ESTABLISHING MONITORING ROUTINES AND ACTION THRESHOLDS FOR A LANDSCAPE IPM SERVICE

by *John Ball and Paul Marsan*

Abstract. Integrated pest management (IPM) has become an important part of pest management services. However, many IPM programs are in name only, since they lack monitoring routines and action thresholds for even their most common pests. This paper discusses basic concepts of monitoring and suggests guidelines for establishing action thresholds.

Integrated pest management (IPM) has been defined differently by many practitioners, but most agree that it has four major components; monitoring, decision-making, intervention and evaluation. Of these, intervention is the one most arborists accept as a necessary part of their pest management service. Intervention, primarily by chemical tactics, has been the dominant feature of pest management services since the turn of the century. Now, arborists under the guise of IPM are continuing their practice of looking for pests to spray. But IPM is a process, not a reaction. Without monitoring, decision-making and evaluation a pest management service is operating a see-and-spray (SAS) rather than an IPM program (2).

The transition from SAS to IPM requires establishment of monitoring routines and treatment thresholds. This is not easily accomplished. Unlike agricultural IPM, few monitoring techniques and action thresholds have been evaluated for use in the landscape (23). The number of host plants and associated pests are much greater in the urban landscape ecosystem than in the entire realm of agricultural production. Pest management services can not rely on university researchers to develop thresholds for all pest and host combinations that occur within their service area. The task is partially up to practitioners.

This paper examines the basics of monitoring and thresholds and provides guidelines for their construction. It primarily applies to insects, although many of the same principles apply to disease management.

Monitoring routines

Monitoring is the routine, systematic inspection of the landscape for pests and environmental conditions that affect plant vitality and appearance. It also includes recognizing the presence and abundance of natural enemies of pests. There are four major categories of monitoring: detection, pest evaluation, plant evaluation and treatment evaluation (6). A good scout is performing all four when inspecting a client's landscape.

Detection. Detection is a qualitative measure generally done by direct observation. The scout is noting only the presence of a plant problem and identifying the causal agent. This is done systematically each time the scout is on a property. Some SAS programs limit their scouts to inspecting only certain plants during a particular monitoring visit. During May, the scout may be told to examine only the pines in the client's landscapes to check for sawflies and scales, treat if found, and ignore the other plants. This approach does decrease monitoring time, but at the risk of missing the unexpected. Services that ignore detection monitoring may find clients reporting pest problems to them. This does not instill client confidence in a pest management service.

Pest Evaluation. Another category of monitoring is pest evaluation. This category of monitoring is probably the most critical to the success of an IPM program. It provides a quantitative estimate of the pest population density that will be compared to a threshold value to determine the need for intervention tactics. The population density can be expressed one of three ways; absolute estimate, relative estimate or a population index (22). Each way has its use in pest evaluation monitoring.

An absolute estimate is the number of insects per unit area or volume. Sampling pest populations to arrive at an absolute estimate is tedious and time consuming. Many IPM services tend to use a closely related measure, the population intensity. The population intensity is the number of insects per unit area of habitat, for example, aphids per leaf (6). Many researchers consider the population intensity a relative estimate, since the area or volume is not identical for each sample.

A relative estimate is the number of insects per unit of measure other than area or volume. For example, the number of black vine weevils caught in a pit fall trap per day. Relative methods are easier to obtain in the field than absolute estimates. They are often used to note the arrival of the life stage vulnerable to pesticide treatment. Pheromone traps are used for timing insecticidal sprays for clearwing moths (19). Yellow sticky traps are used to determine spray windows to minimize scale parasite mortality (21). Relative methods are also used in making treatment decisions. Nielsen suggested a method for sampling spider mites on spruce by shaking the branches over a card to dislodge mites. If one spider mite per beat is collected, the plant is treated (15).

A population index is based upon products of pest activity such as webs or frass. The insects are not directly counted. Assessing fall webworm populations by the number of webs is an example of a population index. Counting the number of webs is a fast, but reliable, estimate of larval population density (13). Another example is estimating lace bug population density by examining the undersides of leaves for fecal spots (9).

All three estimates, absolute, relative and the population index, can be used to assess the pest population density. Regardless of the method selected, there are two important factors to consider; the number of samples to collect and where the samples should be collected. The accuracy and precision demanded in population sampling depends upon expectation and need. Elaborate sampling schemes involving much sampling time and data processing have no place in landscape monitoring. A pest management service requires rapid sampling that will classify a population into one of two categories, treat or do not treat.

A major question in any sampling program is the number of samples required to provide a meaningful estimate of population density. Assume a scout counts 15 aphids on 5 leaves for a mean of 3 aphids per leaf. Is this a true reflection of the aphid population throughout the entire tree? How many leaves should be sampled? Sampling is expensive, but so are wrong treatment decisions based upon poor data. The aim should be to take enough samples to obtain the necessary precision, no more or less. The number of samples to be collected can be easily calculated, if the required precision and population variability are known. However, few arborists are also statisticians. Perhaps the simplest, yet useful, method of obtaining the necessary precision is a procedure outlined by Olkowski and Olkowski (17). Count 10 leaves (or other habitat unit), total the number of insects observed and compute the mean. Count another 10 leaves, total the number of insects observed on the 20 leaves, and compute a new mean. Compare the two means. If they are similar, then the 10 leaf count is an adequate sample size for that particular insect at that density on that host species/cultivar. If the two means are dissimilar, then count 30 leaves and continue the process. Once the size of the sample is established for a particular host/pest combination this procedure does not need to be repeated. Instead, this information can be placed in a booklet or table for the scout to use in the field.

Remember, the purpose of sampling is to estimate a pest population density. This value is compared to a threshold level to determine if intervention is warranted. A scout needs a precise estimate only when the population is near the threshold level. If the population density is far above the threshold, the scout does not need a precise estimate, since the decision to treat is apparent. The same is true of a low population density. In other words, decision-making sampling can tolerate a high error if far from the threshold. This is the basis of sequential sampling.

Sequential sampling was developed during the 1940's as a quality control measure in plants that manufactured defense material (18). In sequential sampling, a series of samples are taken in sequence and the values are added. This sum is used to determine if additional samples are needed or if the threshold to treat or not treat has been reached. Exact estimates of population density is placed in three broad categories; low population—no treatment required, unclassified population—continue sampling, high population—treatment required. Sequential sampling is widely used in forest pest management (26). Procedures are developed for red-pine sawfly (7) and spruce budworm (12), among others. Sequential sampling is most effective when sampling a large host population.

The other important factor to consider is where to sample on the plant. In landscape IPM programs where rapid sampling is essential, it is important to confine the search to specific sites on the host rather than the entire plant. The position of the leaf, twig or branch influences the number of insects found on it. Pest aggregation is due to one or more of the following factors; a favorable microenvironment within or on the host, location of feeding sites within or on the host (terminal buds, new foliage, etc.) and insect communication systems for host identification and mate finding. For example, Cranshaw observed a concentration of cooley spruce gall adelgid galls along the less exposed north and east sides of blue spruce (8). Wawrzynski and Ascerno found that ash flower gall distribution was significantly different among the lower, middle and upper crown levels of the tree (27). The best way to determine where to emphasize sampling is to keep records of where pests are observed and review insect-host relationship articles in technical, trade and scientific journals, including the *Journal of Arboriculture, Journal of Economic Entomology* and *Canadian Entomologist.*

A final comment on pest evaluation monitoring. Practitioners have suggested that in the time it takes to assess population density they could treat the pest and move on. And, that the time required to sample properly is not justified by the price they charge for their service. We need to recognize that monitoring is often more expensive that spraying, in the short term. However, as pesticide cost, in terms of restriction, price and liability increases, sampling will become more cost-effective. The cost of applying an unnecessary pesticide will exceed the cost of sampling. IPM is essential to landscape pest management, so companies should begin or continue to move in this direction. The transition from SAS to IPM is a gradual one.

Plant Evaluation. A third category of monitoring is evaluation of plant damage and vitality. Assessing plant health and appearance is important to a landscape IPM service, since clients are paying for plant care, not pest reduction (1, 14). Since the quality of a service is judged by the appearance and vitality of the landscape plants, it is important that the scout be able to assess the extent of damage (defoliation, dieback, etc.) and place it in categories. A quick method of categorizing damage is to construct damage classes similar to the five class system used for birch dieback (3). A three scale classification; slight, moderate or heavy damage, may be useful for many damage evaluations.

Evaluating vitality is more difficult. The best vitality indicators are ones that measure the current physiological condition, reflect the magnitude of any changes in that condition and can be easily performed. Two of the best methods, stem electrical resistance and root starch, have been reviewed in other papers (24, 25). Vitality testing might be best limited to high-value or "key" trees due to the time and expense involved. Vitality testing is necessary for the long term care of these trees. By having a quantitative measure of a tree's vitality, practitioners can better gauge the success of their tree care practices to themselves and their clients.

Treatment Evaluation. The fourth category of monitoring is treatment evaluation. In its poorest form, treatment evaluation is limited to responding to clients' complaints. But clients are not substitute scouts; treatment evaluation is the responsibility of the service. Treatment evaluation is more than a cursory "it worked, it did not work" examination of pest control effectiveness. It is a quantitative measure of the treatment's influence on pest abundance. By measuring the pest population density before and after the treatment, a practitioner can measure the effectiveness of the intervention and adjust tactics accordingly.

Thresholds

Pest evaluation monitoring by itself has limited value unless used in conjunction with a threshold. IPM is a decision-making process that requires a criterion on which to base a treatment decision, the threshold. A threshold is a value above which something occurs and below which it does not. There are four distinct types of thresholds; visual threshold, damage boundary, economic injury level and the action threshold (Fig. 1).

Visual Threshold. The visual threshold is the lowest density at which the pest can be observed. Many companies that operate a SAS service utilize the visual threshold in their decision to treat (2). If the scout detects a pest on a plant, he or she immediately applies a broad-spectrum insecticide. While this approach is more sophisticated than cover sprays, the population may still be too low to warrant intervention.

Damage Boundary. An equally poor threshold to use for the treatment decision is the damage boundary. The damage boundary is the lowest level of injury where measureable damage occurs (18). In landscape IPM programs where damage is primarily measured by appearance, the damage boundary is often incorrectly used as the signal to treat. Coulson and Witter have referred to this boundary as the dead leaf syndrome, because once any damage is observed, the client expects intervention (6). However, minor damage seldom decreases the vitality of the plant (11). Homeowners have indicated that, within limits, the health of their plants is more important than the appearance (1). Once educated on the relationship between vitality and damage, many clients will not become alarmed when the damage boundary is reached.

Economic Injury Level. The economic injury level (EIL) is the lowest pest density that causes economic damage. It is the level at which the damage is equal in value to the cost of control (5). Some urban researchers suggest landscape IPM services utilize an aesthetic injury level, the pest density causing aesthetic loss (16). The most commonly recognized type of aesthetic damage to ornamental plants is defoliation. Plants can generally withstand 10 to 20 percent defoliation with little decrease in vitality. Some believe that people do not notice defoliation of less than 50 percent (10). However, Sadof and Raupp (20) found that people could discern defoliation levels of less than 10 percent in individual plants. From our experience with clients, we know people can detect equally low levels of defoliation in the landscape, particularly in front foundation plantings. The aesthetic injury level is a valid threshold for defoliation or other types of foliage damage in important landscape settings.

However, the economic injury level still has validity. When a plant's appearance is diminished, so is the value. The magnitude of this reduction is dependent upon the species, it's size and location. A large majestic specimen tree near the entrance of a home is worth more than a small, spindly, weed tree that came up in the back yard. A client will be less tolerant of defoliation damage to the specimen tree and will spend more to reduce the extent of damage. Hence, even with aesthetic injury, economics must be considered when establishing thresholds.

The pest population density selected as the EIL, i.e. the number of aphids per leaf, is dependent upon three important variables; the cost of managing the pest, the monetary value of the plant and the amount of damage each individual pest can create. The pest population density selected as the EIL will rise with the cost of control. Clients will accept defoliation damage if the cost to reduce that damage is extremely high. If it cost $500.00 to prevent defoliation damage to the front foundation spirea, most clients would elect to accept the damage (or remove the plant!). As the plant value increases, the EIL decreases. Referring to the earlier example of the specimen tree and the weed tree, if the cost of management is equal, the EIL will be lower for the specimen tree. Clients are not very tolerant of damage to expensive new plantings or mature trees that have a high value. And last, as the units of damage per insect increases the EIL decreases. A plant can tolerate more insects if each is responsible for very little damage.

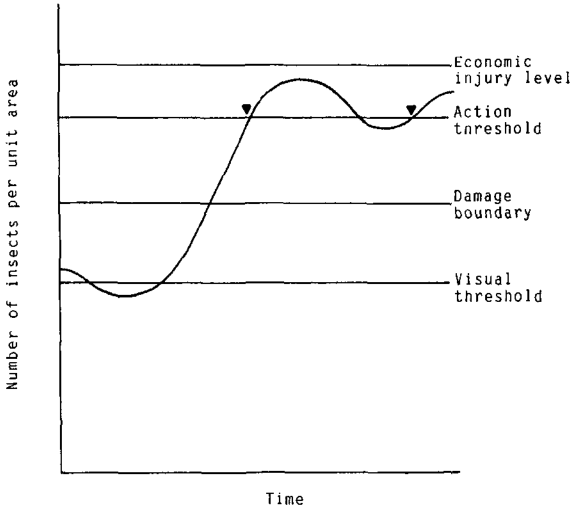

Figure 1. Graph showing the relationships of a hypothetical insect population with the thresholds observed in landscape integrated pest management programs. ▼ = intervention.

Action Threshold. The action threshold (AT) is the pest population density at which action must be taken to prevent the population from reaching the economic or aesthetic injury level (Fig. 1). Establishing AT's is critical to the development of landscape IPM programs (15). However, there are few established AT's for ornamental pests (4). Hence, it is primarily the responsibility of each practitioner or company to develop their own.

Establishing AT's is not a simple nor quick task. Due to the time and expense involved, the most efficient approach for a service is to develop a list of the key pests and plants and establish AT's for the most damaging pests on their most common hosts. Once this list is developed, begin monitoring the pest population on as many hosts of the same species as possible. The more samples, the more reliable the data. The populations are frequently monitored and their numbers are paired with the corresponding level of host damage. By correlating the pest populations to damage preliminary EIL's and AT's can be established. These can be tested the following season to determine their validity and adjusted, if necessary.

This approach is simple, but not very precise. While the AT's will not be based upon rigorous research, they should be useful for an IPM service. When in doubt about an AT, be conservative and lower the population density required to trigger intervention. Also, remember that AT's are dynamic. They can change with environmental conditions, the vitality of the plant and the time of year.

Conclusions

Developing monitoring procedures and establishing AT's is a long and laborious process for a pest management service. Proper monitoring requires extensive data collection and analyses by trained personnel. AT's can take several years to establish and validate. However, the public is beginning to accept, and in some instances demand, a more environmentally sound approach to managing their landscapes. Practitioners that invest the time to develop comprehensive IPM programs will find it pays off in the future.

Literature Cited

1. Ball, J. 1986. *Public perception of an integrated pest management program.* J. Arboric. 12:135-140.
2. Ball, J. and P. Marsan. 1989. *SAS or IPM—which direction for your company?* Arbor Age 9(2):12-14.
3. Ball, J. and G.A. Simmons. 1908. *Bronze birch borer and birch dieback.* J. Arboric. 6:309-314.
4. Byrne, D.N. and E.H. Carpenter. 1986. Attitudes and actions of urbanites in managing household arthropods. **In** Bennet, G.W. and J.M. Owens (Eds.) Advances in Urban Pest Management, VanNostrand Reinhold Co. Inc., New York.
5. Capinera, J.L. 1982. Principles of insect pest management. **In** Evans, H.E. (Ed.) Insect Biology, Addison-Wesley, Reading, MA.
6. Coulson, R.N. and J.A. Witter. 1984. Forest Entomology. Ecology and Management. John Wiley & Sons, Inc., New York.
7. Cannola, D.P., W.E. Waters and E.R. Nason. 1959. *A sequential sampling plan for red-pine sawfly, Neodiprion nanulus Schedl.* J. Econ. Entomol. 52:600-602.
8. Cranshaw, W.S. 1989. *Patterns of gall formation by the cooley spruce gall adelgid on Colorado blue spruce.* J. Arboric. 15:277-280.
9. Davidson, J.A., C.F. Cornell, M.E. Zastrow and D.C. Alban. 1988. *making the pilot fly.* Amer. Nurseryman 169(10):51-60.
10. Knight, F.B. and H.J. Heikkenen. 1980. Principles of Forest Entomology. McGraw-Hill, Inc., New York.
11. Mattson, W.J. and N.E. Addy. 1975. *Phytophagous insects as regulators of primary production.* Science 190:515-522.
12. Morris, R.F. 1954. *A sequential sampling technique for spruce budworm egg surveys.* Can. J. Zool. 32:302-313.
13. Morris, R.F. 1964. *The value of historical data in population research, with particular reference to Hyphantria cunea Druy.* Can. Entomol. 96:356-368.
14. Nielsen, D. 1981. *Alternative strategy for arborists—treat the tree not the customer.* Weeds, Trees & Turf 20(7):40-42.
15. Nielsen, D. 1989. *Integrated pest management in arboriculture: from theory to practice.* J. Arboric. 15:25-30.
16. Olkowski, W. 1974. *A model ecosystem management program.* Proc. Tall Timbers Conf. Ecol. Anim. Control Hab. Man. 5:103-117.
17. Olkowski, W. and H. Olkowski. 1975. *Establishing an integrated pest control program for street trees.* J. Arboric. 1:167-172.
18. Pedigo, L. 1989. Entomology and Pest Management. MacMillian Publishing Co., New York.
19. Potter, D.A. and G.M. Timmons. 1983. *Biology and management of clearwing borers in woody plants.* J. Arboric. 9:145-150.
20. Sadof, C.S. and M.J. Raupp. 1987. *Consumer attitudes towards the defoliation of American arborvitae, Thuja occidentalis, by bagworm, Thyridopteryx ephemeraeformis.* J. Environ. Hort. 5:164-166.
21. Schultz, P. 1985. *Monitoring parasites of the oak lecanium scale with yellow sticky traps.* J. Arboric. 11:182-184.
22. Southwood, T.R.E. 1978. Ecological Methods, with Particular Reference to the Study of Insect Populations. Halsted Press, Wiley, New York.
23. Story, K.O. 1986. Insection, diagnosis, pest population monitoring and consultation in urban pest management.

In Bennett, G.W. and J.M. Owens (Eds.) Advances in Urban Pest Management, VanNostrand Reinhold Co. Inc., New York.
24. Wargo, P.M. 1975. Estimating starch content in roots of deciduous trees-a visual technique. U.S. Dep. Agric. For. Serv. Res. Pap, NE-313.
25. Wargo, P.M. and H.R. Skutt. 1975. *Resistance to pulsed electrical current: an indicator of stress in forest trees.* Can. J. For. Res. 5:557-561.
26. Waters, W.E. 1955. *Sequential sampling in forest insect surveys.* Forest Sci. 1:68-79.
27. Wawrzynski, R.P. and M.E. Ascerno. 1989. *Ash flower gall: within tree distribution and chemical management.* J. Arboric. 15:215-218.

Director of Technical Services
Arrowhead Tree Service
Duluth, MN

ABSTRACTS

BELLOWS, T.S., T.D. PAINE, K.Y. ARAKAWA, C. MEISENBACHER, P. LEDDY and J. KABASHIMA. 1990. **Biological control sought for ash whitefly.** California Agriculture 44(1):4-6.

The ash whitefly, introduced into California in 1986 or 1987, attacks ash as well as fruit and other ornamental trees. Populations have reached extraordinary levels in Los Angeles County. In this report, we briefly describe the origins and scope of the infestation, the pest potential of the species, and current research toward solutions. Pesticide treatment is an option primarily against populations of nursery stock destined for shipment to noninfested areas. Several pesticides have been tested with varying results. None provided completely clean stock. The primary management approach being developed is the importation and colonizing of natural enemies of ash whitefly. Natural enemies include parasitoids, predators and diseases. Future studies will determine the relative effectiveness of different release tactics, such as numbers released, timing of releases, and need for subsequent releases.

HIGGINBOTHAM, J.S. 1990. **Decline.** Am. Nurseryman 172(8):31-34, 36, 38-40.

The harbingers of tree decline are often as subtle as an unnatural thinning of the crown. During the past decade, one species after another has fallen on hard times. Sugar maple, ash, flowering dogwood, oak and several conifers are among the trees in trouble in the eastern half of the US. At times, a single aggressive disease or pest—like chestnut blight or hemlock wooly adelgid—is responsible. However, true "declines" involve tangled relationships between stress and secondary agents. Fortunately, many types of declines that appear insurmountable in the wild prove easier to manage in the nursery or landscape. Control measures that are inappropriate for forest application can often protect valuable crops and specimens. The following overview covers serious instances of genus- and species-specific tree declines now occurring in the US and Canada—and ventures a few predictions regarding decline trends for the years to come.