Insects and disease kill enough trees each year to build over 800,000 single-family homes. As spectacular as the devastation left by the eruption of Mount St. Helens was in 1980, insects and disease kill 70 times that much timber every year.

Modern forest practices can create plantations of even-aged, single-species trees—an invitation to the voracious insect pests for which they are hosts.

**Control, 1987**

Integrated Pest Management (IPM) is the organized approach to pest management today. A decisionmaking process, it uses a full range of tactics: biological, cultural, manual, mechanical, thermal, and chemical. Analysis of site-specific pest situations is the first IPM step and basic to determining the method or combination of methods most effective, least costly, and least harmful to the environment, people, and wildlife.

**Biological Control**

Pheromones, pathogens, predators, and parasites are among the newest weapons of the IPM war on pests. They are usually effective against a single or related species and, because they occur naturally, are considered harmless to the environment.

**Pheromones.** Insects produce and perceive minute amounts of volatile chemicals (pheromones) that attract mates, signal danger, blaze trails to food, and mediate many other interactions. Pheromones are used to trap insects for surveys and suppression. Sex pheromones are used to confuse males so that they cannot find mates.

**Pathogens.** Disease-causing agents can be effective pest management tools. The bacterium *Bacillus thuringiensis* is widely used against lepidopterous defoliators such as tent caterpillars, webworms, gypsy moths, tussock moths, and spruce budworms.

The Forest Service has developed, produced, and distributed a nucleopolyhedrosis virus (NPV) for the Douglas-fir tussock moth (DFTM). In Idaho in 1986 a suppression project showed 3 percent of DFTM larvae died of the virus outside the treatment area; 30 percent died of the virus where NPV was sprayed.

The fungus *Beauvaria bassiana*, the nematode *Neoaplectana* spp. and the protozoan *Nosema locustae* are
pathogens that have been used with varying degrees of success on lepidoptera, bark beetles, and grasshoppers respectively.

**Predators and Parasites.** Birds are important natural enemies of insects. Evening grosbeaks, for example, were found to eat 8,900,000 western spruce budworms over 55 days on a 1-square-kilometer site in Washington State in a 1984 study. The birds concentrated their feeding in the top one-third of trees while predatory ants dined on the budworms in the bottom two-thirds. Managing forests for birds and ants has the potential to mitigate future budworm epidemics.

Rearing and releasing parasites works too. The pine sawfly that attacks eastern white pine and Christmas tree plantations in the South is being controlled by the tiny wasp *Monodontomerus dentipes*. And the larch casebearer, a defoliator of western larch, is being held in check by two introduced wasps, *Chrysocharis laricinellae* and *Agathis pumila*.

**Silviculture**

Techniques for suppressing insect pests are often spectacular, but preventing them is better. Cultural control methods, requiring long-term planning, offer practical solutions.

**Early Harvest.** Harvesting trees before damaging population levels of pests are reached is effective against insects that attack maturing trees.

**Selective Cutting.** Thinning and cutting for commercial and precommercial sales result in greater vigor of remaining trees, making them less susceptible to pest infestations.

**Seed Source.** Selecting the proper seed source for regeneration is directed toward matching the planting site with both species and climatic variants of trees and seeds to produce the greatest stand vigor.

**Species Diversity.** Pure strands of a single species offer vast food supplies to insects of which they are hosts. Supplemental planting, altering the percentage of species within a stand, and allowing forest succession to reach a natural climax after fires and insect epidemics will produce forests of greater resistance to pest attack.

**Host Resistance.** Selecting and producing trees and seeds from varieties that resist pests is a long and costly process in forestry. But it is effective and environmentally sound.

**Clean Cultivation.** Plowing under last season’s crop to destroy developing pests is highly successful in agriculture. An example in forestry is
clearing slash to prevent infestations of *Ips* beetles.

**Timing.** The multiplicity of insect pests in forests makes timing critical. For example, thinning ponderosa pine to control mountain pine beetle, if improperly timed, can result in epidemics of *Ips* beetles.

**Physical and Mechanical Control**
Among the oldest control methods, many of these techniques are still effective, and some have not been fully explored.

Heat, cold, humidity, and light affect insect pests in various stages of their development. Sunlight, kiln drying, cold storage, and the use of plastic heat traps in nurseries are methods that have pest control applications.

The use of sound has long been regarded as a possible deterrent, but results have been disappointing. Barriers, however, are effective; adhesives, for example, reduce populations of spring and fall cankerworms and gypsy moths as they ascend trees. Handpicking is still effective, particularly on high value plantings and in urban forestry.

Mechanical destruction is a widespread technique, using equipment to crush or chip logging slash, seeds, cones, twigs, shoots, branches, or brood trees that serve as feeding, overwintering, or breeding sites.

**Conventional Pesticides**
Conventional pesticides are an integral part of IPM and are apt to remain so as long as pest situations exist for which no effective alternative can be found or developed. Such conditions occur when vast areas are infested, rapidly rising or migrating pest populations spring up, inaccessible terrain limits options, and suddenly introduced foreign pests are involved.

Admittedly, the Forest Service uses few pesticides and in small quantities, but when epidemics threaten highly valuable forest or range land resources, pesticides are often the fastest acting, safest, and least costly means of protecting our renewable resources.

Of the 191 million acres of forest and range land administered by the Forest Service, about 700,000 acres are treated annually with pesticides; that's about three-tenths of 1 percent. Many other acres are treated using the other alternatives described. The total volume of active ingredient used in the United States annually is slightly less than 1 billion pounds. Agriculture accounts for about 75 percent; homeowners and others, 24 percent, and the Forest Service less than 1 percent.

Unquestionably, the use of conventional pesticides is decreasing as more reliance is placed on biologicals and other IPM alternatives. But dramatic explosions of pest populations call for fast action with proven remedies, as happened in 1983 with the western spruce budworm, and in 1985 and 1986 with grasshoppers. Grasshopper epidemics alone accounted for over 600,000 acres of treatment each year on National Forest System land in 1985 and 1986.
The Future

Pesticide research promises exciting innovations. A new concept in pheromone use is releasing them to entice predators and parasites into infested areas. Releasing sterile males to reduce populations and genetically altering insects to produce less prolific offspring are two avenues that may lead to practical application in forestry.

Biotechnology, manipulating the building blocks of genetic information to create new life forms, may lead to the engineering of more effective natural enemies of pests.

Biosynthetic studies reveal enzymes in pheromones that may be inserted into a plant itself to disrupt the mating of pests. By manipulating light, darkness, temperature, and food, the internal rhythms of insects can be shifted to affect life span, mating, and maturation. So called natural pesticides can be developed from plants like the neem tree (Azadirachta indica), which can be grown on land marginal for other crops and which produces an environmentally safe insecticide extracted from its seeds.

New formulations of existing pesticides are being developed to increase effectiveness. Time-release capsules are one example.

Are we beating the bugs? Probably not. But we’re catching up. Each year we do better in protecting our renewable resources in ways that are economically sound, environmentally safe, and acceptable to those who love the land.