Gypsy Moth Management in the United States:
a cooperative approach

Final

Environmental Impact Statement

Summary

November 1995

United States Department of Agriculture

Forest Service

Animal and Plant Health Inspection Service

Summary

This is a summary of the final environmental impact statement. The complete final environ mental impact statement is available, while supplies last, from the USDA Forest Service, Northeastern Area State and Private Forestry, by calling (610) 975-4150.

What is Being Proposed and Why

The Forest Service and Animal and Plant Health Inspection Service (APHIS) propose to adopt a new comprehensive long-term national program to protect the forests and trees of the United States from the adverse effects of the gypsy moth. Gypsy moth management activities are conducted by these agencies of the U.S. Department of Agriculture (USDA) under the authority of Federal laws.

The gypsy moth caterpillar disrupts people's lives, alters ecosystems, and destroys the beauty of woodlands by feeding on the foliage of trees, shrubs, and other plants. During **outbreaks,** when gypsy moth populations increase rapidly, caterpillars pose a hazard to human health and interfere with the enjoyment of hiking, camping, and other outdoor activities. **Defoliation** caused by the caterpillars feeding reduces the vigor and general health of forests and shade trees, leads to tree death, alters wildlife habitat, changes the quality and quantity of water, lowers property values, and reduces the economic value of timber.

Since its accidental introduction in eastern Massachusetts in the late 1860's, the European strain of the gypsy moth has been spreading. By 1994 it was established as a permanent resident in all or parts of 16 States (Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia) and the District of Columbia. People also spread the gypsy moth to areas of the country where it is not established by unknowingly carrying

Even backyard trees are subject to gypsy moth feeding.

eggs, pupae, and caterpillars on recreational vehicles, campers, automobiles, nursery stock, logs, lumber, and outdoor household articles. This accidental spread can result in isolated infestations.

In 1991 the Asian strain of the gypsy moth was discovered for the first time in the United States in Oregon and Washington. It was traced to ships from eastern Russian ports. Eradication in these States has been achieved. In 1993 the Asian strain was introduced to North Carolina from a ship returning military cargo from Germany. This introduction was treated in 1994 and 1995, and is being monitored to determine whether follow-up treatments will be required. The Asian strain is of particular concern because it may spread faster than the European strain. Although both gypsy moth strains are the same species (Lyrnantria dispar), they have different behavioral characteristics. For example, some females of the Asian strain are known to fly up to 18 miles before depositing an egg mass, while females of the European strain do not fly. The Asian strain also feeds on a wider variety of trees and shrubs and may cause more damage than the European strain.

Six possible programs to protect the forests and trees of the United States from the effects of the gypsy moth are being proposed. These programs

Gypsy Moth Life Cycle

Catepillar

8 weeks during spring and early summer

A young caterpillar is black. As it matures, double rows of red and blue spots develop. Insecticides usually are applied when foliage and caterpillars are at an early stage of development.

Pupa

2 weeks during spring-summer

The female pupa is larger than the male. Both are dark reddish brown. Caterpillars pupate in protected areas, and pupae can be moved accidentally by people.

Adult

Several days during summer

The male adult is brown or gray and has feather-like antennae to detect the pheromone emitted by the female, which is white with small black markings.

Egg Mass

9 months, summer-spring

The female lays a buff-colored egg mass on almost any object. For this reason and because the egg is the longest lasting life stage,it is most often moved accidentally by people.

range from using no strategy to using one or more strategies to reduce damage caused by outbreaks where the gypsy moth is established (suppression), eliminate isolated infestations that are detected in other areas of the country (eradication), and slow the insect's rate of spread from the area where it is established (slow the spread).

No suppression, eradication, or slow-the-spread projects will be conducted as a direct result of the decision on the environmental impact statement. Each decision to conduct a treatment project would be made only after a site-specific environmental analysis of the treatment proposal has been conducted. Project proposals will also be analyzed for compliance with applicable Federal laws such as the Endangered Species Act; Wilderness Act; Wild, Scenic, and Recreational Rivers Act; and National Historic Preservation ACC and with presidential executive orders concerning natural resource issues, such as environmental justi~e and floodplain and wetland protection; as well as any applicable State laws.

Gypsy moth caterpillars feed on hundreds of tree species.

Proposed treatment projects will be analyzed on an individual basis to determine whether they are environmentally acceptable, biologically sound, and economically feasible. Suppression projects are often cost efficient, depending on the resource manager's or landowner's objectives and the values at risk. Benefits of suppression include avoiding tree loss that would affect recreation, property, watershed, wildlife habitat, or timber values. The greatest economic benefit of eradication is the absence of long-term suppression costs. A 1991 economic analysis indicated that significant economic efficiency is possible with the slow-the-spread strategy.

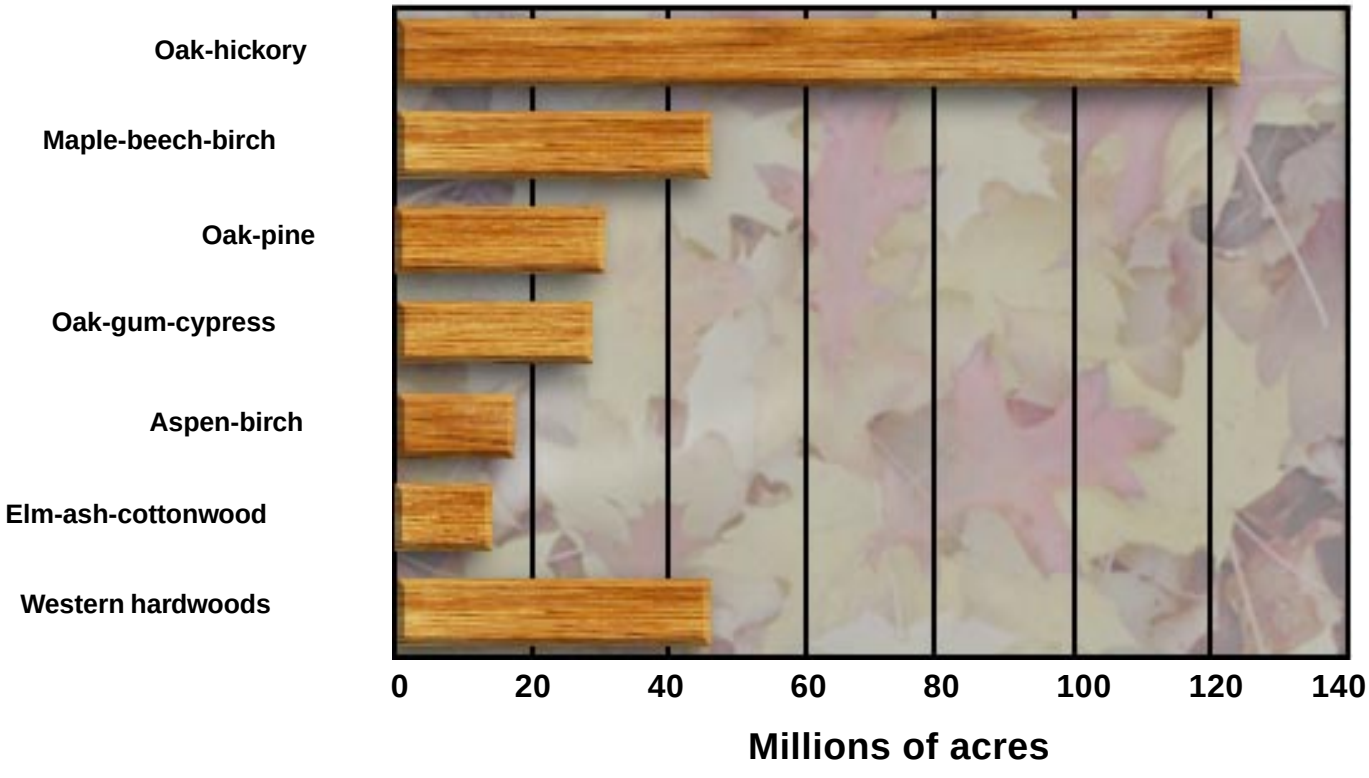
Certain gypsy moth management activities are outside the scope of this environmental impact statement and, consequently, are not examined. These activities include regulatory actions (such as treatment of quarantined items infested with gypsy moths), the boarding and inspection of ships entering seaports, and research and methods development activities carried out by the Forest Service and APHIS, as well as actions against the gypsy moth by other agencies or individuals.

Parts of the Environment That May Be Affected

Within the United States all areas where the gypsy moth is established and could become established constitute the affected environment. Establishment of the gypsy moth in an area depends on the presence of shrubs and trees with leaves that the insect prefers to eat.

The foliage of hardwood trees, particularly of oaks, is preferred by the gypsy moth. At risk from defoliation and damage are at least311 million acres of publicly and privately owned forests dominated by

Susceptible Forest Type Groups



hardwoods. The Asian strain also feeds on conifers such as larch and Douglas-fir. Also at risk are countless urban and rural forested areas throughout the country where plants susceptible to both gypsy moth strains grow naturally or have been planted, such as forested areas in cities, towns, and communities; greenways; parks; wildlife reserves; areas along streams and rivers; and small woodlots.

Strategies

The area of the United States where the European strain of the gypsy moth is established is called the **generally infested area**. Next to this area is a band 50 to 100 miles wide, called the **transition area**, where the gypsy moth is spreading from the generally infested area. The area where the gypsy moth is not established, is called the **uninfested area**. Isolated infestations, the result of accidental spread of the gypsy moth by people, are found in this

Large numbers of caterpillars suddenly appear during gypsy moth outbreaks.

area. Different management strategies apply in these areas: suppression in the generally infested area, slow the spread in the transition area, and eradication of isolated infestations of the European strain in the uninfested area. In addition, the Asian strain maybe eradicated wherever feasible, including the generally infested area.

Suppression

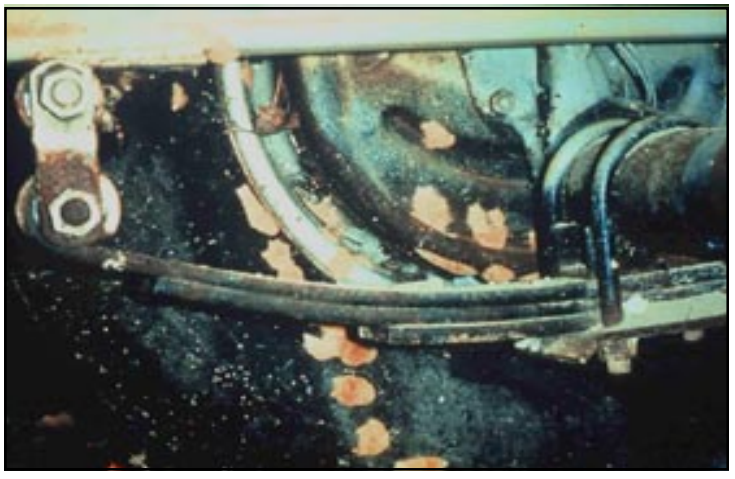
The objective of suppression is to reduce outbreak populations of gypsy moth caterpillars, thus minimizing heavy defoliation. Suppression does not eliminate the gypsy moth from the generally infested area, but reduces damage to ecosystems and effects on people in treated areas. Treatments available for use in suppression are application of the biological insecticides *Bacillus thuringiensis* var. *kurstaki* and the gypsy moth Nucleopolyhedrosis virus (Gypchek), and the chemical insecticide diflubenzuron.

Participation of State or other Federal agencies in cooperative suppression projects is voluntary. Private landowners may participate by coordinating with State and local agencies.

Within the generally infested area, the U.S. Department of Agriculture would provide assistance to cooperating Federal and State agencies for suppression projects wherever gypsy moth outbreaks are likely to cause defoliation. Projects may be conducted in residential areas, recreation areas, uninhabited forests, and special-use areas such as scenic byways and watersheds.

Eradication

The objective of eradication is to eliminate isolated infestations of the gypsy moth that are detected in the uninfested area of the United States, to prevent the insect from becoming established. Infestations of the European strain would be eliminated wherever they are detected in the uninfested area. In addition, infestations of the Asian including the generally infested area when the time, location, and extent of the introduction can be determined or developed from deductive, circumstantial, or investigative information. The objective of treating infestations of the Asian strain in the generally infested area is to eliminate all of the gypsy moths that exhibit traits characteristic of the Asian gypsy moth.



People unknowingly give gypsy moth a free ride.

Treatments available for eradication are application of the biological insecticides *Bacillus thuringiensis* var. *kurstaki* and Gypchek the chemical insecticide diflubenzuron; as well as the use of mass trapping, mating disruption, and sterile insect release. The smaller the treatment area the more likely that noninsecticidal treatments can be used.

The most common cause of isolated infestations is movement of outdoor household articles from the generally infested area to the uninfested area. Therefore, the most likely locations for future isolated infestations are wooded residential areas with high incidence of relocation by people. Sawmills, nurseries, mobile home parks, and tourist attractions such as campgrounds and State and National Parks are other likely locations for isolated infestations.

The U.S. Department of Agriculture does not require private landowners to participate in eradication projects. Participation is governed by State law and by the policies and regulations of the cooperating State agency. In some States, participation in eradication projects maybe

mandatory. If it is determined that State actions are inadequate, the Secretary of Agriculture can declare an emergency and conduct an eradication project.

Slow the spread involves intensive surveys to find the gypsy moth.

Slow the Spread

The objective of slow the spread is to slow the rate of spread of the European strain of the gypsy moth from the generally infested area, to delay the impacts and costs associated with gypsy moth outbreaks. This strategy, which is being tested in a pilot project, entails intensively surveying the transition area and aggressively treating pockets of low-level gypsy moth populations to keep them from increasing rapidly.

Treatments available for use in slow the spread are application of the biological insecticides *Bacillus thuringiensis* var. *kurstaki* and Gypchek and the chemical insecticide diflubenzuron, as well as the use of mass trapping, mating disruption, and sterile insect release.

Alternatives Considered

The strategies of suppression, eradication, and slow the spread-or their absence—are the building blocks for six alternatives analyzed in the environmental impact statement:

Alternative 1. No suppression, no eradication, no slow the spread
Alternative 2. Suppression
Alternative 3. Eradication
Alternative 4. Suppression and eradication
Alternative 5. Eradication and slow the spread
Alternative 6. Suppression, eradication, and slow the spread (preferred alternative).

The alternatives describe how the U.S. Department of Agriculture could respond to the gypsy moth on State and private lands through State agencies, and on Federal lands through appropriate Federal land management agencies.

All alternatives have two elements in common:

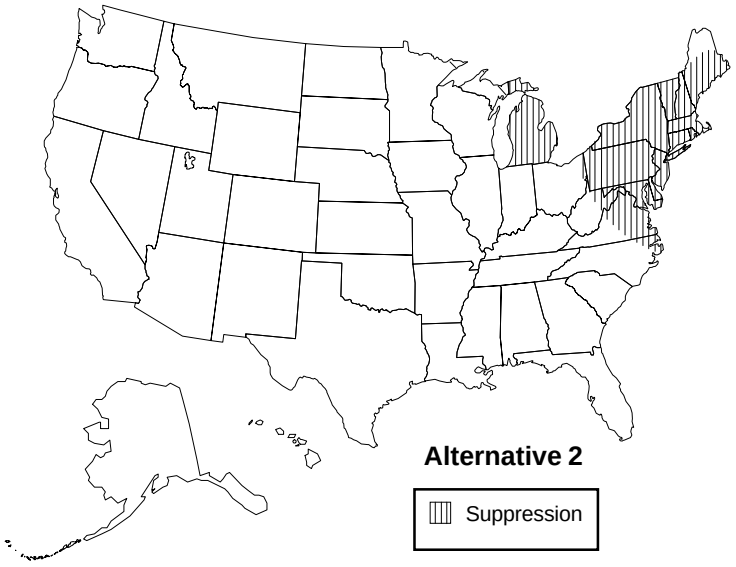
- They offer USDA support for an integrated pest management approach to manage the gypsy moth in the United States.

- They include delivery of technical advice and support to State and Federal cooperators by the Forest Service and APHIS.

The Alternatives

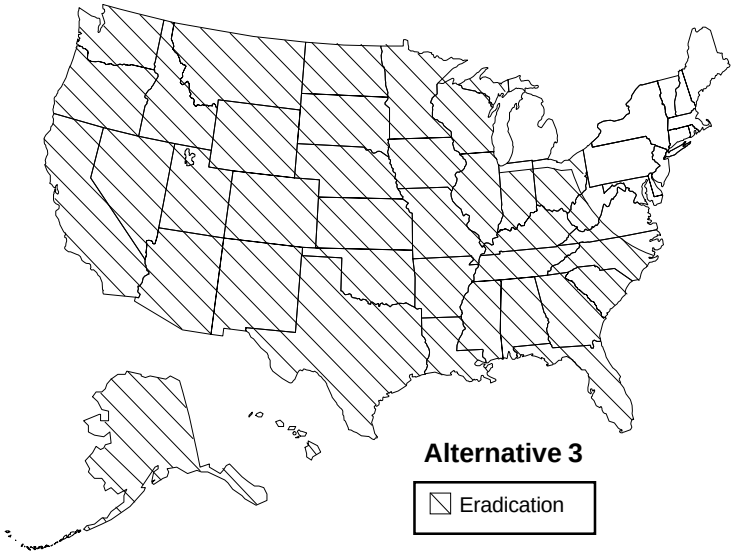
Alternative 1

No suppression,
no eradication,
no slow the spread



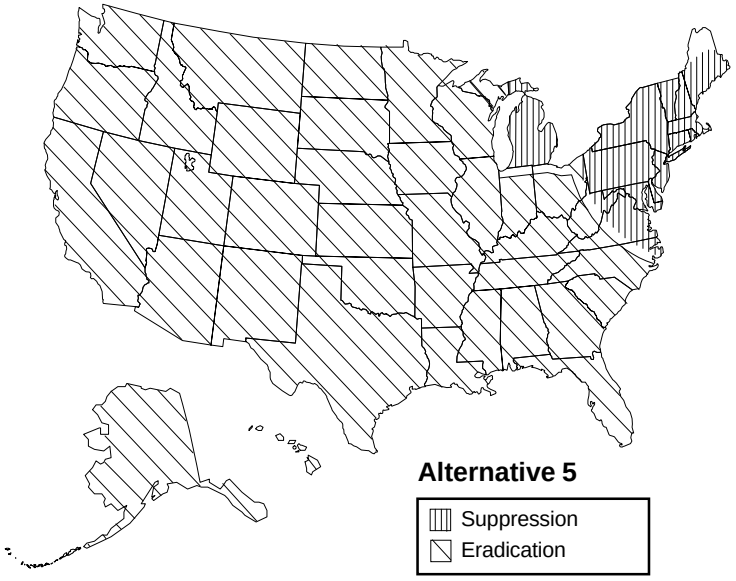
Alternative 2

Suppression



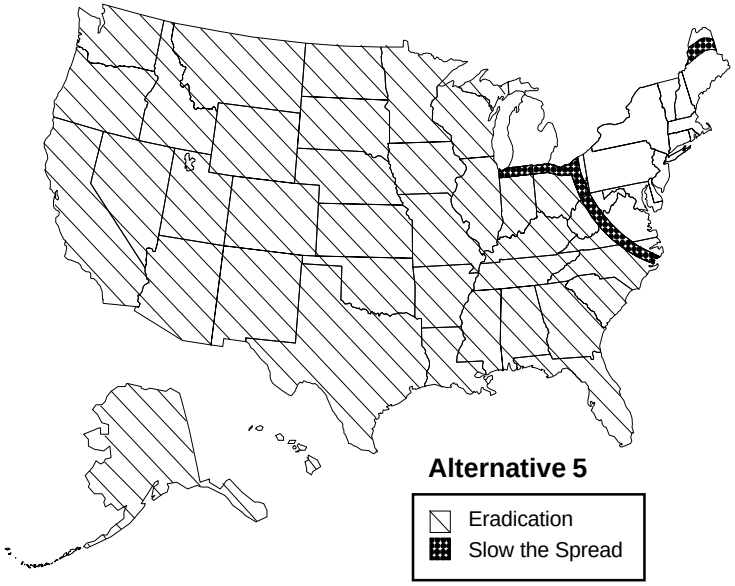
Alternative 3

Eradication



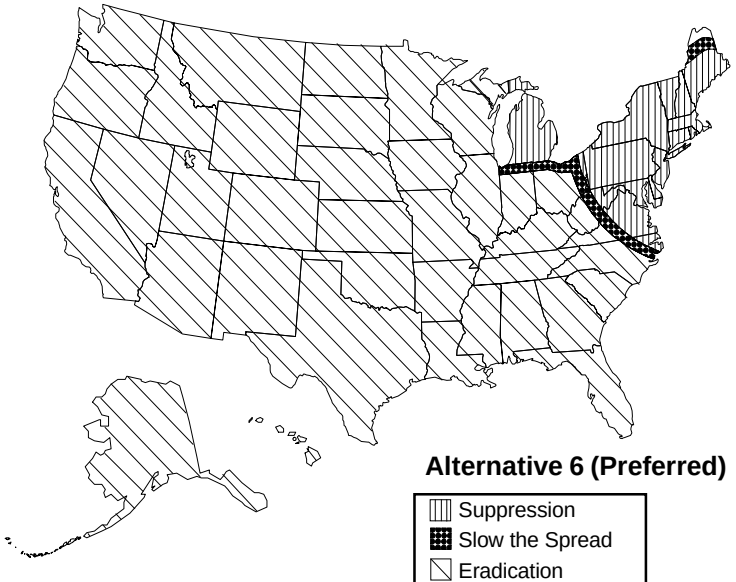
Alternative 5

Suppression
Eradication



Alternative 5

Eradication
Slow the Spread



Alternative 6 (Preferred)

Suppression
Slow the Spread
Eradication

What Are People's Concerns?

To learn the concerns of interested and affected people across the country, the preparers of the environmental impact statement invited public comments for 120 days through a notice in the *Federal Register*, mailings, news releases, articles, and presentations to natural resource managers.

Most of the concerns that were within the scope of the environmental impact statement were centered around the following issues:

1. How does the presence of the gypsy moth affect people and the environment?
2. How do the insecticide treatments applied to the gypsy moth affect people and the environment?
3. How do the noninsecticidal treatments applied to the gypsy moth affect people and the environment?

People's concerns include spraying insecticides and low flying aircraft.

A variety of specific concerns related to the gypsy moth was identified from more than 800 letters received from the public. Specific concerns that are within the scope of the environmental impact statement were analyzed. The following list of broad topics by which the proposed alternatives could be evaluated and compared was developed:

- Human health and safety
- Social and economic characteristics
  - Perceptions and behaviors
  - Economics
  - Recreation
- Ecological characteristics
  - Nontarget organisms
  - Forest condition
  - Water quality
  - Microclimate
  - Soil productivity and fertility.

What Would Be the Consequences of the Alternatives?

The alternatives were evaluated by comparing environmental consequences and how each alternative addressed these criteria:

- Meeting the USDA goal of reducing the adverse effects of the gypsy moth nationwide by protecting forests and trees
- Affording the U.S. Department of Agriculture flexibility in managing or assisting others in managing affected ecosystems.
- Estimated conditions throughout the United States by the year 2010 (conditions in 1994 are provided for comparison-see box)
- How they respond to the three issues, that is, whether they pose risks to people or the environment from the gypsy moth, insecticides, or noninsecticidal treatments.

Summary

Conditions in 1994

Generally infested area	
Total size	155,874,560 *acres*
Gypsy moth outbreaks and defoliation	881,752 *acres*
Suppression treatments	649,653 *acres*
Transition area	
Slow-the-spread treatments	34,309 *acres*
Uninfested area	
Isolated infestations	38 *infestations*
Eradication treatments	71,826 *acres*

Alternative 1. No Suppression, No Eradication, No Slow the Spread

Under alternative 1, the U.S. Department of agriculture would do nothing to reduce the adverse effects of the gypsy moth in the United States. The effects of implementing this alternative arise from the presence of gypsy moth caterpillars and the defoliation they cause. Because no strategies are available, natural resource professionals would have little flexibility to manage affected ecosystems nationwide.

Caterpillar droppings are an unwanted addition to a picnic (Photo by Nate Bacon, photographer)

The generally infested area could grow to 685million acres by 2010. Effects associated with the gypsy moth would be possible on 69 million of those acres.

In the transition area, the gypsy moth would continue to spread from the generally infested area. In 2010, effects from the gypsy moth would be possible on 5 million acres.

By 2010 additional areas within the uninfested area could become generally infested due to isolated infestations of the gypsy moth left untreated. Effects similar to those expected in the generally infested area could also occur on those acres. In 2010 alone, an estimated 76 new isolated infestations could occur.

Alternative 2. Suppression

Under alternative 2, the U.S. Department of Agriculture would reduce the adverse effects of the gypsy moth only in the generally infested area. Flexibility to manage affected ecosystems would be high in this area.

The generally infested area could grow to 685 million acres by 2010. Gypsy moth outbreaks could occur on 69 million of those acres, and 12 million acres likely would be treated with insecticides. Effects associated with insecticide treatments would be possible in treated areas. Effects from the gypsy moth would be possible on 57 million acres where outbreaks would probably not be treated.

In the transition area, the outlook would be the same as under alternative 1.

By 2010 additional areas within the uninfested area could become generally infested due to isolated infestations of the gypsy moth left untreated. Effects similar to those expected in the generally infested area could also occur on those acres. In 2010 alone, 76 new isolated infestations could occur.

Alternative 3. Eradication

Under alternative 3 the U.S. Department of Agriculture would reduce the potential for adverse effects of the gypsy moth in the uninfested area, and of the Asian strain anywhere in the United States. Flexibility to manage affected ecosystems would be high in local areas with isolated infestations.

The generally infested area could grow to 305 million acres by 2010. Effects associated with the gypsy moth would be possible on 14 million acres.

In the transition area, the gypsy moth would continue to spread. In 2010, effects from the gypsy moth would be possible on 500,000 acres.

In the uninfested area, all isolated infestations found since 1994 would have been eliminated.

There would be no effects from the gypsy moth in the uninfested area. The 263 new isolated infestations projected for 2010 would be eradicated. Effects from insecticide treatments could occur on 484,000 acres, and effects from noninsecticidal treatments would be possible on 36,000 acres.

Alternative 4. Suppression and Eradication

Alternative 4 represents no change from the current gyps y moth program. The U.S. Department of Agriculture would reduce the potential for adverse effects of the gypsy moth in both the generally infested and uninfested areas, and of the Asian strain anywhere in the United States. With two strategies available, flexibility to manage ecosystems would be higher than under alternatives 2 and 3.

The generally infested area could grow to 305 million acres by 2010. Effects associated with the gypsy moth would be possible on 12 million acres.

Effects from insecticide treatments could occur on 2 million acres.

In the transition area, the outlook would be the same as under alternative 3.

In the uninfested area, all isolated infestations found since 1994 would have been eliminated. There would be no effects from the gypsy moth in the uninfested area. The 263 new isolated infestations projected for 2010 would be eradicated. Effects from insecticide treatments could occur on 484,000 acres, and effects from noninsecticidal treatments on 36,000acres.

Alternative 5. Eradication and Slow the Spread

Under alternative 5, the U.S. Department of Agriculture would reduce the potential for adverse effects of the gypsy moth in both the uninfested and transition areas, and of the Asian strain anywhere in the United States. With two strategies available, flexibility to manage ecosystems would be the same as under alternative 4 and higher than under alternatives 2 and 3. To slow the spread of the gypsy moth from the generally infested area, pockets of gypsy moths detected in the transition area could be treated with insecticides or noninsecticidal treatments.

The generally infested area would grow to 204 million to 271 million acres by 2010 depending on the success of the slow-the-spread strategy. Effects from the gypsy moth could occur on 8 million to 12 million of those acres.

In the transition area, slow-the-spread projects would be conducted on 250,000 to 300,000 acres by 2010. Effects from insecticide treatments could occur on 230,000 to 270,000 acres, and effects from noninsecticidal treatments would be possible on 20,000 to 30,000 acres.

In the uninfested area, all isolated infestations found since 1994 would have been eliminated. There would be no effects from the gypsy moth in the uninfested area. In 2010, the number of isolated infestations would range from 284 to 324 depending on the success of slow-the-spread projects. Eradication projects could result in effects from insecticide treatments on 530,000 to 605,000 acres, and from noninsecticidal treatments on 40,000 to 45,000 acres.

Alternative 6. Suppression, Eradication, and Slow the Spread

Under alternative 6 —the preferred alternative — the U.S. Department of Agriculture would fully pursue its goal of reducing adverse effects of the gypsy moth (including the Asian strain) anywhere in the United States. A full range of strategies would be available, and flexibility to manage affected ecosystems would be high nationwide — higher overall than under all other alternatives.

The generally infested area would grow to 204 million to 271 million acres by 2010. Effects from insecticide treatments would be possible on 1.0 million to 2.0 million acres where gypsy moth outbreaks would be suppressed. Effects from the gypsy moth would be possible on 7 million to 10 million acres where outbreaks are not treated. Acres affected would vary depending on the success of the slow-the-spread strategy.

In the transition area, the outlook would be the same as under alternative 5.

In the uninfested area, all isolated infestations found since 1994 would have been eliminated. There would be no effects from the gypsy moth in the uninfested area. In 2010, 284 to 324 new isolated infestations could occur depending on the success of the slow-the-spread strategy. Effects from insecticide treatments used in eradication projects could occur on 530,000 to 605,000 acres, and from noninsecticidal treatments on 40,000 to 45,000 acres.

Effects of the Gypsy Moth and Treatments

Effects associated with the gypsy moth and available treatments that could be used in the USDA gypsy moth program are described in general in this section. Where the choice is made not to treat the gypsy moth, effects would be from the insect. In some parts of the generally infested area, gypsy moth populations will be too low to affect people or the environment.

Risk assessments were prepared to logically and scientifically examine how the gypsy moth, insecticide treatments, and noninsecticidal treatments affect human health and the environment.

How People May Be Affected by the Gypsy Moth

After being exposed to young caterpillars during moderate or heavy gypsy moth outbreaks, children and others who spend a lot of time outside may develop rashes or other skin irritation. Irritation to the eyes or respiratory tract is also possible. Some individuals may develop an allergy to the gypsy moth after repeated exposures over one or more years.

Strategies and treatment options available under the alternatives

	Alternative and strategy[1]																
Treatment[2] options	**1**	**2**		**3**		**4**			**5**				**6**				
		S		**E**		**S**		**E**	**E**		**STS**		**S**		**E**		**STS**
Insecticide treatment																	
Bacillus thuringiensis var. *kurstaki*		●		●		●		●	●		●		●		●		●
Diflubenzuron		●		●		●		●	●		●		●		●		●
Gypsy moth virus		●		●		●		●	●		●		●		●		●
Noninsecticide treatment																	
Mass trapping				●				●	●		●				●		●
Mating disruption				●				●	●		●				●		●
Sterile insect release				●				●	●		●				●		●

[1] **S** = suppression strategy: Reduce damage caused by the gypsy moth in the generally infested area
E = eradication strategy: Prevent establishment of isolated infestations of the gypsy moth
STS = slow the spread strategy: Slow the spread of the gypsy moth in the transition area

[2] No treatment is an option in all the alternatives

Summary

On rare occasions gypsy moth outbreaks can create a safety hazard, as caterpillars and their droppings can make roads and walkways slippery. Falling limbs can pose a hazard when trees die as a result of defoliation.

Infestations that are particularly bothersome to people or have a significant adverse effect on esthetic values can induce stress in some individuals.

Because some people will spend less time in outdoor activities to avoid contact with the gypsy moth, and repeated heavy defoliation can change the character of an area, recreation and tourism businesses may suffer. Economic losses can also result from the damage to trees on woodlots and subsequent reduction in property values.

Property owners may incur costs for treating the gypsy moth, removing caterpillars or their droppings, removing or scraping egg masses, repainting buildings, pruning or removing trees, and replacing damaged or dead trees and shrubs.

Contact with caterpillars may cause a rash. (Photo by Nate Bacon, photographer)

Homewowners are faced with cleanup after an outbreak.

How the Environment May Be Affected by the Gypsy Moth

Ecological effects from the gypsy moth vary depending on population levels, the amount of defoliation, and the duration of an outbreak. Defoliation is light (less than 30 percent) when gypsy moth populations are at low levels. Defoliation is moderate (30-60 percent) or heavy (more than 60 percent) during population outbreaks, which may last for 1 to 3 years. Effects are noticeable after moderate and heavy defoliation.

Low Populations and Light Defoliation

In the absence of outbreaks, as gypsy moth populations build, the numbers of certain natural enemies of the insect, such as the gypsy moth virus, parasites, and disease-causing fungi may increase.

Oak trees may produce no new acorns the year of heavy defoliation.

Moderate Outbreaks and Defoliation

Nontarget Organisms

Changes in populations of nontarget organisms may occur as a result of changes in habitat and availability of food after moderate defoliation. Short-lived changes may include increases in gypsy moth parasites and in numbers and types of birds. Populations of some bird species, such as flycatchers, may decline, as may those of gray squirrel and various amphibians. Increases in water temperature could cause short-term increases in aquatic insects, but the habitat quality of some marginal trout streams may decline. Numbers and types of other insects may decrease.

Long-term changes—after two or three consecutive years of moderate defoliation—may include an increase or decrease in numbers of gray squirrel and white-footed mouse, depending on longterm survival rates of trees and the capacity of dominant oaks to produce acorns. Numbers of nongame bird species may increase, but neotropical migrants may not be affected. Salamander populations should benefit from increases in dead and down branches and trees. The numbers and types of pollinators and other insects may increase in response to greater variety within the plant community.

Forest Condition

Short-term impacts of moderate defoliation on forest condition may be slight. Tree health may begin to deteriorate, growth of wood in susceptible trees may decline, and growth of vegetation beneath the tree canopy may increase. After 2 years of defoliation, oaks may begin to produce fewer acorns (hard mast), a situation that can persist for as long as 5 years. Production of berries and other fruit (soft mast) could increase should shrubs and herbaceous plants increase. If an outbreak continues for a third year, the abundance of organisms that attack weakened trees, such as shoestring fungus and two-lined chestnut borer, increases.

Trees killed as a result of defoliation provide nest and den sites.

In the long term, after two or more years of moderate defoliation, some of the shorter subdominant trees may die, resulting in a more onestoried forest. Tree species favored by the gypsy moth will probably decline and less-favored species will thrive. The growth of species that do well in shade, such as red maple, will accelerate. In surviving dominant oaks, the production of acorns eventually will return to predefoliation levels. The forest as a whole will probably become less susceptible to feeding by the gypsy moth. .

Water Quality

Slight short-term increases in water temperature and water yield, as well as decreases in dissolved oxygen, may result from moderate defoliation.

Long-term effects should be few. Sustained moderate outbreaks could result in a seasonal increase in water temperature—for a decade or more—in small streams bordered by susceptible vegetation.

Microclimate, and Soil Productivity and Fertility

Moderate defoliation may cause an increase in the seasonal temperature of soil and leaf litter, and increased exposure to sunlight, resulting in shortterm increases in biological productivity on the forest floor.

Heavy Outbreaks and Defoliation

Nontarget Organisms

Short- and long-term effects of heavy but not complete defoliation on nontarget organisms will probably be similar to those of several years of moderate defoliation. Even 1 year of complete defoliation, however, will have dramatic effects on caterpillars of moths and butterflies, which could suffer large-scale starvation.

Short-term impacts of two or more years of heavy defoliation can be dramatic. The numbers of

gray squirrel are likely to decline, as are those of some bird species, though woodpecker populations may increase. Populations of small mammals and amphibians such as salamanders will probably decline, as may those of the timber rattlesnake. Trout may decline or disappear from small streams, along with small crayfish and snails. Forest-feeding moths and butterflies-particularly those that feed on oaks—and their parasites (and perhaps their predators) also are likely to decline, as may other forest-dwelling invertebrates. Natural enemies of the gypsy moth may increase significantly. White-tailed deer will probably migrate to undefoliated areas, and nesting failures of grouse and turkey may increase. Bear, turkey, and bats may migrate to undefoliated or less defoliated areas.

Bats may move from defoliated areas. (Photo by Craig Stihler, West Virginia Division of Natural Resources)

In the long term, populations of gray squirrel and possibly trout might be reduced or eliminated from defoliated areas for years due to changes in habitat. Other nontarget organisms will increase or remain at predefoliation levels. Species that will increase include those that do not require a closed canopy and multistoried forest and those that associate with herbaceous plants and woody brush. Standing dead trees will provide cavity nests and den sites for animals, and dead and down trees will provide den sites and habitat for a variety of animals. In streams, logs and debris will improve habitat conditions for some species of fish and aquatic insects.

Forest Condition

The condition of trees in the forest canopy will be degraded and mortality rates will increase even after only 1 year of heavy defoliation. Production of both wood and hard mast (nuts and seeds) will decline temporarily. The growth rate of many shrubs and herbaceous plants may increase.

Repeated defoliation reduces a tree's ability to grow and maintain a healthy condition.

Short-Term Changes—After 2 years of heavy defoliation, the production of wood, and hard and soft mast will be greatly reduced. Shoestring fungus and twolined chestnut borer, which attack and kill trees weakened by defoliation, will become more abundant. Mortality is likely within 5 years, both among oaks and among species that are less favored by the gypsy moth. After 3 years of heavy defoliation, mortality will be high in oaks and less favored hosts. The growth of wood will be drastically reduced, and production of hard mast will probably cease for at least 5 years. Shrubs and herbaceous plants, such as raspberry and sweetfern, will increase dramatically.

Long-Term Changes—After 1 year of heavy defoliation, many subdominant trees will be removed in the long term, but few other effects will likely be apparent. After 2 years of heavy defoliation, stands of trees will become one-storied; however, surviving trees will recover, growing at an accelerated rate and

producing mast crops. Shrub cover will increase, as will red maple and other species that grow well in shade.

The two-lined chestnut borer can kill trees weakened by defoliation.

After three successive years of heavy defoliation on poor growth sites, many or most of the overstory trees will die, and sites will revert to plants such as blueberry, sweetfern, and raspberry. Regeneration to young forests will take decades. In areas where trees less favored by the gypsy moth remain, stands will be dominated by species such as red maple and yellow or black birch. If dead trees are not removed, the fire hazard will increase. The resulting forest, particularly on better sites, will be less susceptible to future gypsy moth outbreaks.

Water Quality

After heavy defoliation of trees along small streams, a short-term increase in water temperature is likely. Decomposition of leaf fragments and caterpillar droppings in these small streams could reduce oxygen levels and result in dramatic increases in algae. The capacity to neutralize acids could be reduced in some upland streams. Watershed yields will increase.

In the long term, these same changes in waterconditions may persist for years, though water yields should return to predefoliation levels.

Microclimate, and Soil Productivity and Fertility

After heavy defoliation, increased exposure to sunlight will cause seasonal elevations in the temperature of soil and leaf litter. Soil moisture content may increase temporarily. These factors could result in increased rates of soil decomposition, mineralization, and plant productivity. Such changes should be short-lived.

Effects Associated With Insecticide Treatments

Treatments available for use under all strategies in all parts of the country are formulations of the biological insecticides Bacillus thuringiensis var. kurstaki and the gypsy moth Nucleopolyhedrosis virus product Gypchek, and the chemical insecticide diflubenzuron.

Bacillus thuringiensis var. *kurstaki*

Bacillus thuringiensis var. *kurstaki* (*B.t.k.*), a bacterium that has insecticidal activity against caterpillars of moths and butterflies, is a variety of *Bacillus thuringiensis* (*B.t.*).

How People May Be Affected by *B.t.k.*

If directly exposed to *B.t.k.* spray, some individuals (most likely project workers) may develop minor irritation of the skin, eyes, or respiratory tract. These effects are relatively mild and transient. Pathogenic effects are not likely, even in individuals with impaired immune systems. Allergic responses to *B.t.k*, are conceivable, but have not been documented.

How the Environment May Be Affected by *B.t.k.*

Due to the relatively short insecticidal activity of *B.t.k.*, the risks associated with its use are usually limited to the time immediately after application.

Nontarget Organisms

Some spring-feeding caterpillars of moths and butterflies will be adversely affected by exposure to *B.t.k.* Large caterpillars eat more vegetation than small ones and are more likely to consume *B.t.k.* The potential for exposure to *B.t.k.* and mortality increases with an increase in the application rate and greater height in the tree canopy, because most *B.t.k.* spray is deposited in the tops of trees. *B.t.k.* poses a risk primarily to caterpillars present in spring because it is applied at that time and has relatively short insecticidal activity. Not all of these caterpillars may be affected due to wide differences in response to *B.t.k.* among species. Total numbers of moths and butterflies maybe temporarily reduced. Some species appear to be particularly susceptible to *B.t.k.* and populations maybe eliminated from treatment areas.

Permanent changes in nontarget caterpillar populations are not likely following suppression projects, which usually consist of a single application of *B.t.k.* An exception might occur in certain habitat types that support small isolated populations of moths and butterflies that are highly susceptible to *B.t.k.* If unaffected individuals of the same species are unlikely to or cannot physically migrate from untreated areas to the treated area, a single application of *B.t.k.* may have a greater effect on the ability of those populations to recover.

Data are sparse on the effects of multiple *B.t.k.* applications in one year and sequential yearly applications commonly used in eradication projects. It is reasonable to expect, however, that both the numbers and types of nontarget caterpillars maybe reduced after multiple applications of *B.t.k.*, and that these effects could persist for 1 year or longer. Additional studies on this topic would help to better quantify the effects on nontarget caterpillars.

The predominant effect of *B.t.k.* on some parasites of caterpillars is indirect through effects on their hosts. Caterpillars that are exposed to *B.t.k.* but do not die eat less, grow more slowly, and remain longer in the larval stage, increasing their susceptibility to parasites. Parasitism of the gypsy moth by at least two parasitic wasps increases in areas sprayed with *B.t.k.* Few other species or groups are affected.

The red-eyed vireo eats all life stages of the gypsy moth.

Vertebrates that feed on caterpillars in spring will have a reduced number of prey on which to feed for several weeks. Reductions in caterpillar numbers from application of *B.t.k.* may force a switch in diet for birds and mammals that eat them. In birds, the number of nesting attempts per year maybe reduced, but the overall number of fledglings per breeding territory may not change. Bats that feed on nightflying moths in summer may have to expand their foraging territories and adjust their foraging habits temporarily.

Use of *B.t.k.* reduces the incidence of infection by the Nucleopolyhedrosis virus in gypsy moth populations. *B.t.k.* reduces both the number of early stage caterpillars available for infection by the virus and the amount of virus released that can infect the residual gypsy moth population.

Forest Condition

B.t.k. reduces defoliation caused by some springfeeding caterpillars. As a result, its use is likely to maintain the forest condition.

Water Quality and Microclimate

By protecting tree foliage, *B.t.k.* reduces the likelihood of changes in water quality and microclimate that might be associated with feeding by gypsy moth caterpillars.

Soil Productivity and Fertility

Changes in soil productivity and fertility due to *B.t.k.* are not likely. *B.t.k.* persists for a relatively short time, *B t. is* known to occur naturally in soils worldwide, and applications of insecticides containing *B.t.* do not appear to increase levels of *B.t.* in soil. Some soil invertebrates maybe affected by *B.t.k.*, but additional research is needed to determine what effects, if any, this might have on rates of soil decomposition.

Diflubenzuron

Diflubenzuron (Dimilin), a chemical insecticide, interferes with the growth of some immature insects.

How People May Be Affected by Diflubenzuron

No human health effects are likely from exposure to diflubenzuron as it is used in gypsy moth projects. At very high exposures, increases in methemoglobin, an abnormal blood pigment that reduces the oxygen-carrying capacity of the blood, might be detectable. If other compounds that raise levels of methemoglobin-cigarette or other combustion smoke, carbon monoxide, nitrates in air or water— are present, the effect may be additive.

Aerial application of diflubenzuron may be used in suppression, eradicationn, or slow the spread.

A conservative estimate of cancer risk from exposure to diflubenzuron or 4-chloroaniline, a breakdown product of diflubenzuron, is less than one in 1 million over a lifetime.

How the Environment May Be Affected by Diflubenzuron

Diflubenzuron is persistent on vegetation throughout the growing season and may remain in leaf litter at least 1 year after spraying.

Nontarget Organisms

Moth and butterfly caterpillars, grasshoppers and other leaf- and litter-eating immature arthropods, parasitic wasps, some beetles, spiders, sawflies, aquatic insects, bottom-dwelling crustaceans, and immature free-floating crustaceans could be adversely affected from the lowest application rate of diflubenzuron used in gypsy moth treatment projects (0.25 oz active ingredient per acre). Higher application rates reduce populations even more and affect more types of species groups. More aquatic organisms could be affected at the highest application rate registered for use (1.0 oz active ingredient per acre).

***Terrestrial Organisms*—**Moths**,** butterflies, and grasshoppers may be affected in both the upper and lower tree canopy in spring and fall. Most diflubenzuron spray is deposited in the upper canopy,

and the amount of diflubenzuron residue begins to diminish after spraying in spring. As a result, the population reduction is greater for species that feed in the upper canopy.

Because diflubenzuron can kill caterpillars that serve as hosts, parasitic wasps of caterpillars maybe indirectly affected. Diflubenzuron can have different effects on different species of parasites of nontarget insects. Of predators that eat prey contaminated with diflubenzuron, more of those in immature stages, such as lacewings, die than do adults. In some groups such as ladybird beetles, the adults may produce fewer offspring.

Ground spiders could be directly affected by diflubenzuron applications or indirectly by a reduction in prey. Overall species diversity would remain unchanged.

Vertebrates, adult beetles, and earthworms are not likely to die from exposure to diflubenzuron.

Birds are not directly affected by exposure to diflubenzuron. Some insectivorous species may show subtle changes, such as a switch in diet, reduced fat loads, and expanded foraging territories. Similar changes may occur in bats that feed primarily on moths and butterflies.

Aquatic Organisms—Aquatic organisms may be affected by diflubenzuron treatments in both undeveloped forest areas and developed residential areas. Aquatic organisms that eat fallen leaves will be affected by diflubenzuron that coats leaves thatl enter streams in autumn. Bottom-dwelling insects may be affected in all habitats except ponds in undeveloped forest areas, which have the lowest concentrations of diflubenzuron. Free-floating crustaceans may be less affected in undeveloped areas. Mollusks do not appear to be at risk.

Fish are not likely to be directly affected from exposure to diflubenzuron as it is used in gypsy moth projects. Fish could suffer indirect effects through a reduction in prey but would likely compensate for this by eating other organisms.

Fish are not likely to be affected by exposure to diflubenzuron as used in gypsy moth projects.

Multiple Applications and Recolonization— The effects on most organisms from exposure to diflubenzuron applied 1 to 2 weeks apart, as in eradication projects, would be similar to one treatment at twice the application rate. Consecutive annual applications of diflubenzuron may affect invertebrates in leaf litter more than would a single application, because some diflubenzuron residues would persist into the following spring when the next treatment would be applied.

Some generalizations can be made about the risk of eliminating nontarget invertebrates from an area treated with diflubenzuron:

- Susceptible invertebrates that produce more than one generation per year and are exposed to persistent diflubenzuron (for example, on leaves or in leaf litter) are more likely to be affected severely than similar organisms that produce a single generation per year.

- Invertebrates that disperse rapidly or in large numbers will be able to recolonize treated areas.

- Invertebrates whose populations are severely reduced by diflubenzuron and have low dispersal rates will be affected for the longest period.

- Low dispersal capabilities of invertebrates, treatment of a large area, and frequent retreatment of an area will hinder the recovery of invertebrate populations.

Forest Condition

Diflubenzuron is not poisonous to plants and has no direct effect on them. Diflubenzuron may indirectly help maintain existing forest condition by reducing gypsy moth populations and protecting tree foliage.

Water Quality

Diflubenzuron may reduce numbers of two groups of stream invertebrates: those that process particulate organic matter from plant and animal remains, and those that feed on algae. Changes in water quality due to reductions of organisms in these groups, however, have not been observed.

Microclimate

Diflubenzuron indirectly helps maintain the existing microclimate by reducing the amount of defoliation by the gypsy moth and other insect defoliators.

Soil Productivity and Fertility

Earthworms are not at risk from diflubenzuron. Other invertebrates in leaf litter, particularly mites and ground dwelling spiders, may be affected by exposure to diflubenzuron, but decomposition rates of leaf litter do not seem to be affected.

Nucleopolyhedrosis Virus (Gypchek)

The Nucleopolyhedrosis virus, which occurs naturally, is specific to the gypsy moth. Gypchek is an insecticide product made from the gypsy moth Nucleopolyhedrosis virus.

Caterpillars killed by the nucleopolyhedrosis virus appear wilted and shiny, and often hang limply in an inverted "v" position.

How People May Be Affected by Gypchek

Irritation of the eyes, skin, and respiratory tract is possible from exposure to Gypchek, but this possibility cannot be assessed due to limitations in the available data. Because Gypchek contains gypsy moth parts, irritant effects might be similar to those caused by the gypsy moth itself. Individuals with allergies may be at greater risk of developing irritation. Workers are more likely to be affected than the general public because their exposure will be higher.

How the Environment May Be Affected by Gypchek

The gypsy moth virus is not known to directly affect organisms other than the gypsy moth, and no change in nontarget species or their populations is likely from the use of Gypchek. Gypsy moth parasitoids may be indirectly affected by loss of their host.

Changes in forest condition, water quality, microclimate, and soil productivity and fertility from the use of Gypchek will be minimal compared with those that otherwise would occur from feeding by the gypsy moth.

Effects Associated With Noninsecticidal Treatments

Noninsecticidal treatments available for use in slow-the-spread projects (in the transition area) and eradication projects (primarily in the uninfested area) are mass trapping, mating disruption, and sterile insect release.

Mass Trapping

Mass trapping entails the deployment of large numbers of male moth traps in the treatment area. The purpose is to attract male gypsy moths into the traps and thereby prevent them from mating with female moths. The effect is population reduction and eventual elimination of the infestation.

Two types of traps could be used in mass trapping. Both contain a minute amount of disparlure, a synthetic version of the sex-attractant produced by female gypsy moths to attract male moths. The smaller delta trap has a sticky inside surface for trapping moths. The larger milk-carton trap contains a pest strip impregnated with the insecticide DDVP (2,2 dichloroethenyl dimethyl ester phosphoric acid), also called dichlorvos. To date only the delta trap, which contains no insecticide, has been used in mass trapping. It is possible, however, that the milk carton trap would be effective for mass trapping in the transition area because of its larger capacity. Milk carton traps are commonly used for survey purposes in the transition area and where the estimated number of male moths that would be caught exceeds the capacity of the delta trap.

Milk carton traps contain the insecticide DDVP (dichlorvos).

How People May Be Affected by Mass Trapping

The insecticide DDVP as used in milk carton traps would pose more than a negligible health risk to humans only if an individual were to disassemble a trap and tamper with the DDVP-impregnated strip. Skin contact with the strip or eating the strip could inhibit the production of acetylcholinesterase. This enzyme prevents the accumulation of acetylcholine, the buildup of which can impair the function of the nervous system. Obvious signs of toxicity to the nervous system are possible but unlikely. Exposure to other substances that inhibit acetylcholinesterase, including similar insecticides, could have an additive effect with DDVP. The cancer risk from eating the strip or from skin contact with it is about one in 1 million over a lifetime.

The use of the smaller delta trap (which contains no insecticide) poses no known risks to people.

How the Environment May Be Affected by Mass Trapping

Invertebrates that inadvertently enter delta or milk carton traps are likely to die. Invertebrates that come into contact with a DDVP strip that has accidentally fallen on the ground, vegetation, or in water might also be adversely affected. The potential for adverse effects decreases over time as DDVP dissipates from the strip. Large animals, such as bears, that may tamper with traps are not likely to be affected by DDVP strips.

Female gypsy moths produce a chemical to attract males.

Mass trapping using either type of trap is not likely to cause changes in forest condition, water quality, microclimate, or soil productivity and fertility.

Mating Disruption

Mating disruption entails the aerial application of tiny plastic flakes or beads that contain disparlure, the synthetic version of the gypsy moth sex attractant. The effect is to confuse male moths and prevent them from locating and mating with females.

How People May Be Affected by Mating Disruption

By analogy to other insect pheromones, the risk of toxic effects from exposure to disparlure is believed to be slight. After direct contact with disparlure, a person (most commonly a project worker) may attract male gypsy moths. Although this attraction may last for years, and could be annoying and particularly stressful for individuals with an aversion to insects, it is not known to pose a health risk. The general public is not likely to be exposed to sufficient amounts of disparlure to experience this rare effect.

How the Environment May Be Affected by Mating Disruption

Disparlure has low toxicity to vertebrates and is specific to the gypsy moth. As used in mating disruption (and as an attractant in mass trapping), disparlure is not likely to cause changes in nontarget organisms, forest condition, water quality, microclimate, or soil productivity and fertility.

Sterile Insect Release

The purpose of sterile insect release is to add large numbers of sterile gypsy moth adults to a treatment area. The sterile adults will mate with fertile adults. The effect is population reduction and eventual elimination of the infestation. This technique can include the release of male pupae that were sterilized by a dose of radiation, male pupae

Sterile insect release often involves pupae.

that have been irradiated but not sterilized, or egg masses that were produced from mating of irradiated males with nonirradiated females.

How People May Be Affected by Sterile Insect Release

Because this treatment increases the number of gypsy moths in the treatment area, it could increase both the chance of effects from the gypsy moth and contact with gypsy moth caterpillars.

How the Environment May Be Affected by Sterile Insect Release

Effects from releasing sterile male pupae occur only in the year of treatment, while the effects from releasing irradiated male pupae or egg masses from an irradiated parent occur over 2 years.

Release of egg masses could add enough gypsy moth caterpillars to the treatment area to cause light defoliation in the year of release. Effects from this defoliation would be negligible.

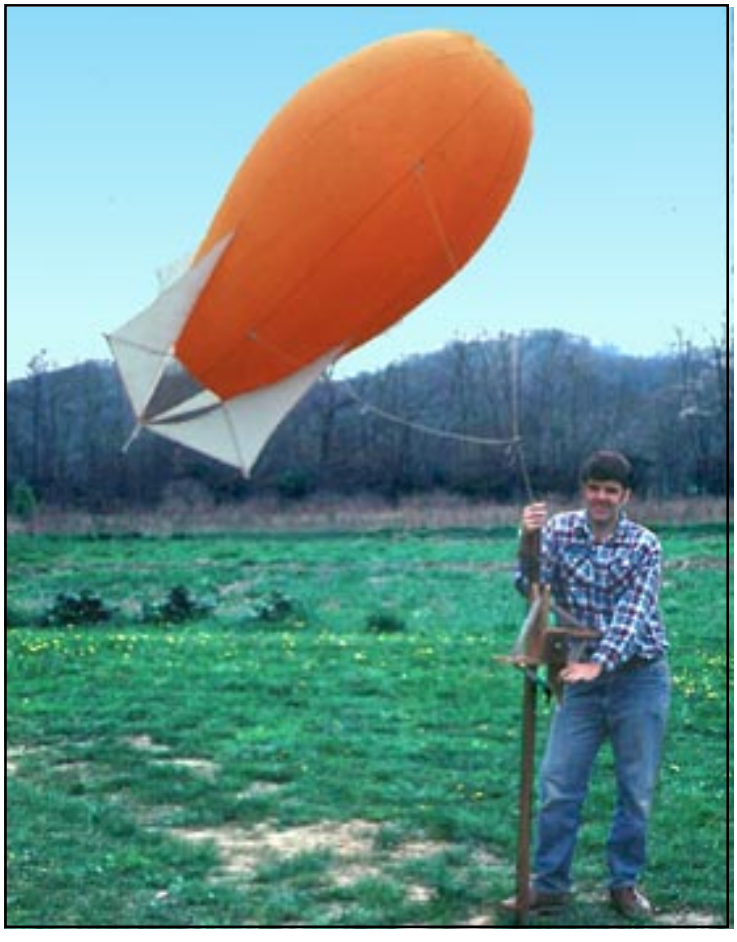
None of the three release approaches has any known effect on other organisms, or on forest condition, water quality, microclimate, or soil productivity and fertility.

Mitigating Adverse Effects

In some cases, different treatments can be used to avoid possible adverse effects. When the use of an alternate treatment is not possible on a treatment site, effects may be lessened and sometimes avoided by using mitigating measures.

For example, applying insecticides when weather conditions favor spray deposition and establishing an untreated buffer zone around a treatment site can prevent the drift of insecticide spray into a habitat of special concern, for example, a body of water or an organic farm.

Informing the public about treatment projects can help avoid inaccurate perceptions and reduce anxiety. Notifying people of the insecticide application schedule allows those who live in treatment areas or



Balloons may be used to mark locations were sensitive species exist and that are off-limits to treatment

who use recreation areas to plan their activities so that exposure can be avoided.

Mitigating measures are largely project-specific and are developed on a site-by-site basis during environmental analyses conducted for each proposed treatment project.

Public Involvement Improves the Environmental Impact Statement

In April 1995 the Forest Service and APHIS published a draft environmental impact statement and asked the interested public to review and comment on it. A public outreach effort was conducted through the use of direct mail, newspapers, magazines, newsletters, radio, and the Internet, and in response 146 letters were received.

The comments were analyzed and addressed in the final environmental impact statement. The comments indicated that no significant changes to the document were needed, and provided information that resulted innumerous improvements.

This summary is volume one of the five volume final environmental impact statement. To obtain the complete document, please contact the USDA Forest Service at (610) 975-4150.