Successful Strategies for Reducing Pesticide Use in the Landscape: Examples from California

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Summary. Pesticide use in the landscape has been reduced through the implementation of integrated pest management (IPM) (Holmes and Davidson, 1984, Olkowski et al., 1978; Smith and Raupp, 1986). IPM emphasizes prevention, identifying pests and their symptoms, regular surveying for pests, determining action thresholds and guidelines, and using sound management methods. Monitoring techniques such as pheromone traps, degree-day models, and ELISA kits, in addition to traditional methods, have enabled pest managers to determine accurately when to apply IPM techniques. Examples of serious California landscape insect pests successfully controlled through IPM include the ash whitefly [*Siphoninus phillyreae* (Halliday)], the Nantucket pine tip moth [*Rhyacionia frustrana* (Comstock)], and the eucalyptus longhorned borer (*Phoracantha semipunctata* F.).

A major reason for the reduced use of pesticides in California landscapes has been the adoption and implementation of integrated pest management (IPM) (Holmes and Davidson, 1984; Olkowski et al., 1978; Smith and Raupp, 1986). While the reduced use of pesticides is an important achievement, there has also been a move towards safer pesticides such as biorationals, soaps and oils (Parrella, 1990). New chemistries that are selective or have unique modes of action against a pest have also helped to reduce pesticide use and minimize the effects of pesticides on nontarget species and the environment.

IPM emphasizes prevention, identifying pests and their symptoms, surveying for pests regularly, determining action thresholds and guidelines, and using sound management methods (Dreistadt, 1994). Prevention is extremely important in a state such as California, which is a center for international trade and travel and has an abundance of climates and plant species that can enable exotic pests from other countries to become established. The first line of defense against such pests are government quarantines. Despite quarantines, exotic pests have been introduced into California.

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Monitoring is an important part of IPM. Quarantines and action thresholds depend on monitoring to be effective. Control strategies such as using pesticides or biological control depend on timing the strategy to attack low populations during their most susceptible stage in time or place. Such strategies, when properly timed, have reduced pesticide use tremendously. To be effective, monitoring must be done on a regular schedule, using a repeatable method such as counting the number of insects in or on a trap, beating, sweeping, collecting by-products of feeding (frass, scats, honeydew), or conducting a timed visual count. New technologies such as the ELISA (enzyme linked immunosorbent assay) kits that are now commercially available enable pest managers to verify the presence of diseases such as *Phytophthora*, *Pythium*, *Rhizoctonia*, and *Xanthomonas* and various viruses. Now, instead of automatically applying a prophylactic treatment of fungicide, pest managers can test for the pathogens and apply fungicide only if they are present. A positive reaction on an ELISA test indicates the need to treat the identified problem, while a negative reaction tells an experienced diagnostician to look for another cultural, biological, or abiotic reason for poor plant health or death.

IPM has reduced the use of pesticides in the landscape because it uses all the possible management methods available. This has required the education of pest managers and has been greatly aided by pesticide regulations in California, which require state-licensed pest control advisors to make written recommendations. These recommendations must consider all possible control alternatives in addition to pesticides to control a pest.

Worker safety regulations and the requirement that production agriculture and commercial applicators file 100% pesticide-use reports has also helped to reduce pesticide use. A major change in the last two decades has been a change of pesticide preference by pest managers. Before the advent of widespread concern about pesticides and the resultant regulations, pest managers often preferred highly toxic, broad-spectrum, long-lived pesticides. Preference is now toward pesticides that are less toxic to mammals and the environment, selective and short lived in the environment, have a short worker reentry interval, are labeled for the pest and site, and require less active ingredient per acre. This has resulted in an increased use of biorationals (fungi, parasitic nematodes, insect growth regulators, *Bacillus thuringiensis*), soaps, and oils, which often require greater attention to pest identification and biological, environmental, and physical factors to be effective.

A pesticide's failure to control a pest can be due to resistance to the pesticide; however, it is just as likely that there is another cause. In university tests, a pesticide may control ≥90% of a pest population, yet pest managers often report having very little control of a pest with the same compounds. Spray applications based on monitoring information or action thresholds that do not provide adequate control may be the result of either resistance or not getting the pesticide to the target organism. Using proper equipment that is properly maintained and calibrated results in excellent results and few, if any, repeat applications. Using surfactants on surfaces that are hard to wet and adjusting the pH of the spray solution when using pH-sensitive pesticides also maximizes the efficacy of an application. Where pest managers are not responsible for irrigation, especially overhead irrigation, it is important to communicate with the irrigator to ensure that irrigation is not turned on before the pesticide dries or becomes activated. Sometimes pesticides such as preemergent herbicides require a specified amount of water (0.5 to 1 inch) that will activate the herbicide without causing excessive runoff that can move the herbicide off site.

Biological control integrated with other methods has been used successfully to control several exotic pests. When an introduced pest builds up high populations in the absence of it's natural enemies, scientists often try classical biological control. Classical biological control includes looking for natural enemies from the pest's point of origin and establishing them on the introduced population. Augmentation and conservation of biological control agents are two other strategies used in biological control programs.

Examples of serious California landscape insect pests successfully controlled through IPM include the ash whitefly, the eucalyptus longhorned borer, and the Nantucket pine tip moth.

THE ASH WHITEFLY was introduced into southern California in 1986 and spread rapidly through California. It became a serious pest in the landscape because of the extremely high populations that built up on plants, the wide host range of plants it feeds on, and the large amounts of honeydew and sooty mold produced from its feeding. The problem was so severe that many picnic areas were unusable due to clouds of whitefly that would get into the mouths and noses of picnickers. In urban areas, the honeydew would completely cover cars and sidewalks. Pesticides had a minimal impact due to the almost immediate reinfestation by ash whiteflies from other nearby trees. The Univ. of California (UC) Cooperative Extension and county agricultural commissioner offices were receiving several hundred calls a day about this problem from citizens and politicians from all levels of government. The public and commercial pesticide applicators were asked to refrain from using pesticides by the UC researchers working on this pest and the California Dept. of Food and Agriculture (CDFA), because they might kill the beneficial insects, possibly delaying their establishment. Scientists from CDFA and UC Riverside imported a parasitic wasp, *Encarsia partenopia* (Walker), and a predatory lady beetle, *Clitostethus arcuatus* (Rossi), which were successfully released and established in southern California counties that had ash whitefly problems (Bellows et al. 1990).

Ash whitefly populations later became established in several northern California counties and were controlled by university, private, and government collaborative efforts, which shared in the cost of rearing and releasing parasites and informing the public of the adverse effects that spraying pesticides would have on the biological agents.

THE EUCALYPTUS LONGHORNED BORER is native to Australia and was first detected in Orange County, Calif., in 1984. Attacked trees may produce copious amounts of resin (kino), and the treetops, branches, or entire tree may be killed. The larva bore into the living cambial tissue beneath bark, and a single gallery can extend several feet and can girdle a tree. Insecticide sprays have provided inadequate control and are expensive due to the large size of typically attacked trees, the long period of activity of the beetle, and the inability of insecticides to get to the larval stage in the cambial layer. Natural enemies such as the larval parasites *Jarra phoracantha* Austin, Quicke and Marsh., *Jarra maculapennis* Austin, Quicke and Marsh., and *Syngaster lepidus* Brulle and the egg parasite *Avetianella longoi* Siscaro have been introduced from Australia and may provide a long-term solution (Hanks et al., 1996). By reducing beetle populations on healthy trees to a lower level, natural enemies reduce borer damage because vigorous trees can survive a few attacks. The eucalyptus longhorned borer is attracted to stressed trees; therefore, the IPM strategy recommended by UC is to inspect trees regularly for stress and provide appropriate irrigation, especially during prolonged dry periods. UC scientists also recommended that dead branches and dead trees be removed and destroyed as soon as possible because they are prime breeding sites for the eucalyptus longhorned borer. Eucalyptus longhorned borer adults are also attracted to fresh wounds or pruning cuts; therefore, another recommendation is to restrict pruning to December and January when adult beetles are inactive. Dead wood can be kept on site if the bark is removed or the wood is solarized by sealing it in a sunny location under an ultraviolet-resistant, clear polyethylene tarp for at least 6 months (Paine et al., 1995). Susceptible species such as *Eucalyptus diversicolor* F. Mueller, *E. globulus* La Billardiere, *E. grandis* Hill ex Maiden, *E. nitens* (Dean & Maiden), *E. saligna* Sm., and *E. viminalis* LaBillardiere should not be planted. Instead, UC scientists have recommended that resistant species such as *E. camaldulensis* Dehnhardt, *E. cladocalyx* F. Muller, *E. robusta* Sm., *E. sideroxylon* A. Cunn. Ex Woolls, and *E. trabutii* (a hybrid of *E. camaldulensis* and *E botryoides*) be used (Hanks et al., 1995).

THE NANTUCKET PINE TIP MOTH is a serious pest of Monterey pine (*Pinus radiata* D. Don.) and was first found in southern California in 1967. It has a fairly broad host range and can attack most yellow pines. Feeding is indicated by webbing near the bases of developing needles. As the larva feed and grow, more webbing with frass and resin becomes visible. The shoot's conductive tissue is ultimately severed, killing the shoot and resulting in the visibly characteristic brown, dead shoot tips. Heavy infestations of tip moth can result in severe malformation of the trees. The moth became a major problem in Christmas tree plantations, and growers were spraying up to twice a week over a 7-month period to try and control this pest. The problem became worse in the early 1980s when the moth became established in the many Monterey pine trees planted in southern California landscapes. These populations provided a reservoir of Nantucket pine tip moths, which would reinfest pesticide-treated trees. Christmas tree plantations that had been treated with pesticides were also immediately attacked by moths from the surrounding landscapes, making it almost impossible to control this pest without almost continual pesticide applications. The IPM program developed by UC (Malinoski, 1986) consists of monitoring using pheromone traps, degree-day modeling, chemical control, and biological control (*Campoplex frustranae* Cushman) and has resulted in populations that normally do not warrant chemical control in the landscape. In Christmas tree plantations, commercial applicators have been able to reduce pesticide applications to two or three per season. Pheromone traps and degree-day modeling were crucial in reducing the use of pesticides by identifying when the most susceptible newly hatched larvae were present. Moth catches in the pheromone traps and daily temperatures are needed to use the degree-day model. Pheromone traps are used to monitor moth flights, and, by plotting the moth counts on graph paper, it is possible to see the population cycles and generations.

Traps are used to determine the first day of moth flight in each of generations 2 and 4. The flight of generation 2 generally begins in early April. Degree-day accumulation is then started for each successive day after this date (biofix) until a total of 1033 degree-day units is reached. This should be within a day of the peak flight counts. When an additional 200 °F degree-days are accumulated, it is time to treat. In the winter this may be 10 to 14 d after a peak flight, and in the summer this may be 4 to 7 d after a peak flight. This is the period during which the largest percentage of hatching larvae will be feeding on the outside of the trees and vulnerable to insecticide sprays. Sprays are used to ensure thorough coverage, especially to the tops of the trees where most tip damage occurs. To prevent pesticide resistance, pesticides with different modes of action or different classes are recommended. Cultural practices, such as shearing trees during a time when moths are not flying, reduce the number of eggs laid and moth damage. Any newly hatched larvae or eggs on sheared growth will not complete development and will die. Mature larvae in sheared tips can complete development and emerge to reinfest trees and should be removed and destroyed.

Conclusion

The examples of three serious California landscape insect pests successfully controlled through IPM demonstrate the importance and effectiveness of IPM. However, to increase the successful use of IPM, funding is needed for fundamental research and implementation that follows the systematic levels of operation (basic research, synthesis, demonstration, training, and implementation) for interdisciplinary pest management research (Poe, 1981), and to understand the interactions of plants, sites, management practices, pests, and the aesthetic thresholds that would be acceptable to homeowners, local or regional maintenance managers, and government agencies responsible for pest management in public areas (Elmore, 1981). Pest managers need easy access to technical, economic and environmental information, and training materials on using IPM in the landscape.

Identifying key plants (Raupp et al., 1985) and working with city, state, and community maintenance managers to implement IPM (Flint et al., 1991; Raupp and Noland, 1984) are other ways that IPM adoption can be expedited. However, the greatest delay in IPM implementation in the landscape has been the lack of research-based information and individuals trained to practice IPM.

Literature cited

Bellows, T.S., T.D. Paine, K.Y. Arakawa, C. Meisenbacher, P. Leddy, and J.N. Kabashima. 1990. Biological control sought for ash whitefly. Calif. Agr. 44(1):4–6.

Dreistadt, S.H. 1994. Pests of landscape trees and shrubs. Univ. of Calif. Div. of Agr. and Natural Res. Publ. 3359.

Elmore, C.L. 1981. Urban pest management in horticulture—Weed science. HortScience 16:507.

Flint, M.L., S. Daar, and R. Molinar. 1991. Establishing integrated pest management policies and programs: A guide for public agencies. Univ. of Calif. IPM Publ. 12.

Hanks, L.M., T.D. Paine, J.G. Millar, and J.L. Hom. 1995. Variation among *Eucalyptus* species in resistance to eucalyptus longhorned borer in southern California. Entomologia Experimentalis et Applicata 74:185–194.

Hanks, L.M., TD. Paine, and J.G. Millar, 1996. Tiny wasp helps protect eucalyptus from eucalyptus longhorned borer. Calif. Agr. 50(3):14–16.

Holmes, J.J. and John A. Davidson. 1984. Integrated pest management for arborists: Implementation of a pilot program. J. Arboricult. 10(3):65–70.

Malinoski, M.K. 1986. Nantucket pine tip moth: Biology and control. Univ. of Calif. Coop. Ext. Div. of Agr. and Natural Res. Lflt 21243.

Olkowski, W., H. Olkowski, T. Drlik, N. Heidler, M. Minter, R. Zuparko, L. Laub, and L. Orthel. 1978. Pest control strategies: Urban integrated pest management. In: E.H. Smith and D. Pimentel (eds.). Pest control strategies. Academic Press, New York.

Paine, T.D., J.G. Millar, and L. M. Hanks. 1995. Integrated program protects trees from eucalyptus longhorned borer. Calif. Agr. 49(1):34–37.

Parrella, M.P. 1990. Integrated pest management. Calif. Assn. of Nurserymen's Pacific Hort. Trade Show Sem., Los Angeles.

Poe, S.L. 1981. An overview of integrated pest management. HortScience 16:3–8.

Raupp, M.J., J.A. Davidson, J.J Homes, and J.L Hellman. 1985. The concept of key plants in integrated pest management for landscapes. J. Arboricult. 11(11):317–322.

Raupp, M.J. and R.M. Noland. 1984. Implementing landscape plant management programs in institutional and residential settings. J. Arboricult. 10(6):161–169.

Smith, D.C. and M.J. Raupp. 1986. Economic and environmental assessment of an integrated pest management program for community-owned landscape plants. J. Econ. Entomol. 79:162–165.