PRINCIPLES OF ERADICATIVE PRUNING

by Pavel Svihra

Abstract. Excision of infected or infested branches from woody plants was recommended as a control tactic more than 150 years ago. The term "eradicative pruning" was first introduced for Dutch elm disease control. Eradicative pruning can eliminate local and regional branch (limb) infection or infestation to prevent further spread of a pathogen or pest in the tree. When combined with other chemical and cultural treatments, eradicative pruning fits well to the concept of Integrated Pest Management (IPM) or Plant Health Care (PHC). Timing of pruning, severity and extent of symptoms, location of pathogen or pest attack, stage of infection or infestation, and contamination of pruning tools all influence the success of eradicative pruning. This report presents a guide for selected disease and pest attacks that can be successfully eradicated from woody plants in California.

Pruning of trees is one of the oldest plant treatments (27). Excision of an infested or infected branch from a tree was first recommended as a control tactic in 1841 by T.W. Harris (14). The success of excision as a tree cure varied greatly, mainly because the life histories of insects and pathogens were not well known and, additionally, because appropriate chemicals were not available. Ironically, with the advent of synthetic insecticides and fungicides and a high reliance on their use after 1945, excision as a control tactic was abandoned. In 1972 Brown (5) revived pruning as one of the "weapons of defense in the fight to prevent the spread of 21 pests and diseases." But he warned that many factors would influence the effectiveness of such pruning.

The public is now demanding decreased use of chemicals to control pests and diseases in the urban forest ecosystem (23). A great opportunity thus exists for arborists to specialize in eradicative pruning to control local insect infestations or pathogen infections in landscape plants. The variety of pruning tools, the arborist's climbing skills, hydraulically operated aerial lifts capable of carrying the operator near the symptomatic branch, and advances in tree care and proper pruning cuts (27) have made it possible to save many trees by eradicative pruning.

Evolution of "Eradicative Pruning"

Several decades of experience with the pruning of elm branches infected by the Dutch elm disease (DED) fungus, *Ceratocystis ulmi*, clearly demonstrate the concept. At the National Shade Tree Conference in 1944, Zentmyer and Wallace (33) reported the survival of American elms, *Ulmus americana*, after branches infected with the DED fungus had been pruned. May and Douglas reported similar observations (25). More careful studies of the progress and remission of fungal infections in diseased elms disclosed that pruning of symptomatic branches in some cases stopped and in others greatly retarded further progress of *C. ulmi* (24). In 1976 Campana (6) established that the success or failure of pruning was related to the length of the discoloration in the xylem. Since then pruning as a control technique has received serious attention by plant pathologists and arborists (16). Later, in 1978, Campana (8) defined this specialized control tactic as **"eradicative pruning"** and concluded that the subsequent survival of an elm heavily depended on the population dynamics of the pathogen's vector, the European elm bark beetle, *Scolytus multistriatus*.

Despite these major advances in determining why some cuts were successful and others were not, it soon became clear that excision of branches alone had a limited effect on recovery of trees infected by the DED fungus (7,16). Researchers (12,18) took the approach that eradicative pruning could not be blamed for failure when the discoloration traced beneath the bark had spread beyond the pruning cut (e.g., the infection had penetrated into the main trunk) or, in some cases, the progress of the pathogen was invisible in the tissues as a stain. They hypothesized that an additional therapeutic procedure had to be employed to affect the pathogen beyond the cutting area and the survival of the elm.

Gregory (12) first injected a fungicide into American elms that had 10 percent or less of the foliage manifesting DED symptoms and then one or two weeks later removed each symptomatic limb beyond the discolored wood whenever possible. After pruning, 71 to 79 percent of the trees survived. However, if discolored wood could not be pruned to clearwood, only 45 to 61 percent of the elms survived.

Kondo (18) recommended cutting flush at the limb origin, followed by root injection. His results showed that if the tree possessed an acceptable rating index to become a candidate for eradicative pruning and fungicidal injection (about 5 to 10 percent of foliar symptoms) and if it was injected annually, it would remain free of foliar symptoms and have a healthy external appearance. Only elms with less than ten percent foliar symptoms were candidates for the pruning and therapeutic treatment.

Such experiences with this deadly disease of shade trees suggest that eradicative pruning has a great potential for removing infection, but it requires more than just cutting off the symptomatic branch. Eradicative pruning is an ecologically demanding control tactic, because it:

- may inadvertently increase the disease or insect threat by cutting into healthy living tissues, allowing reinoculation of the pathogen if the open wound becomes attractive to bark beetles (2);
- requires knowledge of the tree's biology;
- requires knowledge of the pathogen's life cycle and that of its vector, *S. multistriatus*;
- requires assessment of the visible external foliar symptoms as well as the extent of internal vascular browning that quantitatively and qualitatively determines a candidate tree suitable for treatment; and
- must include other preventive techniques and cultural practices to boost a tree's defenses and its chances of survival.

The word "eradicative pruning" has entered the vocabulary of arboriculture but the arborist has not always *"eradicated, wiped out, eliminated, destroyed, or exterminated"* the Dutch elm disease fungus from the tree. As studies by Shigo (26) have shown, a susceptible species like the American elm can confine and survive an infection of the tissues, with the DED pathogen remaining alive in the system. Such examples are well documented from California (29). "Eradicative pruning" in the arboricultural context is hard to define and even harder to use well. It is doubtful that the term could be described in any other way that would make it more useful in practice, e.g., *therapeutic pruning* or *tree surgery* (4,9).

While the primary goal of eradicative pruning is the complete elimination of local or regional branch infection or infestation to prevent further spread of the pathogen or pest in the tree, the goal of this technique must be to boost plant defenses through a combination of cultural and chemical treatments. Eradicative pruning deals with the situation in a particular tree and has little or no effect on the disease or pest population in the urban forest ecosystem where the tree is growing. For this reason, the arborist must consider the influence of many other factors alluded to by Brown (5), which can affect pruning success.

Sanitation *vs.* Eradicative Pruning

Sanitation is also designed to eradicate known sources of disease and insect breeding by destroying host material where either one can reproduce, take refuge, or overwinter. In horticultural and fruit tree crops it has been particularly effective through destruction of tree prunings (11). Sanitation is a continuous operation around the plant—raking leaves from under plants susceptible to the *Entomosporium* leaf spot, pruning of dying and dead branches from elms, disposal of elm firewood to reduce breeding sites for *S. multistriatus*, and the like.

While very important, sanitation practices eradicate neither the causal fungus nor the insect vectors and may reduce their populations only nominally (9). But if the arborist were to perform successful eradicative pruning on an elm displaying the very early stage of DED infection but neglected sanitation by leaving dead branches on the same tree or others in the vicinity (where the insect vector can breed and the DED fungus survives in the saprophytic stage), such an effort would almost certainly be futile.

Sanitation addresses dieback and known breeding sites that began or were established in

the previous growing season and their elimination may lead to the killing of many individuals in the population, but remnants remain around the plant. Eradicative pruning responds swiftly to the just-developing symptoms on twig, branch, or limb to excise them and stop the progress of dieback.

Eradicative Pruning as an IPM or PHC Tool

Eradicative pruning is compatible with IPM or Plant Health Care (PHC), because it affects local infection or infestation in a tree, uses pesticides locally or not at all, and requires the concerted application of several cultural practices. Knowledge about the development of wound resistance to infection has practical IPM consequences, e.g., as wounds age, the tissues become increasingly resistant to infection (22).

The dynamics of wound resistance or susceptibility to reinoculation by the pathogen (or insect infestation) is an important consideration for establishing the period during which prophylactic sprays should effectively protect wounds (3,10). As infection or infestation is prevented by these sprays, the induced natural production of plant defensive chemicals (lignins, phenols, tannins, alkaloids, amino acids, terpenes, etc.) is fully developed (21). The tree thus becomes less predisposed to an attack as the wound ages and the sprayed chemical becomes ineffective. What is required is accurate information about the tree or shrub, an understanding of the pathogen or insect life cycle and interaction with the host, the diagnosis, and corresponding treatment(s) timed according to phenological periods of the plant and pathogen/pest.

Phenologies (27) of both plants and associated organisms are important and the role of the arborist is to take action at the time when the tree benefits the most, while the destructive activity of the pathogen or insect is at a minimum. Such favorable conditions are not always achievable when the life of the plant is threatened and eradicative pruning must be done without delay. A pathogen or insect's most destructive effect on a tree's health occurs during the following phenological periods: onset of growth, storage of energy, and dormancy (27). The arborist's job is to consider phenological periods, collect appropriate data about tree management and life history of the pathogen/insect, assess the magnitude of infection or infestation, and then organize all the above information for optimal long-term IPM or PHC practices to benefit tree defenses and survival.

Some Practical Aspects of Eradicative Pruning

Case studies: In an 11-year-old apricot tree, dieback occurred in eight branches, each of which was less than 1 inch in diameter scattered in the canopy. The homeowner noticed the symptoms for the first time in the previous growing season. Each instance of dieback was associated with several rough cankers and amber-colored gum (Fig.1). The causal pathogen was bacterial canker, *Pseudomonas syringae.*

For diagnostic purposes a cut was made 2 inches below the canker next to the lateral. Staining was still quite visible near the cut line (Fig.2). The third cut 6 inches below the stain eradicated the infection (Fig.3). Unfortunately, this cut was done in the dormant season, not in the summer when

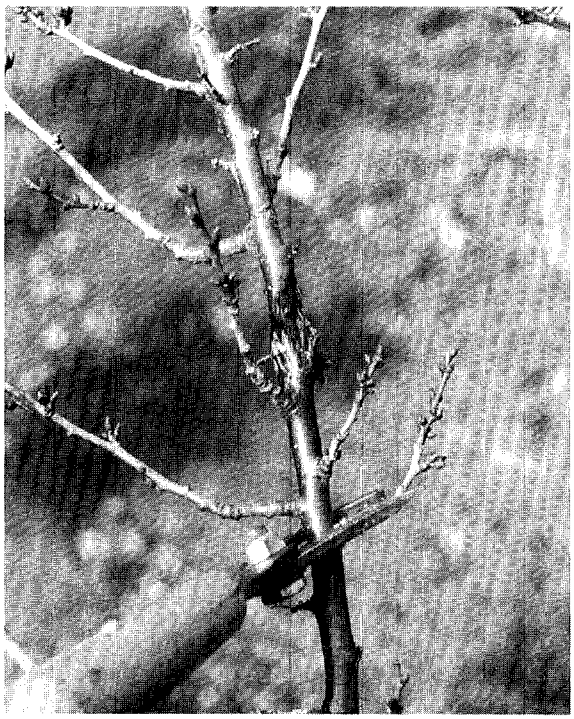

Figure 1. Branch infected with Pseudomonas syringae.

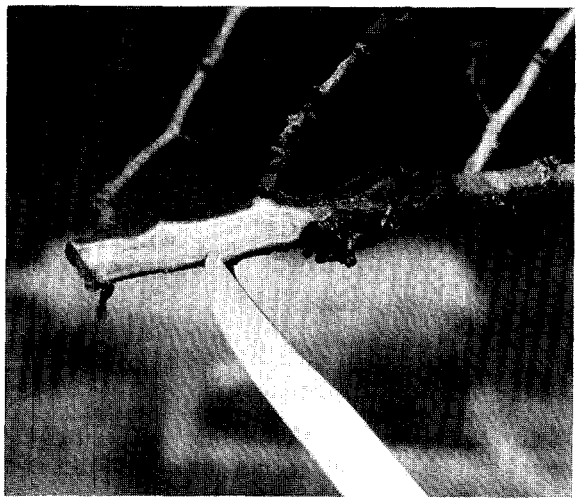

Figure 2.Pruning cut made two inches below the canker has not eradicated infection. Discolored-infected wood is clearly visible at the pruning cut.

conditions for bacterial re-infection are least favorable in California's hot and rainless summer.

In this case we only partially fulfilled the requirements of eradicative pruning by gathering information about the tree species and manifestation of the disease symptoms, consulting the diagnostic laboratory to determine the causal pathogen, and executing appropriate treatment.However, by pruning in the dormant season we disregarded the pathogen's life cycle and related proper time of pruning that favors the host's defense and not that of the pathogen.

The techniques of eradicative pruning cuts are nearly identical to those of general pruning except that, by eradicative pruning the arborist traces the pathogen or pest to excise an infection or infestation to prevent a tree's death or further progress of branch dieback. This technique differs from other types of pruning, such as for maintenance, health (sanitation), size control, flowering, fruiting, and vigor (15), in which predictable tree growth, form, and habit are the factors and not a life-threatening pathogen or pest. Thus, the recommendation of timing for these other types of pruning (15,19,27) must be adjusted to the life history of the pathogen/pest threatening the tree in the area. For example, spread of certain fungal or bacterial diseases is reduced by preventing branch crowding. The dormant season is the best time to distinguish and correct overcrowding by thinning the tree canopy, but at that same time the bacterium *P. syringae* is active in some deciduous trees in California. In contrast, if done in the summer, thinning will stimulate growth of succulent new shoots susceptible to pathogen infection (19). Nevertheless, canopy thinning to prevent branch crowding must be done in the summer when there is minimal risk of rain that helps to spread *P. syringae* in California.

Figure 3. Cut made seven inches below the canker, next to the lateral, eradicated infection from the branch.

The arborist must objectively evaluate the severity and extent of symptoms and then assess whether pruning can succeed while also preserving an acceptable aesthetic appearance. Location of infection is also very important. Eradicative pruning cannot benefit Monterey pine, *Pinus radiata*, infected on major stems with western gall rust caused by *Endocronartium harkenessii*. But if one or two infections are detected on lateral branches, eradicative pruning will be successful.

Another major factor is the stage of infection or infestation. Clearly, if all major limbs of white

alder, Alnus *rhombifolia*, are infested by the flatheaded borer, *Agrilus burkei*, it would be pointless to prune such a tree for both aesthetic and health reasons. For example, in an Alamo, California experimental site with 28 white alders infested by *A. burkei*, 14 alders were selected at random for eradicative pruning treatment (30,31). In one instance (Fig.4), the alder was infested on 64 places, requiring the removal of 29 branches in the winter (Fig.5). Prophylactic sprays by Dursban 4C prevented further beetle attack. However, I disregarded that the white alder is susceptible to sunscald. Such radical opening of the crown (Fig. 5) brought sunscald damage to exposed limbs and the main trunk. Drawing from this experience, the arborist is advised to shield the post-prune exposed trunk and limbs with a shade cloth on their southwestern sides.

Each woody plant species responds differently to pruning cuts through which the pathogen can re-enter the plant system (3). Also, host volatiles attractive to some borers are released by pruning (2). Appropriate planning for a wound treatment is essential, because

a) Open wounds become attractive and can predispose the tree (such as elm, pine, alder, ash, birch and eucalyptus) to attack by boring insects. Spray the wound and its vicinity with insecticides to prevent further attack by borers.

b) Open wounds are an invitation for re-infection by a pathogen via contaminated tools or naturally when climatic conditions favorable to the pathogen develop. Prevent inoculation of a disease organism into pruning wounds by sterilizing cutting tools (bleach, Physam, 75% alcohol, or alcohol-based Lysol), and spray pruning wounds with a fungicide or bactericide when recommended by a plant pathologist.

Figure 4. Flatheaded borer infested 29 branches of white alder.

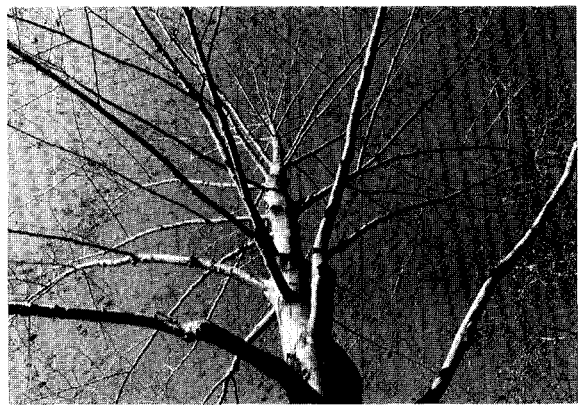

Figure 5. Eradicative pruning maintained natural character of white alder, but it radically opened canopy, making the tree susceptible to sunscald.

c) Tree care should promote tree defenses and rapid wound closure ("healing"). Water deficits may impair wound healing in bark (3). Vigorous trees accumulate sufficient carbohydrates to heal injuries and maintain physiological processes at levels necessary to sustain life (20). In many cases, tree care will require ancillary sprays of insecticides or fungicides to control other fungi or insects that may subsequently attack the tree treated with eradicative pruning. For example, spraying the canopy of Siberian elm, U. *pumila,* is justified after a branch infected by the DED fungus has been removed in the spring, if the arborist detects even a low infestation of the elm leaf beetle (ELB), *Xanthogaleruca luteloa*. ELB can complete two to three generations annually, resulting in partial or complete defoliation by the end of the growing season. Such loss of leaves reduces production of carbohydrates that elms use in their defense against invasion by pathogens and insect attacks (20).

Pre-planned visits to assess tree responses to eradicative pruning and to cultural practices aimed at boosting plant defenses must be incorporated into the post-treatment program.

Table 1. Fungal and bacterial diseases that can be controlled by eradicative pruning.

Disease (Host)	Symptoms	Treatment
Fireblight: ***Erwinia amylovora*** (Pears)	Wilt and collapse of blossoms. The bacteria causing fireblight are sucked back into the vascular tissues far below the visible symptoms.	Promptly cut 6 to 12 inches below the edge of discolored area, back to the closest lateral.
Brown, blossom or twig blight: ***Monilinia spp.*** (Prunus spp.)	Collapse of young blossom spurs, leaves and shoot.	Remove infected twigs and branches in the winter. Prune the tree canopy to improve air movement.
Eutypa Canker: ***Eutypa sp.*** (Grapes & Apricot)	Sudden limb collapse during summer heat.	Make a cut at least 6 inches below discoloration. Prune tree when there is minimal risk of rain and no fog. Treat wounds with thiophanate-methyl.
Bacterial canker and blast: ***Pseudomonas syringae*** (*Prunus* spp.)	Blossom shoot blast. Cankers develop on branches, gum exudes from canker margins.	Cut 6 inches below stain. Remove symptomatic twigs in the summer. Sterilize pruning tools.
Powdery mildew on apples: ***Podosphaera leucotrica*** (Apple)	White powdery growth on leaves and shoots.	Prune out diseased twigs.
Silver leaf of prunes, pears or peaches: ***Chondrostereum purpureum*** (*Prunus* spp.)	Leaves on one or more branches have a silvery appearance. Branch dies.	Prune off the branch at the stem when symptoms are visible. THIS DISEASE ORGANISM IS TRANSMITTED THROUGH PRUNING WOUNDS!
Olive knot: ***Pseudomonus savastonoi*** (Olive)	Rough galls or swellings	Remove heavily infected branches in July or August to prevent wound infection.
Leaf gall in azaleas: ***Exobasidium vaccinii*** (Azalea)	Thickened, distorted and crisp leaves.	Remove galls in the late summer.
Dutch elm disease: ***Ceratocystis ulmi*** *(Ulmus spp.)*	Wilted, yellow and brown foliage.	**PROMPTLY** prune infected branch **10 FEET** below the discolored tissue. Sterilize pruning tools.
Chinese elm anthracnose: ***Gleosporium sp.*** *(Ulmus parvifolia)*	Irregular, black, tar-like spots on the leaves. Cankers on branches and limbs.	Prune infected branches to the next healthy lateral. Excise bole cankers.

Table 1 (continued)

Cypress canker: ***Seridium cardinale*** *(Cupressus spp.)*	Girdling cankers with resin drip on branches.	Prune out diseased branches, below visible infection (6 inches) in the hot, dry summer. **SPRAY WOUNDS** with Thiophanate-methyl or Chlorothalonil.
Branch dieback of coast and giant Sequoias and canker of madrone: ***Botryosphaeria dothidea***	Death and dieback of branches. Cankers on branches.	Prune out dead and diseased branches. **SPRAY WOUNDS** with Thiophanate-methyl.
Sycamore anthracnose: ***Apiognomonia platanii*** *(Platanus spp.)*	Irregular, dead areas along the veins of a tree's leaves. Cankers on twigs.	Prune out and destroy infected twigs on young trees. Make cuts into previous years growth.
Pitch canker of pines: ***Fusarium subglutinans*** f. sp. ***pini*** *(Pinus spp.)*	Fading of shoots to yellow, then red at the early stage. Needles fall later. Bole and branch cankers.	Prune off infected shoots down to the 2nd whorl from the canker between November to February. Sterilize pruning tools. Chip and dispose of infested branches.
Leafy mistletoes: ***Phoradendron sp.*** (Many deciduous trees)	Clusters of evergreen mistletoe appear on the trunk and branches of many susceptible deciduous trees.	Prune off branches infected with mistletoe at least **one foot** below the haustorium.
Western gall rust: ***Peridermium harknessii*** *(Pinus spp.* two- and three-needle pines in the western United States)	Galls on the branches. Stunted growth — witches' brooms.	Prune off branches with galls from October to January. Wrap galls with plastic on the main trunk in January to prevent dispersal of spores. Chip and dispose of infested branches.

Table 2. Insect infestations that can be controlled by eradicative pruning.

Insect (Host)	Symptoms	Treatment
Flatheaded borer in white alder: ***Agrilus burkei*** (white alder)	D-shape exit holes. Branch suddenly dies in midsummer.	Prune externally stained branches before the end of March. Chip and dispose of infested branches.
Juniper twig girdler: ***Periploca nigra*** (*Juniperus spp.*)	Scattered dying or dead branches. Entire plant is never dead.	Prune off dying branches before May. Chip and dispose of infested branches.
Pacific flatheaded borer: ***Chrysobothris mali*** (many species)	Dieback of branches or entire plant. (Attacks many different plants).	Prune off infested branches before March. Chip and dispose of infested branches.
Shothole borer: ***Scolytus rugolosus*** (Many deciduous trees)	Shotholes found in the bark. Decline or dieback of branches on many broadleaf deciduous trees.	Prune off infested branches in the summer and fall. Chip and dispose of infested branches.
Bronze birch borer: ***Agrilus anxious*** (*Betula spp.*)	D-shape exit holes. Dieback of branches.	Prune off infested branches before May. Chip and dispose of infested branches.
Eucalyptus longhorned borer: ***Phoracantha semipunctata*** (*Eucalyptus spp.*)	Off-color light green to yellow foliage on limbs — entire branch dies. Broad galleries beneath bark.	Prune off infested limbs and dispose of them.
Sequoia pitch moth: ***Synanthedon sequoiae*** (*Pinus spp.*)	Pitchy masses 1 to 4 inches in diameter protruding from trunk and limbs.	Prune off branches from October to February. Excise pitch masses and kill larvae in the trunk. Chip infested branches.

Figure 6. An initial stage of infection by leafy mistletoe in black oak.

Eradicative Pruning for Control of Some Diseases and Insects in California

Tables 1 and 2 provide information about some destructive disease and insect problems in California that can be controlled by eradicative pruning. It is hard to develop a guide, since so many variables can affect execution. For example, one *Quercus kelloggii*, infected by the leafy mistletoe (Fig.6) required the removal of only eight branches to eradicate the parasite from the tree. In contrast, if the infection has been neglected long enough to allow its spread to all major limbs of Modesto ash, *Fraxinus velutina* 'Modesto', the result is not eradicative pruning but undesired maiming of trees which then become an aesthetic disgrace in the neighborhood (Fig 7 and 8).

The guide (Tables 1 and 2) highlights important aspects of the biology and natural history of the host plant and the pathogen or insect as well as timing of eradicative pruning described in a variety of sources (1,6,8,13,17,28,30,32). However, it will be the arborist's experience and knowledge of local conditions that effect a successful application of eradicative pruning.

Figure 7. Modesto ash heavily infected by leafy mistletoe.

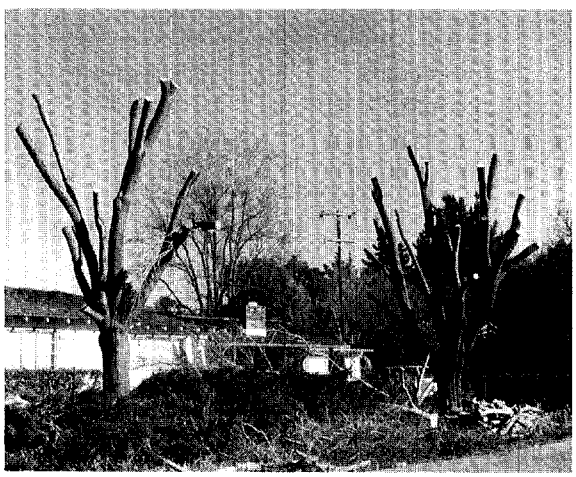

Figure 8. This is absolutely not eradicative pruning.

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Résumé. La coupe des branches infectées ou infestées de plantes ligneuses a été une tactique de contrôle recommandée durant plus de 150 ans. Le terme «élagage sanitaire» a été introduit à l'origine pour le contrôle de la maladie hollandaise de l'orme. L'élagage sanitaire peut servir à éliminer des branches secondaires ou primaires infectées ou infestées afin de prévenir la propagation d'un pathogène ou d'un insecte parasite dans l'arbre. Lorsque l'élagage sanitaire est combiné avec d'autres traitements chimiques ou culturaux, cette technique se marie alors très bien au concept de lutte intégrée des insectes et des maladies. La période de coupe, la sévérité et l'étendue des symptômes, la localisation de l'attaque du parasite (insecte ou maladie), le stade de l'infection ou de l'infestation, et la contamination des outils employés pour l'élagage sont tous des facteurs exerçant une influence sur le succès ou l'échec de l'élagage sanitaire. Cet article présente un guide de maladies et d'insectes qui peuvent être éradiqués des plantes ligneuses avec succès en Californie.

Zusammenfassung. Das Abschneiden von infizierten Ästen von Büschen und Bäumen ist seit mehr als 150 Jahren eine empfohlene Bekämpfungsmaßnahme. Der Begriff 'eradikativer Rückschnitt' wurde erstmals in der Bekämpfung von Holländischer Ulmenkrankheit eingeführt. Durch eradikativen Rückschnitt können Infektionen von Ästen beseitigt werden bevor sich der Erreger im Baum weiterausbreiten kann. Wenn der Rückschnitt mit chemischen und anderen Maßnahmen kombiniert wird, so fügt er sich gut in das Konzept des Integrierten Pflanzenschutzes (IPS) ein. Der Erfolg des eradikativen Rückschnitts wird beeinflußt durch den Zeitpunkt der Behandlung, die Ernsthaftigkeit und Ausdehnung der Symptome, des örtlichen Auftretens des Erregers oder des Schädlings, dem Infektionsstadium und der Kontamination des Werkzeugs. Dieser Bericht liefert eine Liste von ausgewählten Krankheiten und Insektenbefallsarten auf Gehölzen in Kalifornien, die erfolgreich ausgerottet werden können.