GYPSY MOTH MANAGEMENT IN ROCK CREEK PARK, WASHINGTON, D.C.

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Abstract. The National Park Service (NPS) first detected the gypsy moth in Rock Creek Park in the late 1970s. The potential tree defoliation caused by this exotic insect presented a serious threat to the recreational and ecological value of Rock Creek Park. In response to NPS policy concerning the management of exotic biota, an integrated pest management plan was adopted in 1983 to manage the gypsy moth in this unique urban park. The plan, a cooperative effort between the USDA Forest Service and the National Park Service, was designed to minimize defoliation and tree mortality while avoiding the adverse effect of management tactics on non-target species. A variety of control methods were directed by intensive monitoring. Mating disruption and parasite releases, tactics designed for use in isolated, low density populations, were used initially. As the population increased, the biological pesticides *Bacillus thuringiensis* (*B.t.*) and the gypsy moth specific nucleopolyhedrosis virus (Gypchek®) were applied to distinctly defined areas of heavy infestation. Defoliation never occurred in the Park and further treatments have not been necessary since 1989. Monitoring activities continue.

After more than 100 years we have learned to anticipate and adjust to the presence of the gypsy moth (*Lymantria dispar*) in the United States. Since its introduction in the late 1860s, management approaches have progressed from early attempts at eradication to more recent initiatives that encourage accepting the gypsy moth and learning to understand and adjust to the consequences of defoliation.

The intensity of gypsy moth management today varies with the nature of the resource and the objectives of the affected land managing agency. National Park Service (NPS) policy on exotic species states that the management of such species, up to and including eradication, will be undertaken wherever such species threaten park resources or public health and when control is prudent and feasible. The management of natural resources and, therefore the gypsy moth, is based on a park's management zones as established in an approved statement for management or a general management plan (10).

Aggressive actions may be taken to control gypsy moth populations in cultural and developed zones where management objectives may require preservation of specific trees as historic objects and/or the protection of foliage in high-use public areas. However, in NPS areas congressionally mandated as natural zones, the gypsy moth is generally not to be aggressively managed unless it is likely that unique or significant park resources will be lost if management is not implemented (11). For example, small, wooded tracts surrounded by urban development provide significant recreational and aesthetic resources. The ecological significance of these areas as vestiges of the previous surrounding landscape and as natural islands within an urban expanse is complex and poorly understood. Defoliation and tree mortality in such areas pose unknown and possibly serious consequences.

Rock Creek Park in Washington, D.C., a 1754-acre park within the National Capital Region (NCR) of the NPS, poses just such a concern. This Park was established in 1890 to preserve the "timber, animals, and curiosities in as natural a condition as possible" and has remained much as originally intended with the attractive stream valley scenery and surrounding forested slopes still very much intact. However, the Park has become almost completely surrounded by the city with over 1100 contiguous neighbors along its 55 miles of border.

Eighty percent of Rock Creek Park is zoned natural and contains unusual or significant natural resources of local, regional, or national importance including natural springs and significant plant habitat, lands essential for watershed protection, and important scenery such as the central valley of the Park. Deciduous trees, whose leaves are suitable for consumption by the gypsy moth, predominate including oak, hickory, and beech. A

major loss of trees would have drastic effects on the recreational and ecological values of the Park.

One of the more serious concerns is the invasion of exotic plants such as Asiatic bittersweet (*Celastrus orbiculatus*), porcelain berry (*Ampelopsis brevipedunculata*), and Japanese honeysuckle (*Lonicera japonica*). These and other exotics which thrive in disturbed, open sites already have a foothold in the Park. Voids created by dead trees would be exploited by these invasive plants and radically change the Park's natural resources.

Recognizing the known social and possible ecological significance that small island woodlands possess, the NCR was concerned that the consequences of non-intervention could, in some cases, exceed those of direct management. As a result, an integrated pest management (IPM) approach was adopted to manage the gypsy moth and minimize adverse effects on non-target species in Rock Creek Park.

IPM Plan

In 1983, an IPM plan was developed to manage the gypsy moth in Rock Creek Park. This was a cooperative effort among the USDA Forest Service, Forest Pest Management, NCR's Center for Urban Ecology, and Rock Creek Park. The Rock Creek Park IPM program was similar in design to the Maryland Gypsy Moth IPM Pilot Project, a cooperative effort of the Maryland and U.S. Departments of Agriculture (7). The objectives of the Rock Creek Park IPM plan were: 1) protect the natural resources of Rock Creek Park by minimizing defoliation and tree mortality which could adversely affect other aspects of the natural environment, 2) develop a monitoring program that provided a consistent, comprehensive portrayal of the gypsy moth population that directed and delimited management tactics, 3) apply management tactics specific to the gypsy moth and which posed little threat to other natural resources within the Park (9).

Four operational components of this IPM program included: *Monitoring* to regularly record quantitative and qualitative observations of gypsy moth and natural enemy populations along with other elements indicating change in the forest ecosystem. *Decision-making* matrices to identify intervention actions based on survey data and subsidiary information. *Intervention* tactics used to manage gypsy moth populations at specific densities. *Evaluation* methods to determine the outcome of project actions over the short and long-term (6). A more detailed description of these elements follows.

Monitoring. A monitoring system was established to determine the distribution, abundance, and quality of the gypsy moth population. Four monitoring techniques were used: 1) male moth traps baited with pheromone, 2) burlap bands for larval and pupal sampling, 3) egg mass surveys, and 4) aerial defoliation surveys.

In 1984 a monitoring grid based on universal transverse Mercator (UTM) coordinates was established within Rock Creek Park. Thirty-four monitoring points or primary monitoring sites (PMS) were installed at 500-meter grid intervals within the contiguous park acreage (Fig.1); and ten additional PMS were installed in Battery Kemble, Glover Archbold, and along the Rock Creek & Potomac Parkway, satellite parks outside the main Park. All gypsy moth life stages were monitored at each PMS. A training program was subsequently established to help the Park staff identify gypsy moth lifestages and to conduct the necessary monitoring. The 1/40th acre plot technique (4) and the 5-minute walk technique (3) were reviewed at this training.

In 1986, 12 PMS were added to Pinehurst Parkway (a finger of parkland along the northwest border of the Park) and along Oregon Avenue because numerous egg masses were found in the residential area adjacent to Pinehurst Parkway (Fig. 1). In response to this increase and with the abundance of susceptible tree species throughout Rock Creek Park, additional secondary monitoring sites (SMS) were established within the main Park interior and in nine of the satellite parks. The result was a total of 200 monitoring sites (PMS & SMS) within the approximately 2975 acres of Rock Creek Park and its satellite parks. Male moth trap surveys, 1/40th acre plot surveys, and ground defoliation surveys were conducted at each of these sites (Fig. 1).

Occasional shifting of the monitoring site from

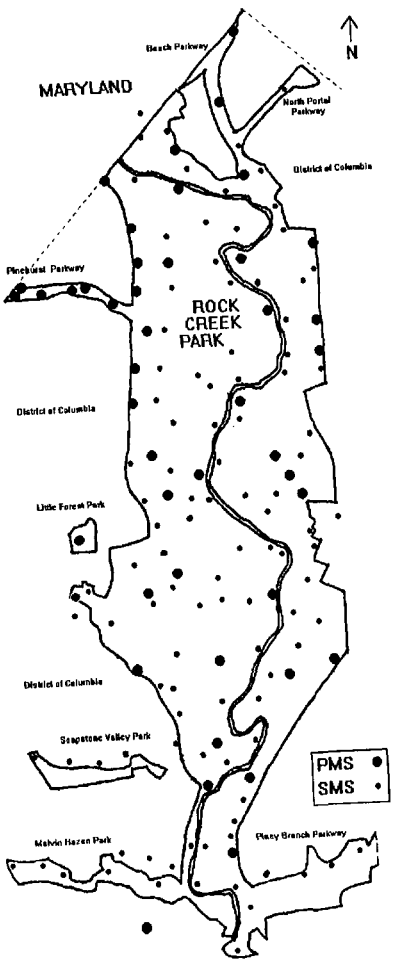


Figure 1. Rock Creek Park gypsy moth monitoring sites.

the grid point was necessary to avoid non-forested areas and non-host species. Such adjustments are necessary to adequately survey the resource at risk and obtain an accurate, comprehensive portrayal of the infestation (12). Five-minute walks were conducted in between the grid points to better define the extent of the infestation.

Decision-making. Monitoring data, information on forest stand composition and gypsy moth host preference, and land use objectives were used to determine which, if any, intervention tactics to use. Three management options, as outlined in the Maryland IPM Program (7), were considered:

1) No Action. No aggressive action was taken when gypsy moth populations were less than 10 egg masses (em) per acre and other information such as species composition indicated little potential for impact or spread. Only surveillance activities were conducted.

2) Preventive Action. Population controls were taken when populations were low to moderate (10-100 em per acre), but showed increases over the previous year, and other information indicates potential risk to the resource. Management techniques for gypsy moth populations of less than 20 em per acre included Luretape®, a vinyl plastic tape impregnated with a copy of the female gypsy moth pheromone disparlure. This material is designed to manage gypsy moth populations by confusing the males in their search for females and thereby interfering with mating. Luretape® has been shown to have limited practical value in moderate or dense gypsy moth populations, and performs better on isolated and sparse populations (5). At populations of 20 to 100 em per acre, attempts were made to enhance or augment actions of natural gypsy moth enemies through the release of such insects as the larval parasite *Cotesia melanoscelus* (Korean strain).

3) Suppressive Action. Aggressive actions were taken when the population escaped the control of natural enemies and other environmental constraints. Suppressive action was triggered by a large increase in population levels (above 250 em per acre) and was undertaken to subdue populations. The microbial insecticide *Bacillus thuringiensis* (*B.t.*) and the chemical insect growth regulator diflubenzuron (Dimilin®), have been the most routinely used insecticides for gypsy moth suppression. Gypchek®, another biological insecticide, is a formulation of the nucleopolyhedrosis virus (NPV) currently produced in limited quantities by a USDA Animal & Plant Health Inspection Service/Forest Service cooperative project. This product is prepared from gypsy moth larvae that have been killed by the naturally occurring virus. Gypchek® has an extremely narrow host range and does not have adverse effects on beneficial insects (8).

Intervention and evaluation. Surveys in 1984 and 1985 detected increasing levels of all gypsy moth lifestages. In 1984, larvae were found at five sites located in the east central section of the

Park. All 40 male moth traps recovered contained positive catches (4 traps were vandalized and the data lost). The five sites with the highest moth counts were scattered throughout the Park indicating a building gypsy moth population. Only one egg mass was found in 1984 and that was in the north near the Maryland border.

In 1985, larval counts at the 34 PMS increased 1100% over the 1984 levels while moth counts at the same sites increased approximately 39%. Two preventive measures were subsequently implemented in 1985. In early May of that year, over 11,000 *Cotesia melanocelus* were released at six locations throughout the Park (Fig. 2) and in June, Luretape® was installed on a ten-meter grid at three sites encompassing approximately 3,760 square meters (Fig. 2). These sites were located in areas where the highest larval counts had occurred.

Larvae, collected from burlap banded trees at the grid points, were reared and examined for parasites. No parasites were collected suggesting that *Cotesia* had not become established. The distribution of 11,000 wasps over six sites may not have been sufficient to assure establishment of the parasite.

In surveys conducted in November 1985, only 2 egg masses were found in the Park, neither of which was located near the Luretape® treatment areas (Fig. 2). However, in January of 1986, numerous egg masses were found in the residential area outside the northwest corner of the Park near Pinehurst Parkway. Nineteen 5-minute walk surveys conducted along the Park boundary and in the adjacent neighborhood found 206 egg masses, 10 of which were on park property. Four walks conducted just outside the Park boundary had counts ranging from zero to over 800 egg masses per acre.

In 1986, Luretape® was again installed in the Pinehurst Parkway area and along the western border of the Park adjacent to the infested residential community (Fig. 2). There was no defoliation detected in Pinehurst Parkway or within the rest of Rock Creek Park in 1986. Severe defoliation, however, did occur in the residential area just south of Pinehurst.

Egg mass surveys of 1/40 acre plots, conducted in late summer 1986, found 211 egg masses in Pinehurst Parkway and only 22 egg masses throughout the rest of the Park. In addition, egg mass searches among street trees in the residential area to the south of Pinehurst Parkway revealed numbers ranging from 11-1592 egg masses. The gypsy moth population within Pinehurst Parkway and the adjacent residential area had developed to levels with defoliating potential for 1987.

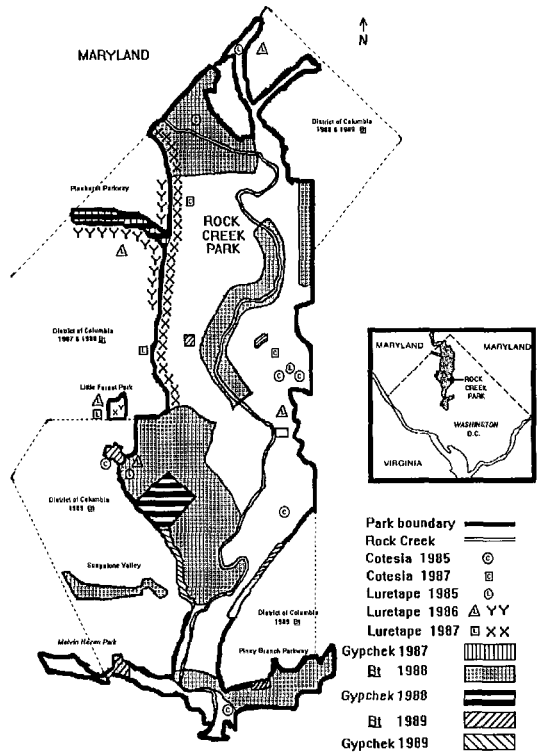


Figure 2. Gypsy moth treatment history at Rock Creek Park, 1985-1989.

To protect the foliage, suppressive action was required in 1987. The preferred choice of treatment for Rock Creek Park was Gypchek® because it has an extremely narrow host range and is biocompatible with beneficial insects. Gypchek® was provided by the Forest Service for treatment of the 18 acre Pinehurst Parkway (Fig. 2). In addition, Luretape® was again applied to the western border of the Park (Fig. 2) and 5000 total *Cotesia* were released on the western and eastern borders of the Park and at one satellite park.

No defoliation occurred in any part of Pinehurst Parkway or the main Park in 1987. Reductions of

all gypsy moth life stages within Pinehurst contrasted sharply with the general increase observed throughout the rest of the Park. Larvae, pupae, male moths, and egg masses in Pinehurst were reduced by 70%, 89%, 38%, and 65% respectively (Fig. 3). Populations at the 34 PMS in the center of the Park, however, increased (Fig. 4).

Gypchek® had a noticeable effect on larval mortality (Fig. 5). Larvae sampled from May to July exhibited the characteristic limp, melting configuration of virus infected larvae. Mortality displayed a bimodal pattern which, according to Woods and Elkinton (13), has been observed in a wide range of gypsy moth densities. Cadavers of early instars provide virus inoculum for late developing instars resulting in a second peak of mortality (1,13) (Fig. 6).

The Luretape® reduced the 1987 mean male moth count 80%, a reduction in sharp contrast to an increase of 145% in male moth capture at sites within the main Park interior (Figs. 4,6). An adjacent District of Columbia spray block treated with the biological insecticide *B.t.* (Fig. 2) may have contributed to the male moth reductions in both the Gypcheck® (Fig. 3) and the Luretape® treatment areas (9).

Despite preventive actions taken in the northwest area of the Park, the infestation continued to develop parkwide in 1987 and expanded the focus of concern from Pinehurst Parkway to the

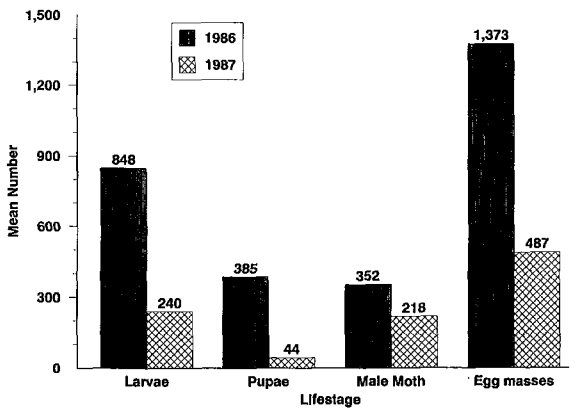


Figure 3. Gypsy moth lifestages found in Pinehurst Parkway, Rock Creek Park, before (1986) and after (1987) treatment with Gypchek (nucleopolyhedrosis virus, NPV).

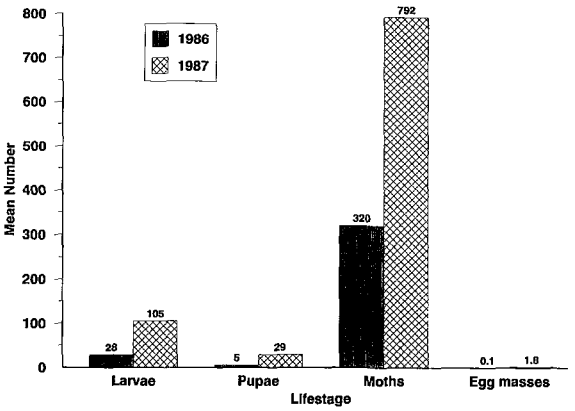


Figure 4. Gypsy moth lifestages found at the 34 Primary Monitoring Sites in Rock Creek Park in 1986 & 1987.

main park interior and several satellite parks. Although gypsy moth populations at Pinehurst were reduced below the pre-treatment levels, the post treatment population of almost 500 egg masses per acre still posed a threat of defoliation for 1988. The male moth catches were reduced in the Luretape® areas, but egg masses increased almost 8-fold. At some monitoring sites many more egg masses were found outside the grid determined plot. The occasional occurrence of better egg mass habitat outside the grid point may have accounted for this phenomenon. Consequently, surveys were expanded from the 1/40th

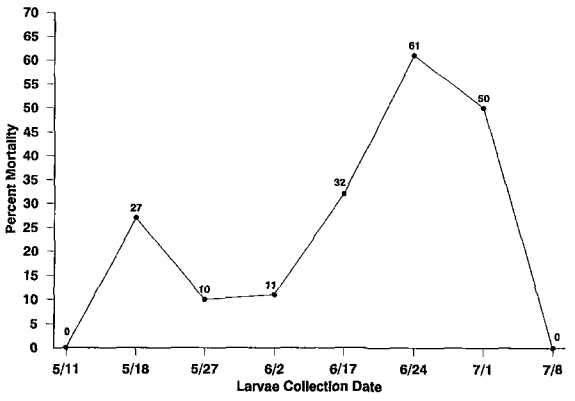


Figure 5. Percent larval mortality observed at 6 Primary Monitoring Sites in Pinehurst Parkway, Rock Creek Park following treatment with Gypchek (nucleopolyhedrosis virus, NPV) on May 1 and 8, 1987.

acre grid point plots to surveys outside the established grid points. Five-minute walk surveys showed a more intense and widespread infestation than had been observed with the fixed 1/40th acre grid plots. This experience demonstrates the necessity for both fixed plots and random walks to more fully define the distribution and size of the population. Fixed plots, if monitored in the same manner each year, can describe population growth, while a five-minute walk survey appears to provide a better portrayal of the distribution of the infestation (9).

By 1988, the gypsy moth could be found to some extent throughout Rock Creek Park. The rapid population development had, by then, limited management options to insecticide treatments. Using 250 egg masses per acre as a threshold, we hoped to be able to suppress the gypsy moth population early by using materials such as *B.t.* and Gypchek® rather than having to use a chemical insecticide later. A total of 10 spray blocks ranging in size from 10 to 356 acres and encompassing 761 acres were designated for aerial *B.t.* treatments. A limited amount of Gypchek® was available for treating 48 acres including Pinehurst Parkway (Fig. 2). Aerial defoliation surveys conducted in June found that both *B.t.* and Gypchek® treatments achieved foliage protection in all spray blocks.

Egg mass counts in 1988 showed an overall decrease in egg mass numbers (Fig. 6). However, certain areas of the Park still warranted treatment, and in 1989, 10 spray blocks ranging from 2 to 24 acres and encompassing 140 acres were treated with both *B.t.* (90 acres) and Gypchek® (50 acres) (Fig. 2). This was an 80% reduction in treated acreage from 1988. Aerial defoliation surveys conducted in June found no defoliation.

Since 1989, gypsy moth populations in Rock Creek Park have remained below the treatment threshold (250 em/acre). No treatments were necessary in the Park in 1990 and 1991 and aerial defoliation surveys again revealed no defoliation in the Park. This decline was expected and was likely a consequence of increased natural parasite and predator activity as well as by direct intervention.

Current Program Status

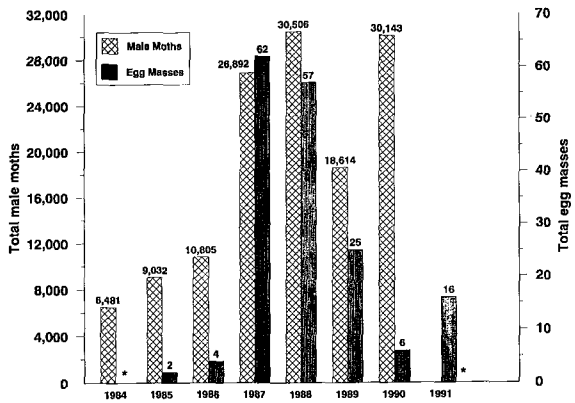
The gypsy moth has declined throughout the Washington metropolitan area and 1992 was the third year in which treatment has not been necessary in Rock Creek Park. However, monitoring will continue since the Park is within the generally infested area and a resurgence is likely.

Burlap band monitoring will be used to measure the presence of late larval instars and pupae, parasite and predator activity, and diseases. Male moth monitoring, however, has been discontinued at the PMS as it has been shown to be an inappropriate monitoring tool in areas where the yearly catch often exceeds 1000 males per trap (2). In 1990 and 1991, 47% of the trap sites in Rock Creek Park exceeded 1000 moths per trap.

Management tactics will continue to be based primarily on egg mass surveys consisting of 1/40th acre plots and 5-minute walks. Surveys will be conducted primarily at those grid points located in areas with a species composition of at least 30% oak. This new criteria was chosen to eliminate the grid points which are not representative of gypsy moth susceptible habitat.

Discussion

Through early confirmation of the gypsy moth's presence in Rock Creek Park, intensive monitoring, and suppressive action, we were able to achieve the management objectives outlined in the Rock Creek Park IPM Plan. Since the arrival of the



* indicates that moth or egg mass data was not collected at 34 PMS in that year.

Figure 6. Gypsy moth male moths and egg masses found at the 34 Primary Monitoring Sites from 1984 to 1991 at Rock Creek Park.

gypsy moth in the Park, no noticeable defoliation has occurred despite the high numbers of moths in some areas and the predominance of oak, hickory, and beech throughout the Park. In 1988, the height of the infestation, only 27% of the Park was treated. Between 1987-1989 only 30% of the Park acreage was sprayed with either *B.t.* or Gypchek®, compared to 60% of the adjacent residential areas which were sprayed with *B.t.* by the District of Columbia Department of Public Works.

Occasional modification of the Rock Creek Park monitoring grid was necessary to avoid non-forested areas and non-host species, allowing us to adequately survey the resources at risk and to obtain an accurate and comprehensive portrayal of the infestation. The monitoring program has helped direct and delimit the management tactics which we have chosen.

The management actions selected for Rock Creek Park have protected the natural resources while striving to minimize adverse effects to non-target species. Mating disruption (Luretape®) and parasite releases (*Cotesia melanoscelus*) were two preventive actions taken when the population was considered low to moderate. As the population increased from 1987 to 1989, suppressive action was taken in areas where population levels exceeded 250 em per acre. By using 250 em as an action threshold, considered a low threshold by many agencies, we have been able to maintain foliage protection and some population reduction using the biological insecticides *B.t.* and Gypchek®. If we had waited for the populations to build before intervening, we may have had to resort to using the chemical insecticide Dimilin®, normally the insecticide of choice for higher egg mass levels.

Although *B.t.* treatments may have killed some non-target lepidopterans, intensive monitoring allowed us to limit treatment to multiple, tightly defined blocks thus avoiding treatment of larger areas which may have had greater impact on non-target species. Furthermore, the impacts resulting from the judicious use of *B.t.* may be less detrimental in the long run than the consequences of extensive defoliation and tree mortality in a small urban forest. In some unprotected parks within the Washington metropolitan area, a single year's defoliation has caused extensive tree mortality.

Rock Creek Park and its associated parklands are a major element of the overall Washington landscape. Forested scenery predominates along 55 miles of common boundary with the city and along important entrance routes to the Nation's Capital. A loss of natural resources in the Park due to defoliation could have serious implications for the ecological and recreational attributes Rock Creek Park is valued for.

The Rock Creek Park IPM program will continue even though gypsy moth populations in the metropolitan Washington area are currently below action thresholds. Hopefully, the increasing environmental concerns about the effects of *B.t.* and Dimilin® on non-target organisms will result in increased Gypchek® availability by the time the next wave of gypsy moths arrive. This will allow the NPS and other land management agencies to protect critical natural areas with minimal risk to non-target species.

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Résumé. Le National Park Service (Service national des parcs) détecta pour la première fois, à la fin des années '70, la spongieuse dans le parc de Rock Creek. En réponse à la politique du National Park Service concernant la gestion d'un biote exotique, un plan intégré de gestion des parasites était adopté en 1983. Le plan, découlant d'un effort coopératif entre le USDA Forest Service et le National Park Service, était établi dans le but de minimiser la défoliation et la mortalité des arbres tout in évitant les effets néfastes des tactiques de gestion sur des espèces non ciblées. Une variété de méthodes de contrôle était administrée au moyen d'une surveillance intensive. Les procédures initialement employées consistaient à perturber l'accouplement et à utiliser des dispersions de parasites. Avec l'accroissement de population, des pesticides biologiques, tel le Bacillus thuringiensis (B.t.) et le virus nucléopolyhédrique spécifique de la spongieuse (Gypcheck®) étaient appliqués à des zones distinctes de forte infestation. Aucune défoliation ne s'est produite dans le parc et aucun traitement supplémentaire a été nécessaire depuis 1989. Les activités de surveillance se poursuivent.

Zusammenfassung. Der NPS (National Park Service) entdeckte den Schwammspinner erstmals in den späten 1970's im Rock Creek Park. Ein "Integrated Pest Management Plan" wurde eingeführt in Reaktion auf die Vorgehensweise des NPS bezüglich des Umgangs mit exotischen Lebensformen. Dieser Plan, ein gemeinsames Bestreben des USDA Forest Service und des NPS, wurde entworfen, um die Entlaubung und das Baumsterben zu minimieren, während gleichzeitig nachteilige auswikungen auf andere ("non-target") Arten verhindert werden soll. Cine Vielzahl von Kontrollmethoden wurde durch intensive Überwachung gesteuert. Als erstes unterbrach man den Paarungszyklus und setzte Parasiten frei. Als die Population wuchs, wurden biologische Pestizide wie Bacillus thuringensis (B. t.) und das Schwammspinner-spezifische nucleopoly-hedrosis Virus (Gypcheck®) in ganz bestimmten, desonders befallenen Gebieten freigesetzt. Im Park traten niemals entlaubungen auf und weitere Behandlungen waren nach 1989 nicht mehr notwendig. Die Überwachung wird Portgesetzt.