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Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

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Cover

The legacy of the Santa Rita Experimental Range in southern Arizona goes back to the turn of the century. Results from grazing and other studies are being used today to develop grazing systems and other land management plans for semidesert regions throughout the world. Details begin on page 4.

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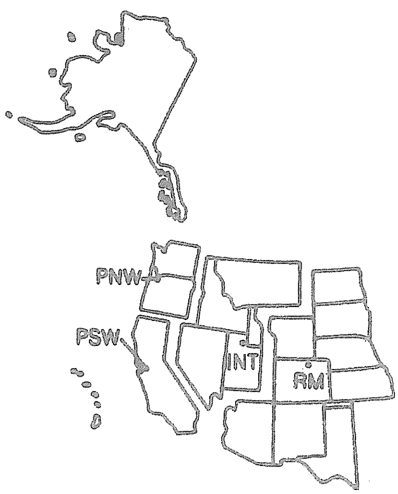


Insects and ecosystem management

by Michael I. Haverty, Patrick J. Shea, and Connie Gill
Pacific Southwest Station

California, Oregon and Washington contain forests of extraordinary beauty and enormous commercial value. For many years California has been one of the top three lumber-producing states in the nation, yet, nowhere is the competition for forest resources more intense or more controversial.

Abundant forest resources were available during California's early history. The general mode of thinking was that the supply would last forever. Today, rapid population growth has placed alarming demands on these resources and now, although it's a top producer, California imports nearly 60 percent of the timber it uses.

More than 30 million people live in the State; their resource values are complex, diverse and dynamic. Demands for amenity values are increasing rapidly as urban development encroaches upon the wildland. These demands often create conflicts with the traditional uses of forests, compounded by a high per capita consumption of wood fiber and other natural resources. Awareness of environmental issues in California is intense. Residents are concerned about timber harvesting activities, but have difficulty connecting these management scenarios with everyday use of forest products.

Over the last few years, the public has become increasingly vocal about land-use issues. Land usage patterns driven by production values are being challenged and replaced by more holistic values. Federal land management agencies are attempting to meet these changing needs and values. Concern for threatened and endangered species has led to a reduction in the land base for timber production in the West, requiring more efficient use of wood and wood products. Forest management is shifting from clear cutting for even-aged stands to uneven-aged management. In addition, many forest plans are addressing nonconsumptive commodities such as recreation, wildlife habitat, and watersheds, rather than timber, minerals, and grazing.

Harvest restrictions have left many forests overstocked because they were planted or managed using silvicultural tactics that are no longer acceptable to the public. Overstocked forests, combined with encroachment of people within the urban-wildland interface, places trees under extreme stress, resulting in increased insect infestation.

Insects are usually perceived as detrimental to a forest. However, insects are not always pests, are not always bad, and tree losses are not always detrimental events.

Entomologists with the Pacific Southwest Research Station are working to discover answers to the complex issues of insect behavior and their relationship to forest ecosystem health.

Scientists are encouraging a different attitude toward insects and their effects in wildlands. Although insects cause mortality in forests and can even cause severe losses to commercial timber, they can also enhance wildlife habitat and secondary productivity. This new perspective requires a better understanding of this balance and the positive functions of insects in forest ecosystems.

Insect benefits

Insects have many beneficial roles in forests and wildlands. Defoliating insects often reach epidemic levels and can denude a significant component of the forest tree canopy, or may even affect the success of regeneration. However, defoliators also serve as a primary food source for many wildlife species. Bark beetles can affect forest stand density and diversity, and in some cases, create snags or openings that are beneficial for wildlife habitat. Wood-degrading insects (termites, wood-inhabiting beetles, and carpenter ants) are among the predominant decomposers of large pieces of wood in the Sierra Nevada Ecoregion. They usually follow bark beetles in the succession of organisms contributing to the early stages of tree degradation. When successfully established, they greatly accelerate the


Ponderosa pine killed by western pine beetle attracted to trees by aggregation pheromones for snag creation.

decomposition process. Along with wood-degrading fungi, dampwood termites weaken root systems and woody tissues to hasten the conversion of standing, dead trees into coarse debris on the forest floor. This transformation drastically alters wildlife habitat as it imparts nutrients to forest soils. In natural ecosystems, insects influence recycling of organic matter, improvement of soil structure, regulation of pest populations, and tree mortality.

Forest managers can manage wisely and avoid problems if they have a working understanding of what organisms are present (biodiversity), the critical roles they play, and what their ecological requirements are. Lack of this knowledge can lead to errors that adversely affect the positive roles and accentuate negative roles.

Scientists believe that actions to control tree mortality should be as environmentally sensitive as possible. Today's forest managers and pest management specialists need cheaper, more effective, more ecologically based and less risky methods to reduce damage by insect pests.

To help meet those needs, entomologists with the Station's Chemical Ecology of Forest Insects research work unit will investigate the chemical aspects of insect behavior (the chemical communication between forest insects of the same species and other species within their environment/habitat) to understand the biology and ecology of key species, and develop means for managing insect pests when necessary. To achieve this goal, they are addressing three problem areas.

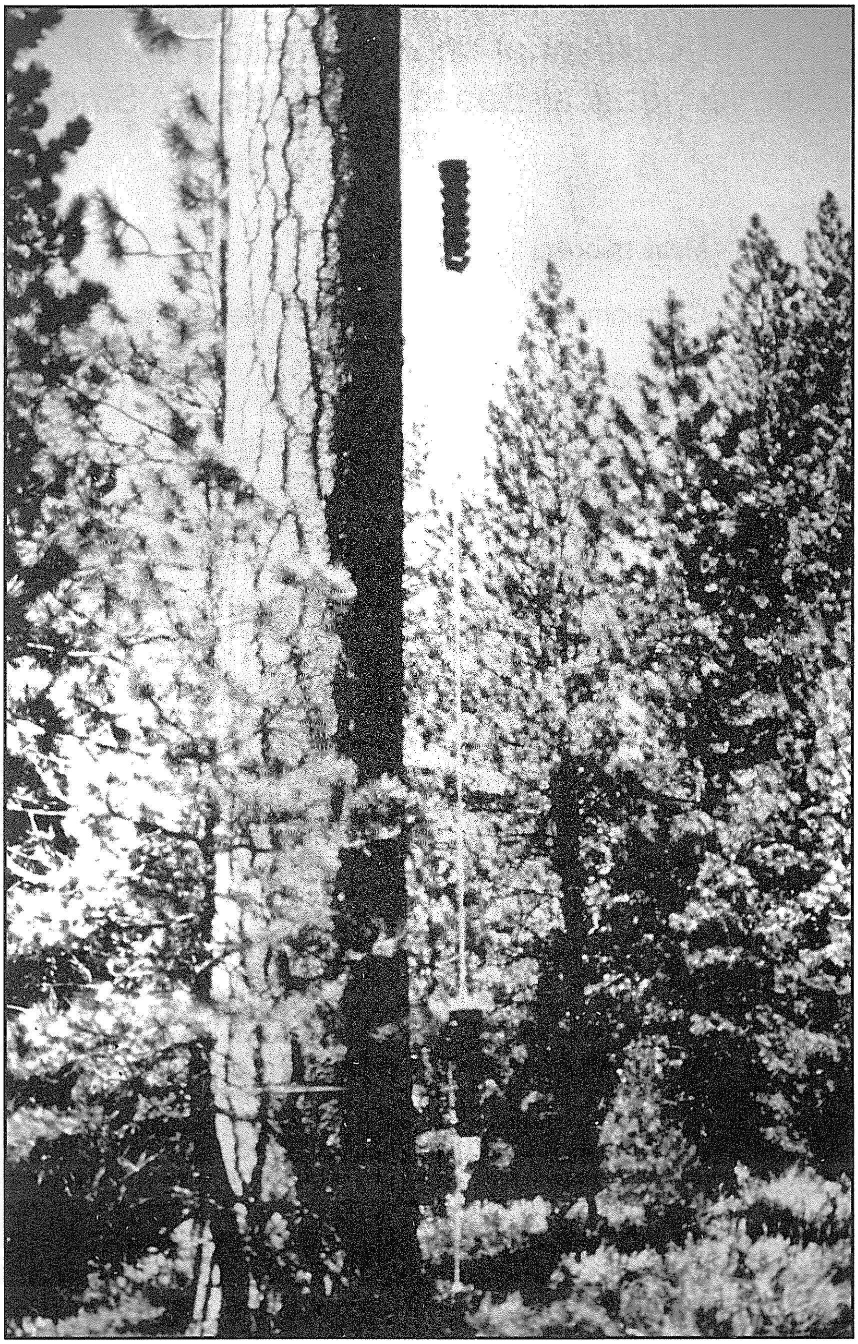
Problem #1

More information on the roles and impacts of insects in forest and wildland ecosystems is needed to maintain healthy, productive forest environments.

Pest management tactics that are environmentally sound and effective will become available to pest management specialists during the next decade. Instead of relying on the application of large quantities of broad-spectrum chemical insecticides, pest management specialists may be able to use more sophisticated or environmentally friendly approaches, such as pheromone or other behavior-modifying chemicals.

Solution

Research in this area focuses on the function of insects in forest and wildland ecosystems. Scientists will concentrate on the role of bark beetles in production of snags and/or openings in forest stands (wildlife habitat), and the role of wood-degrading organisms in the recycling of nutrients and reduction of coarse, woody debris. They will follow the life of a tree once it is



Pheromone traps—Lindgren traps.

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Strategies of bark beetle management using semiochemicals.

fatally attacked by bark beetles to see what happens until it returns to the soil. They will investigate the dynamics of everything connected with the tree, ie. bird and small mammal utilization, arrival and colonization of secondary insects, so accurate informed recommendations can be made for forest managers.

Problem #2

Taxonomy, behavior, and life histories of insects in forest and wildland ecosystems are essential in developing safe, effective pest management strategies.

Frequently it is difficult to identify insects that damage forest resources. In other words, knowledge of the taxonomy of many important forest insects is obsolete and in need of revision. The use of pheromone-based monitoring systems or pest management systems requires exact identification of insect species, subspecies, or biotype to accurately characterize the pheromone or other semiochemicals to be used.

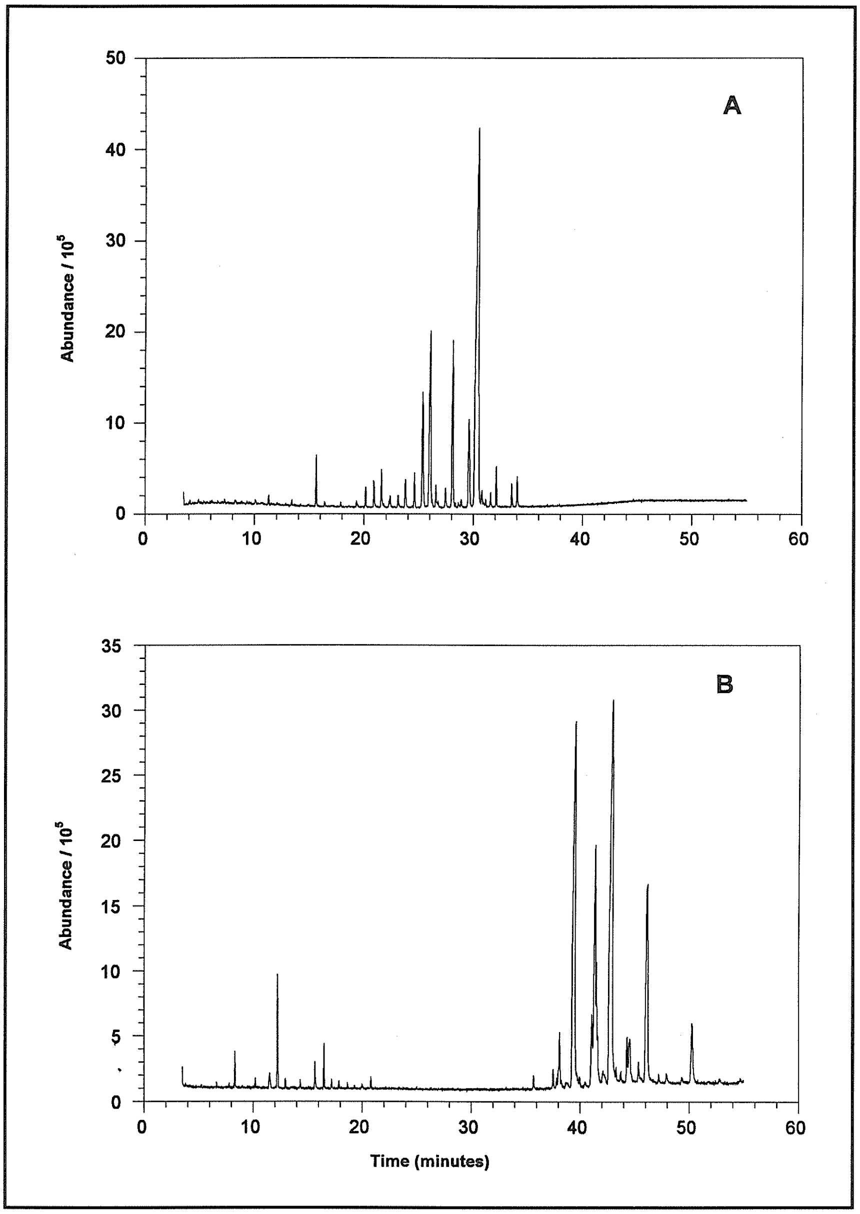
For decades, forest entomologists have had a basic understanding of the roles of some important semiochemicals in forest insect biology and their potential in pest management applications. Semiochemical-based pest management has only recently become an economically feasible reality because of changes in public perception, advances in pheromone synthesis and analytic chemistry procedures, new neurophysiological assays, and technological improvements in pheromone formulation and release devices. It remains the challenge of the scientific community to develop semiochemical-based methods for forest ecosystems and to demonstrate their efficacy to forest managers and to the public. Similarly, new analytical techniques, such as those used in molecular biology and cuticular hydrocarbon characterization, have opened new approaches to the study of taxonomy.

Solution

Investigations are helping understand the chemical ecology of forest insects. Morphological variation often leads to questionable species determinations in many ecologically important groups of forest insects. First, as an adjunct to classical taxonomy based on morphology, scientists will use the chemotaxonomic technique of characterizing cuticular hydrocarbons for discriminating species of forest insects. Pioneering work by Station scientists shows that in many genera, hydrocarbon mixtures can be correlated with insect species determinations. Conversely, new taxa have been recognized on the basis of unique hydrocarbon profiles. Whenever possible, cuticular hydrocarbon profiles and morphological descriptions will be complemented by genetic analyses. Second, behavioral studies will enable scientists to identify important behavioral chemicals for these taxa, and integrate them into environmentally sound, effective pest management systems. Both insect pheromone and attractants produced by the hosts (kairomones) will be studied, as well as possible insect allomones mediating insect-plant interactions. Third, basic ecological and life-history studies of important forest insects are essential for the identification of "weak links" in insect life histories that render them vulnerable to population manipulation. Furthermore, such studies are critical in managing forests wisely and avoiding problems due to lack of adequate knowledge of key components of forest ecosystems.

Characterization of the cuticular hydrocarbons of insects is a new technology under investigation. All insects are covered by a waxy coating. The primary function of this outer layer is to prevent water loss. It is composed of about 90 percent hydrocarbons. They are removed by soaking the insects in hexane. The extract is then purified and concentrated. A small amount is injected into a gas chromatograph to separate the hydrocarbons on the basis of their boiling point.

The theory underlying this technology is that each species within a group of related species will have a unique mixture of hydrocarbons. The presence or absence of abundant and highly modified hydrocarbons is used to separate insects into groupings that correlate with discrete species. Once the insects are



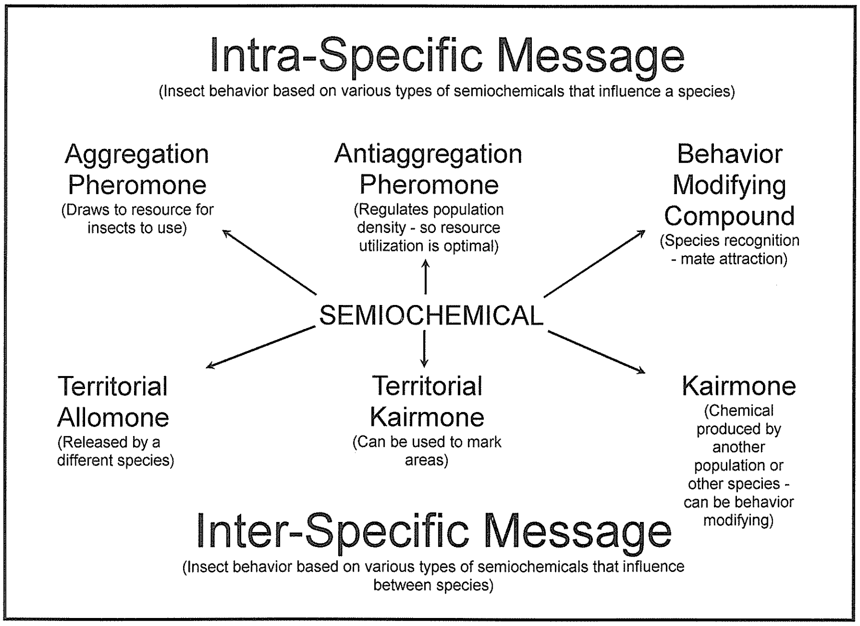
Total ion chromatograms of the cuticular hydrocarbons of workers of (A) Nasutitermes costalis *and (B)* Nasutitermes acajutlae *from the British Virgin Islands.*

separated on the basis of cuticular hydrocarbons, corresponding morphological differences are found that can be used more easily to identify specimens to species.

Problem #3

Methods are needed to detect, monitor and manipulate insect populations in forest and wildland ecosystems.

Once semiochemicals are characterized, devices must be developed to detect and monitor populations of pestiferous and beneficial insects. Once a decision has been made to influence an insect population, methods are needed for manipulating the population below or above the critical or desired threshold, and for maintaining the population at the appropriate level. Detection and monitoring methodology, appropriate population thresholds, and methods for manipulating populations must then be packaged into decision support systems for population management programs. The public will benefit from reduced cost of pest management and improved esthetics of forests and wildlands.



Insect behaviors based on semiochemicals that influence a species.

Solution

Scientists are concentrating on two primary lines of research. The first is the development of monitoring systems and devices to assess populations of detrimental and beneficial forest insects. This will rely on characterization of semiochemicals and development of trapping strategies. The second area is the development of population manipulation techniques. This will include evaluating chemical pesticides and alternative control techniques and devices for protection of high-value trees. More refined techniques will exploit semiochemicals to reduce damage by insects using mating disruption, mass-trapping, toxic trap tree, "bait-and-switch," and "push/pull" strategies. The ultimate product will be decision support systems for management of bark beetles. Scientists are also working to understand how to initiate increases in insect populations, how to turn off the enhancement, when it is appropriate or inappropriate to use this technology, and when such technology will or will not work.

Conclusion

This work will add to overall forest insect knowledge and lead to better understanding of forest entomology. A new link associated with insect behavior may be discovered that can be used to enhance or stiffle insect activities. This research, through cooperation with other units at this and other Stations, universities, state agencies and private corporations, will help evaluate other information products and enhance forest insect chemical ecology.