) immature
Pedicia (Tricyphona) calcar
Pedicia (Tricyphona) inconstans
Dolichopeza (Oropeza) carolus
Nephrotoma alterna
Nephrotoma virescens
Tipula (Lindnerina) senega
Tipula (Lunatipula) apicalis
Tipula (Lunatipula) bicornis
Tipula (Lunatipula) duplex
Tipula (Lunatipula) fuliginosa
Tipula (Lunatipula) hirsuta
Tipula (Lunatipula) monticola
Tipula (Lunatipula) submaculata
Tipula (Lunatipula) valida
Tipula (Pterelachisus) entomophthorae
Tipula (Pterelachisus) trivittata
Tipula (Schummelia) hermannia
Tipula (Vestiplex) longiventris
Tipula (Yamatotipula) sayi

11. Butterflies

Family Papilionidae (Swallowtails)

Pipe-vine Swallowtail (*Battus philenor)*
Black Swallowtail *(Papilio polyxenes)*
Eastern Tiger Swallowtail (*Papilio glaucus)*
Spicebush Swallowtail (*Papilio troilus)*

Family Pieridae (Sulphurs)

Cabbage White (*Pieris rapae)*
Clouded Sulphur *(Colias philodice)*
Orange Sulphur (*Colias eurytheme*)
Cloudless Sulphur (*Phoebis sennae)*

Family Lycaenidae (Coppers and Blues)

American Copper (*Lycaena americana*)
Eastern Pine Elfin (*Callophrys niphon)*
Banded Hairstreak (*Satyrium calanus*)
Gray Hairstreak *(Strymon melinus)*
Red-banded Hairstreak (*Calycopis cecrops)*
Spring Azure *(Celastrina argiolus)*
Eastern Tailed Blue (*Everes comyntas)*

Family Nymphalidae (Brushfoots)

Great Spangled Fritillary (*Speyeria cybele)*
Aphrodite (*Speyeria aphrodite)*
Meadow Fritillary *(Boloria bellona)*
Variegated Fritillary (*Euptoieta claudia)*
Silvery Checkerspot (*Chlosyne nycteis)*
Pearl Crescent *(Phyciodes tharos)*
Question Mark (*Polygonia interrogationis*
Eastern Comma (*Polygonia comma)*

Compton's Tortoiseshell (*Nymphalis vau-album*)
Mourning Cloak (*Nymphalis antiopa*)
Buckeye (*Precis coenia*)
Red Admiral (*Vanessa atalanta*)
American Painted Lady (*Vanessa virginiensis*)
Painted Lady (*Vanessa cardui*)
Red-spotted Purple (*Limenitis arthemis astyanax*)

Subfamily Satyrinae (Satyrs and Nymphs)

Appalachian Brown (*Enodia appalachia*)
Northern Pearly Eye (*Enodia anthedon*)
Common Wood Nymph (*Cercyonis pegala*)
Little Wood Satyr (*Megisto cymela*)

Family Danaidae (Milkweed Butterflies)

Monarch (*Danaus plexippus*)

Subfamily Pyrginae (Open-winged Skippers)

Hoary Edge (*Achalarus lyciades*)
Silver-spotted Skipper (*Epargyreus clarus*)
Northern Cloudywing (*Thorybes pylades*)
Wild Indigo Duskywing (*Erynnis baptisiae*)
Juvenal's Duskywing (*Erynnis juvenalis*)
Sleepy Duskywing (*Erynnis brizo*)
Dreamy Duskywing (*Erynnis icelus*)
Common Sootywing (*Pholisora catullus*)
Checkered Skipper (*Pyrgus communis*)

Subfamily Hesperinae (True Skippers)

Swarthy Skipper (*Nastra lherminier*)
European Skipper (*Thymelicus lineola*)
Least Skipper (*Ancycloxypha numitor*)
Peck's Skipper (*Polites coras*)
Crossline Skipper (*Polites origenes*)
Long Dash (*Polites mystic*)
Indian Skipper (*Hesperia sassacus*)
Leonard's Skipper (*Hesperia leonardus*)
Northern Broken Dash (*Wallengrenia egeremet*)
Little Glassy-wing (*Pompeius verna*)
Delaware Skipper (*Atrytone logan*)
Dun Skipper (*Euphyes vestris*)
Zabulon Skipper (*Poanes zabulon*)
Hobomok Skipper (*Poanes hobomok*)

12. Moths

Family Apatelodidae (Apatelodid Moths)

Apatelodes torrefacta
Olceclostera angelica

Family Lasiocampidae (Tent Caterpillars and Lappet Moths)

Malacosoma americanum
Malacosoma Americana
Phyllodesma Americana
Tolype velleda

Family Saturniidae (Giant Silkworm Moths)

Anisota virginiensis
Dryocampa rubicunda
Actias luna

Family Sphingidae (Sphinx Moths)

Darapsa myron
Darapsa pholus
Deidamia inscripta
Paonias exaecatus
Dolba hyloeus
Lapara bombycoides
Sphinx gordius

Family Oecophoridae (Oecophorid Moths)

Machimia tentoriferella
Antaeotricha leucillana
Antaeotricha schlaegeri

Family Drepanidae (Hook-tip Moths)

Drepana arcuata
Oreta rosea

Family Epiplemidae (Epiplemid Moths)

Calledapteryx dryopterata

Family Geometridae (Inchworm Moths)

Heliomata cycladata
Anagoga occiduaria
Cepphis armataria
Metanema inatomaria
Metarranthis amyrisaria
Metarranthis duaria duaria
Metarranthis indeclinata
Metarranthis mestusata
Metarranthis refractaria
Plagodis alcoolaria
Plagodis fervidaria
Plagodis serinaria

Probole alienaria
Probole amicaria
Probole nepiasaria
Xanthotype urticaria
Euchlaena effecta
Euchlaena irraria
Euchlaena johnsonaria
Euchlaena obtusaria
Euchlaena serrata
Pero hubneraria
Pero morrisonaria
Biston betularia cognataria
Hypagyrtis unipunctata
Aethalura intertexta
Anacamptodes ephyraria
Anavitrinella pampinaria
Ectropis crepuscularia
Epimecis hortaria
Hesperumia sulphuraria
Iridopsis larvaria
Protoboarmia porcelaria porcelaria
Apodrepanulatrix liberaria
Campaea perlata
Ennomos magnaria
Ennomos subsignaria
Gueneria similaria
Homochlodes disconventa
Eufidonia notataria
Melanolophia canadaria crama
Melanolophia signataria
Nacophora quernaria
Antepione thisoaria
Besma endropiaria
Besma quercivoraria
Caripeta divisata
Eugonobapta nivosaria
Eusuarca confusaria
Eutrapela clemataria
Lambdina fervidaria athasaria
Lambdina fiscellaria fiscellaria
Nematocampa resistaria
Nepytia canosaria
Nepytia pellucidaria
Patalene olyzonaria puber
Prochoerdes transversata
Tetracis cachexiata
Itame argillacearia
Itame pustularia
Itame ribearia
Itame subcessaria
Semiothisa aemulataria
Semiothisa bicolorata
Semiothisa bisignata
Semiothisa fissinotata
Semiothisa granitata
Semiothisa minorata
Semiothisa signaria dispuncta
Chlorochlamys chloroleucaria
Hethemia pistasciaria pistasciaria
Nemoria bistriaria bistriara
Nemoria mimosaria
Hydrelia inornata
Hydrelia lucata
Trichodezia albovittata
Eubaphe mendica
Eupithecia spp.
Horisme intestinata
Anticlea multiferata
Dysstroma hersiliata hersiliata
Coryphista meadii
Eulithis diversilineata
Hydria prunivorata
Lobophora nivigerata
Euphyia unangulata intermediata
Orthonoma centrostrigaria
Orthonama obstipata
Xanthorhoe ferrugata
Xanthorhoe lacustrata
Cyclophora pendulinaria
Pleuroprucha insularia
Scopula limboundata
Idaea demissaria demissaria

Family Thyatiridae (Thyatirid Moths)

Habrosyne scripta
Pseudothyatira cymatophoroides

Family Mimallonidae (Sack-bearers)

Lacosoma chiridota

Family Arctiidae (Tiger Moths)

Apantesis nais
Grammia anna
Grammia virgo
Holomelina opella
Hyphantria cunea
Pyrrharctia isabella
Spilosoma congrua
Spilosoma latipennis
Spilosoma virginica
Haploa clymene
Cycnia tenera
Euchaetes egle
Halysidota tessellaris

Clemensia albata
Crambidia pallida

Family Lymantriidae (Tussock Moths)

Dasychira basiflava
Dasychira obliquata
Lymantria dispar
Orgyia definita
Orgyia leucostigma

Family Noctuidae (Noctuid Moths)

Cerma cerintha
Hyperstrotia secta
Lithacodia muscosula
Lithacodia musta
Maliattha synochitis
Pseudeustrotia carneola
Tarachidia erastrioides
Thioptera nigrofimbria
Acronicta americana
Acronicta exilis
Acronicta hasta
Acronicta increta
Acronicta innotata
Acronicta interrupta
Acronicta lobeliae
Acronicta ovata
Acronicta retardata
Acronicta superans
Agriopodes hebraeicum
Eudryas grata
Amphipoea americana
Amphipoea pyramidoides
Amphipoea tragopoginis
Anorthodes tarda
Balsa labecula
Balsa tristrigella
Callopistria mollissima
Chytonix palliatricula
Condica vecors
Cosmia calami
Elaphria festvoides complex
Elaphria versicolor
Euplexia benesimilis
Hyppa xylinoides
Magusa orbifera
Ogdoconta cinereola
Oligia crytora
Oligia illocata
Oligia modica
Papaipema impecuniosa
Papaipema inquaesita
Phlogophora iris
Phologophora periculosa
Phosphila miselioides
Phosphila turbulenta
Platyperigea multiflora
Spodoptera frugiperda
Allotria elonympha
Caenurgina elonympha
Caenurgina crassiusucula
Catocala amica complex
Catocala andromedae
Catocala antinympha
Catocala coccinata
Catocala ilia
Catocala micronympha
Catocala palaeogama
Catocala praeclara
Catocala sordida
Catocala ultronia
Euparthenos nubilis
Hypsoropha hormos
Metalectra discalis
Metalectra richardsi
Metalectra tantillus
Pangrapta decoralis
Panopoda carneicosta
Panopoda ruimargo
Parallelia bistriaris
Scoleocampa liburna
Spargaloma sexpunctata
Zale minerea
Anathix ralla
Chaetaglaea sericea
Eucirroedia pampina
Lithophane hemina
Sunira bicolorago
Paectes oculatrix
Achatia distincta
Crocigrapha normani
Homorthodes furfurata
Homorthodes lindseyi
Lacinipolia lorea
Lacinipolia renigera
Leucania linda
Leucania multilinea
Leucania phragmitidicola
Leucania ursula
Morrisonia confusa
Morrisonia evicta
Morrisonia latex
Nephelodes minians
Orthodes crenulata

Orthodes cynica
Polia detracta
Protorthodes oviduca
Pseudaletia unipuncta
Pseudorthodes vecors
Spiramater lutra
Trichordestra legitima
Ulolonche culea
Bleptina caradrinalis
Chytolita morbidalis
Idia aemula
Idia americalis
Idia diminuendis
Idia forbesi
Idia julia
Idia laureni
Idia lubricalis lubricalis
Idia rotundalis
Idia scobialis
Macrochilo orciferalis
Palthis angulatis
Palthis asopialis
Phalaenophana pyramusalis
Phalaenostola larentioides
Phalaenostola metonalis
Renia discoloralis
Renia factiosalis
Renia salusalis
Renai sobrialis
Zanclognatha cruralis
Zanclognatha jacchusalis
Zanclognatha laevigata
Zanclognatha lituralist
Zanclognatha ochreipennis ochreipennis
Zanclognatha protumnusalis
Bomolocha baltimoralis
Bomolocha madefactalis
Bomolocha palparia
Plathypena scabra
Dyspyralis puncticosta
Hypenodes caducus
Hypenodes fractilinea
Abagrotis alternata
Agnorisma badinodis
Agrotis ipsilon
Diarsia jucunda
Euretagrotis attenta
Euxoa (Euxoa) velleripennis
Feltia jaculifera
Heptagrotis phyllophora
Noctua pronuba
Ochropleura implecta
Peridroma saucia
Protolampra brunneicollis
Pseudohermonass bicarnea
Spaelotis clandestina
Trichosilia geniculata
Xestia (Megasema) dolosa
Xestia (Xestia) dilucida
Xestia (Xestia) normaniana
Xestia (Xestia) smithii
Meganola minuscula
Charadra deridens
Colocasia propinquilinea
Panthea furcilla
Raphia frater
Abrostola ovalis
Allagrapha aerea
Autographa precationis
Chrysanympha formosa
Pseudoplusia includens
Rivula propinqualis
Baileya opthalmica
Comachara cadburyi

Family Notodontidae (Prominents)

Heterocampa biundata
Heterocampa guttivitta
Heterocampa umbrata
Hyparpax aurora
Hyperaeschra georgica
Lochmaeus manteo
Macrurocampa marthesia
Oligocentria lignicolor
Oligocentria semirufescens
Schizura ipomoeae
Gluphisia septentrionis
Nadanta gibbosa
Odontosia elegans
Peridea angulosa
Peridea ferruginea
Symmerista canicosta
Datana ministra
Clostera albosigma

Family Pyralidae (Pyralid Moths)

Desmia funeralis
Pantographa limata

Family Sesiidae (Clear-winged Moths)

Synanthedon acerni

Family Tineidae (Clothes Moths)

Acrolophus arcanellus
Acrolophus morus
Acrolophus popeanellus

Family Limacodidae (Slug Caterpillars)

Adoneta spinuloides
Apoda biguttata
Apoda y-inversum y-inversum
Euclea delphinii
Isa textula
Lithacodes fasciola fasciola
Packardia albipunctata
Packardia geminata
Parasa chloris
Prolimacodes badia
Sibine stimulea
Tortricidia flexuoss
Tortricidia pallida
Tortricidia testacea testacea

Family Zygaenidae (Smoky Moths)

Pyromorpha dimidiata

13. Tardigrades (Water Bears)

Minibiotus intermedius
Macrobiotus cf. echinogenitus
Milnesium tardigradum
Diphascon pingue
Diphascon propsirostre
Diphascon simplex
Macrobiotus simplex

Appendix B
Considerations for Deer Management

Pellet Group Count Technique for Deer Population Estimation

The technique requires counting all the deer pellet groups in a known area (representative of the property as a whole), determining how long they could have accumulated there, assuming a standard defecation rate, and extrapolating the resulting density of deer to the entire area from which the sample was taken. The standard sample area is a two-mile transect six feet wide, with a recommended hourglass configuration. A pellet group is counted if as at least 10 pellets fall within the sample area (3 feet on either side of transect). The accumulation time for the fecal pellets depends on leaf fall, snowfall, or deterioration rate. It is best to conduct a survey after snow cover has remained for some time or in the spring after snow melt. The pellet groups will not decompose over the winter, and this will allow you to assume the pellet groups have accumulated since the end of leaf fall (usually November 15). The Forest Service has done studies and shown that deer defecate in observable pellet groups approximately 13.5 times per day.

A survey is best conducted using two people, one to keep the compass bearing and pacing, and the second to count pellet groups. The only required equipment is a compass and a tallywhacker. The process begins by laying out the transect on a property map, with care taken to represent the entire major topographic and cover-type features. The next step is to go to the field, walk the transect, and record all pellet groups found on the transect. Finally, plug the numbers into the following equation:

Deer density (deer/square mile) = number of groups/day x number of days accumulated x number of square miles sampled

The number of groups per day is 13.5, the number of days accumulated you must determine, and the number of square miles sampled in 0.0022727 (2 miles x 6 feet).

Elements of a Successful Deer Management Program

1. Consider increasing the effectiveness of individual hunters, possibly the new ones, through a proficiency test administered at least every five years. This will weed out hunters who are poor marksman, increase the chances of quick, clean kills, and increase the safety of other hunters and Sanctuary users. Consult with focus group of sanctuary hunters before implementing to ensure their support for this method.

2. Extend the hunting window by allowing archery and flintlock hunter's access to more remote areas of the Sanctuary during the early seasons.

3. Allow hunting in most of the Sanctuary during doe season.

4. Focus on removing does. Hunters should be informed that they are a critical part of a management program. The goal of the program, however, is not on trophy bucks, but on reducing the population. This is most quickly achieved and maintained through the removal of does. They should be clear that the success of the program and their continued participation therein depends upon meeting that goal. The Pennsylvania Game Commission is proposing several changes to the game laws for the 2000 hunting season (such as allowing does to be taken on the last Saturday of the buck season) which would help hunters meet this goal. The Sanctuary also could require Sanctuary hunters to have a doe tag for Berks and/or Schuylkill County and to hunt during doe season even if they have taken a buck earlier.

In general, the program should increase the effectiveness of the hunt and the safety of the hunters and Sanctuary users. The following is an example of a controlled hunt program that has proved effective at a number of preserves in southeastern Pennsylvania. It can be used as a starting point for developing a program at Hawk Mountain.

Model Deer Management Program Rules & Regulations

The Sanctuary conducts controlled deer hunts to manage deer populations consistent with the Sanctuary's natural resource management goals. Hunters receiving permits for the deer management program are expected to conduct themselves in a safe, honest and ethical manner. Unacceptable behavior includes, but is not limited to, the following:

- Failing to follow up every shot.
- Shooting in marginal situations such as at running deer, when vital organs are obstructed, and at excessive distances.
- Displaying game animals unnecessarily.
- Disrespect of Sanctuary employees, adjacent landowners, and other Sanctuary users.
- Drinking alcohol or using controlled substances.

The following are regulations/requirements for hunters on the Sanctuary:

1. Hunters must comply with all Pennsylvania Game Commission regulation (including returning report cards).
2. The Sanctuary will determine the days and hours of hunting permitted at a site.
3. All hunters must present proof that they have completed the Pennsylvania Game Commission Hunter/Trapper Education Course, **and,** for archery hunters, the National Bowhunter Education Foundation Course.
4. Hunters must have an antlerless deer license for the county of the Sanctuary.

5. All hunters must pass a proficiency test with the sporting arm with which they plan to hunt. For firearms - at 45 yards (shotgun) or 75 yards (rifle), a hunter must place 4 out of 5 slugs in a 9-inch paper plate. No buckshot allowed. For archery - shooting from a treestand 10 feet above the ground, an archer must place five out of six arrows in the vitals of a 3-D target. The target will be placed at five, ten and fifteen yards from base of tree.
6. Bow hunters must harvest an antlerless deer before being eligible to harvest a buck.
7. Hunters must hunt at least 12 hours per year.
8. Only portable tree stands may be used and hunters must wear a safety belt. No screw-in steps are allowed. All tree stands must be removed by two weeks after the season ends, or they will be forfeited.
9. All hunters must attend a preseason orientation course to be conducted by the Sanctuary manager.

Hunting Procedure: A metal box will be placed in a convenient spot accessible to hunters, without requiring the Sanctuary manager to be involved with opening it. Armbands and the hunting log will be stored in the box.

The hunting procedure will operate as follows: A hunter on arriving at the site removes one of the armbands and puts it on the exterior of his/her hunting coat. Hunters must wear the arm bands at all times while hunting. Once the supply of armbands is exhausted, no additional hunters may hunt until a hunter returns from the field and returns an armband to the metal box. Hunters must return armbands to the metal box when finished hunting. Hunters must mark the map where they plan to hunt, and remove the mark when they leave. Hunters are required to fill in the hunting log each time they hunt. One hunting permit will be issued to each hunter. The hunter must carry his/her permit card while hunting. Hunters must display a parking permit on the dashboard of their vehicle.

Appendix C
Elements of a Possible Sanctuary Management Program for Exotic Invasives

The following are guidelines that can be used to establish an invasives management program at the Sanctuary. The Relative Forest Function-Health map highlights areas that are impacted now by invasives. The staff should use this map to select areas in which to focus initial monitoring and restoration efforts.

Overview

Any attempt to alter the vegetation of a site will succeed or fail according to its effects on the major forces (light, water, inorganic nutrients, atmospheric gases, collectively known as the "growing space") that support plant growth in that area. Given that growing space in any area is finite, successful management will be those practices which make more growing space available to desirable species and less to non-desirable species — in this case, exotic invasives.

Physical Removal

The most effective practice is the selective removal of invasives without disturbing the surrounding desirable vegetation. This approach is preferable whenever possible, although it is limited as a practical alternative by the available manpower and equipment relative to the size, quantity, and type of invasive(s) present. It is generally desirable to remove as much of the root system as possible (to prevent resprouting), although removal of the crown is usually sufficient to prevent rapid reestablishment of the plant. The degree of success through this method will depend upon the thoroughness with which the plant is removed and the speed at which desirable vegetation can occupy newly available growing space.

Cutting

Removing some or all of the photosynthetic parts of the plant without disturbing the surrounding vegetation is another way to redistribute the available growing space and control invasives. It is less effective, but also less labor intensive, than physical removal. Cutting the plant with a pruner, handsaw, or lightweight chainsaw reduces its above-ground growing space without disturbing surrounding vegetation. However, the entire root system and any uncut stems can resprout and reoccupy the growing space. For this reason, it is best to cut the plant as low as possible to the ground and to combine it with an herbicide application (refer to Herbicides section below for further details on use).

This option is most appropriate for controlling invasives in wooded areas. In this situation, the surrounding vegetation (trees) is usually situated above the residual live

plant material. Because the surrounding trees limit sunlight needed for food production, the cut plant is forced to rely on stored root reserves to feed the remaining plant material and for refoliation.

Cutting is less effective in open areas. In this case, their prolific nature allows invasives to quickly resprout and occupy the available growing space. The problem is alleviated only temporarily — cutting will be required again within a few years. This is particularly true at edge sites (where open fields meet woodlands) and hedgerows. There the vines gain the added benefit of tree support, which they can utilize to occupy greater growing space to the detriment of the trees.

Late fall and winter are the most efficient and least painful (to the worker) times to perform cutting operations. Problem areas are more easily traversed and cool weather clothing gives added protection to the work crew. Following initial treatment, an annual or biennial inspection and control schedule should be adopted to prevent initial conditions from recurring. Frequent treatments are more effective in preserving the native integrity and aesthetic quality of the site.

Planting

Another option to remove growing space from invasives is through the planting of native species of trees and shrubs where areas have been disturbed or invasives removed to shade out invasives. Planting should only be done using seeds or seedlings native to Hawk Mountain. This can be helpful where removing invasives from disturbed areas. It is particularly important do this where high light areas occur and exotics are likely to quickly recolonize. Planting should occur in early spring or fall to optimize plant survival. Because they must compete with exotic invasives, only Hawk Mountain-native species that are also highly adapted to the particular site's condition (particularly light and soil water availability) should be planted.

Herbicides

In most cases the use of herbicides is not an effective long-term solution for controlling invasives. Difficulties in delivering an adequate amount of the chemical only to the target plants at the correct time in their growth cycle, and the potential health risks to workers and the environment are all legitimate drawbacks to their use. In addition, inherent in the sole reliance on herbicides is a "once and done" attitude that is not conducive to the long-term control of invasives. If they are used appropriately, however, herbicides can sometimes be an important tool for land managers in certain situations. Personnel properly trained in the safe use of each herbicide and the identification of desirable verses undesirable plant species only should apply herbicides.

To safely administer herbicides to the target plant it is best to minimize the above-ground volume of the plant prior to herbicide application. To control small trees, shrubs, or vines, apply an herbicide with glyphosphate (such as Roundup) to the fresh sprouts two weeks after cutting. Applying Garlon or Roundup directly to the freshly cut stump can most effectively control larger plants. This second method works best in fall and winter when sap flow is into the roots. With some species, such as ailanthus, cutting often stimulates root sprouting. It is often more effective to apply the herbicide (one formulated for bark application) directly to the basal bark.

Fire

Fire has been a major influence in the evolution of the herbaceous and woody flora of this area. Deliberate fires set by Native Americans and colonists, and accidental lightning fires gave a strong edge to fire tolerant species. The use of fire to control invasives by giving an advantage to desirable native species is an exciting new application for an old management tool. The difficulty in utilizing this tool is the obvious destructive power that can arise from its misuse. Local governments and fire companies are often not receptive to the use of fire. Some fire companies, however, use controlled burns as training exercises. In certain circumstances, the potential benefits for the control of invasives may be sufficient to face the bureaucratic challenge. However, before considering fire as a management tool, the Sanctuary should fully investigate all possible short and long-impacts, social and environmental and only move forward if other management possibilities have been exhausted.

Setting Staff Priorities in Invasive Management/ Forest Restoration:

Generally, priorities for invasives control and forest restoration work should occur as follows:

1. Cutting vines in the relatively healthy woodlands with low to moderate impact by invasive vegetation. In most cases this can be accomplished with a minimal amount of staff resources. This recommendation should be tempered by the fact that native vines (grape, Poison Ivy, Virginia Creeper) are important wildlife food and only should be cut if they are seriously impacting canopy trees or preventing natural regeneration of woodland gaps.

2. Reforesting woodland gaps. This will allow the canopy to close quicker and deter the establishment of invasive vegetation. The options are: (1) installing deer fencing and relying on natural regeneration; (2) planting native (to Hawk Mountain) seedlings and protecting them from browse with deer fence or tree shelters; and (3) planting large-sized material (native to Hawk Mountain) that is above deer browse height.

3. Cutting (or girdling) and herbiciding understory invasive trees and shrubs in low to moderately impacted areas. This will free up growing space for existing desirable vegetation (native tree seedlings and saplings, and shrubs) and for new seedlings to become established through natural regeneration or planting. The amount of time to accomplish this will vary by the level of invasion and size of trees, but in most cases will not be substantial.

4. Cutting vines in the moderately to heavily impacted woodlands. Unless they are severely impacted by invasive vines, canopy trees usually respond by putting out new growth to capture more of the growing space. This helps to deter the amount of subsequent resprouting and new establishment of invasives. These areas will require a more substantial amount of staff time.

5. Reducing invasive ground covers such as Japanese Stiltgrass (which usually results from high deer populations) that can spread even under shaded conditions. These species can form dense mats and not allow regeneration by native herbaceous vegetation.

Priorities may need to be modified for best short-term efficiency of labor and long-term results according to the time of year or availability of labor. For example, the cutting and herbiciding of understory invasive trees is best done during fall and early winter when sap is flowing into the roots, while the planting of seedlings is best done in the late winter and early spring. If labor is first available in the spring, then it would be best to plant seedlings in moderately to heavily impacted woodlands and wait till the fall to cut the invasive trees in low to moderately impacted areas.