Invasive Species Management and Control:

Gypsy moth (*Lymantria dispar*)

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1.0 INTEGRATED MANAGEMENT

“To address the economic and environmental impacts caused by the expanding range of the gypsy moth infestation, a national strategy was developed to manage gypsy moth populations along the leading edge of the infestation. The goal of this USDA Forest Service project, known as the ‘Slow the Spread of the Gypsy Moth’ (STS) program, is to intensively monitor populations along the leading edge and apply treatments such that the rate of expansion of the infested area is reduced by 50%. These goals are achieved through the use of a sophisticated Internet-based data management system and a decision algorithm to aid in decision making (Tobin et al., 2004). The STS program was pilot tested in 1993, became fully implemented in 2000, and currently includes 10 states and nearly 40 million ha (Sharov et al., 2002a)” (Tobin et al. 2007).

More information is available in the gypsy moth Slow the Spread (STS) website and factsheet.

2.0 PREVENTATIVE MEASURES

Landscapes may be protected from the gypsy moth in many different ways. The forest can be altered to prevent outbreaks. High-risk forests can be harvested before outbreaks occur to prevent some economic loss. Thinning stands of medium to high quality can increase the vigor of surviving trees, reducing the risk of major outbreak. Thinning to reduce the proportion of primary gypsy moth hosts can also reduce the frequency and intensity of defoliation. After defoliation has occurred, salvage logging can be carried out within 6 to 12 months of tree death to prevent complete economic loss and to advance regeneration.

In New Zealand legislation and quarantine procedures may require vessels from areas with established gypsy moth populations before entering port to undergo 'high risk' inspection for gypsy egg masses eight kilometres off shore. If found, the vessel is directed back to the 20 nautical mile limit for cleaning, before 'high risk' inspection will be continues once again at eight kilometres off shore (M. Dijkhuis pers. comm April 2005).

3.0 PREDICTION OF SPREAD

One obstacle in developing sound approaches to managing biological invasions is the lack of reliable methods for estimating and predicting the spread of an introduced species. Therefore
developing effective spread estimates for invasive species is a primary concern of management programs. Tobin and colleagues (2007) used county level presence/absence quarantine records and detailed pheromone trap data from the Slow the Spread program to estimate gypsy moth spread using a number of methods. The gypsy moth is one of the most extensively monitored species in the world, thus STS data is a unique resource. STS pheromone trap data is spatially extensive and uniformly spaced due to a network of over 100,000 traps placed annually over the transition zone between infested and uninfested areas (Tobin et al. 2004 in Tobin et al. 2007). However despite the fact that the county level records were far more crude data, overall rates of spread did not differ substantially from estimates obtained by more costly pheromone traps, particularly in longer time series. These results are encouraging, as records of simple presence/absence by municipality can be used to obtain comparable estimates of spread rates if use of extensive trapping grids is not feasible (Tobin et al. 2007).

Peterson et al. (2007) carried out ecological niche modeling using climate data from the native range of the Asian L. dispar. This revealed that ecological niche data from the Asian race was able to relatively accurately predict the geographic distribution of the much better known European L. dispar populations, indicating that ecological characteristics of the two races are very similar. The ecological niche model predicted that the global potential distribution of both the Asian and European gypsy moths is quite broad and that “these populations appear to have the potential to colonize almost all temperate-zone areas, except for montane regions and deserts” (Peterson et al. 2007). However Asian gypsy moth is likely to be more difficult to control due to faster maturation and better dispersal abilities (Barnachikov 1989 in Peterson et al. 2007).

4.0 MONITORING OF IMPACT

“Despite efforts to prevent the ongoing spread of the gypsy moth, the affected area of North American forests continues to expand. With the increased area of infestation, ecological, environmental and economic concerns about gypsy moth disturbance remain significant. As such, the pressure on current monitoring tools is greater than ever”. Traditional sketch-mapping and observer based programs are likely to become less able to comprehensively quantify the areas of impact. Moderate Resolution Imaging Spectroradiometer (MODIS) is an important tool for broad-scale detection of defoliation by L. dispar. de Beurs and Townsend (2008) determined that daily MODIS data is optimal for monitoring insect defoliation on an annual time scale, rather than eight or 16 day data which is of less use due to the ephemeral effects of gypsy moth disturbance (de Beurs and Townsend 2008).
5.0 PHYSICAL CONTROL

Removing gypsy moth egg masses with a paint scraper during the winter months will minimize or prevent infestations in spring. The use of sticky barrier bands on tree trunks can prevent caterpillars from reaching the canopy. Commercial double-sided tape, Tanglefoot® or grease can be used. Burlap bands can also be used to trap older caterpillars that use the shade provided by the band to escape the heat. The band should be checked daily and caterpillars removed. Sticky and burlap bands are most effective on isolated trees and need to be regularly checked during the summer. It is important to note that neither band is effective against caterpillars that “balloon” [disperse] in the spring (USACHPPM 2007).

6.0 CHEMICAL CONTROL

Aerial spraying of populations is the most common method for eradicating new isolated populations and is also used to suppress outbreaks in well established populations. Aerial applications are conducted synthetic insecticides such as diflubenzuron (Dimilin), carbaryl (Sevin), and mimic (tebufenozide).

In recent years semiochemical-based [compounds produced naturally by insects that govern their behavior] pest management is being increasingly used. They have the advantage of being environmentally friendly, non-toxic to vertebrates and beneficial insects and are highly selective to the target pest species. Semiochemical-based control techniques include mating disruption, mass trapping, “lure and kill” and to a lesser extent “lure and infect” (Klein and Lacey 1999 in El-Sayed et al. 2006). “The concept of mass trapping uses species-specific synthetic chemical lures, such as sex and aggregation pheromones and food/host attractants, to attract insects to a trap where they would be confined and die” (El-Sayed et al. 2006). Lure and kill is similar to mass trapping, whereas mating disruption involves using sex pheromone to disorient insects and prevent males from locating and mating with females. Mating disruption is the most widely used technology in pest management (El-Sayed et al. 2006) and is the most preferred technology for gypsy moth control (Reardeon et al. 1998 in El-Sayed et al. 2006)

Mating disruption is the primary treatment technique used in STS due to advantages including target specificity, relatively inexpensiveness and effectiveness in low-density, newly establishing populations (Sharov et al. 2002b in Tobin et al. 2007). Disrupt® II plastic laminated flake formulation of sex pheromone disparlure (Hercon Environmental, Emigsville, PA) is currently the only commercial product available for operational use (Tobin et al. 2007). However work by Solari and colleagues (2007) aims to identify synthetic pheromone derivatives that are stronger
attractants than the natural pheromone disparlure to be used for monitoring and mating disruption.

7.0 BIOLOGICAL CONTROL

The most common eradication method used against the gypsy moth is the naturally occurring *Bacillus thuringiensis* (B.t) bacteria. B.t occurs naturally in the soil and on plants. Different varieties of this bacterium produce a crystal protein that is toxic to specific groups of insects. *Bacillus thuringiensis kurstaki* (B.t.k) produces a toxin that is specific to moths and butterflies only at their caterpillar stage of development (Weeden *et al.* n.d.).

B.t.k has been developed into sprays consisting of spores and crystalline proteins, combined with water, preservatives and approved ingredients to make the spray stick to foliage. Foray® and DiPel® are two commercially produced *Bacillus thuringiensis var. kurstaki* (Btk) sprays. See Information on *Bacillus thuringiensis subspecies kurstaki* (Btk) for more information on these sprays.

B.t.k is sprayed on to foliage. Spraying is generally done in the spring when the gypsy moth caterpillars emerge from the egg masses (Public Health – Seattle & King County 2009). The foliage must be eaten by caterpillars before it can take effect. Once it has been eaten, the toxin in B.t.k is activated by the alkaline gut contents of the caterpillar, causing gut paralysis. Minutes after eating the caterpillar will stop feeding, movement will slow, and death results in several days time (Weeden *et al.* n.d.).

A recent study conducted by Kati *et al.* (2007) analysed a variety of B.t.k strains to determine pathogenicity. They found that Bn1 strain had higher toxicity compared with the standard HD-1 strain that is commercially used. 90% mortality was observed against *L. dispar* and *Malacosoma neustria* larvae. Further studies are needed to characterize this strain and work towards development of a Bn1 pesticide (Kati *et al.* 2007).

For more information on B.t please see About Bt.

In addition to B.t there are a variety of other natural parasitoids and predators that kill gypsy moths in nature. Small mammals are important predators, particularly at low population densities. A number of birds are also known to prey on gypsy moths, but this does not substantially affect populations in North America. Gypchek® is a naturally occurring virus that kills the pest by attacking its internal tissue. This is used in the STS program (APHIS 2003b).
8.0 BREEDING RESISTANT TREES

Current research is being carried out by Barbehenn and colleagues which aims to find a basis for engineering resistance to *L. dispar* in trees.

Barbehenn *et al.* (2007) evaluated the potential of engineering elevated levels of ascorbate oxidase in poplar, and found that it was unlikely to serve as a basis for defense against *L. dispar* and other herbivores. A 2008 study by Barbehenn and colleagues assessed transgenic trees displaying increased polyphenol oxidase levels. Surprisingly there was little to no effects on feeding rate of *L. dispar* caterpillars (Barbehenn *et al.* 2008). The most recent approach investigated the effects of manipulating foliar tannins in oak and sugar maple trees to provide increased resistance. They found that although artificially increased levels of hydrolysable tannins increased oxidative stress in caterpillars, tree resistance may require additional resistance factors. Further work is needed to evaluate these factors (Barbehenn *et al.* 2009).