TABLE 1

Typical symptoms from air pollution injury on hardwoods and conifers.

Pollutant	Hardwood Symptoms	Conifer Symptoms	Indicator Plants
Ozone	Upper leaf surface stipple or fleck, often purple or black in color. Premature leaf drop.	Current-year needle tip necrosis (tipburn), shortened needles (chlorotic dwarf), needle mottling. Premature needle drop.	Bel W-3 tobacco, Milkweed, Green ash, Eastern white pine.
Sulfur dioxide	Bifacial, interveinal tan or brown necrosis.	Current-year needle tip necrosis (extending toward base when severe). Yellowing of older needles.	Alfalfa, Blackberry , Birch, Eastern white pine.
Herbicides	Necrotic spotting, leaf curling, twisting, or bleaching.	Needle chlorosis, needle necrosis and twisting (necrosis worst at needle base).	Grapes, Tomato, Boxelder.
Deicing salts	Leaf margin chlorosis or necrosis, premature fall coloring, dieback, witches'-brooming.	Needle tip chlorosis or necrosis for one-half needle length or more (visible in late winter or spring). Premature needle drop.	Eastern white pine, Hemlock.
Hydrogen fluoride	Leaf tip or margin chlorosis or necrosis.	Current-year needle-tip necrosis (extending toward needle base when fumigation is severe).	Gladioli, European larch.

around aluminum, brick, cement, glass, steel, and phosphate processing plants.

Acid Rain

The acidification of precipitation, related to man's increased burning of fossil fuels, has received considerable attention in the past few years, especially with regard to the dramatic effects on Adirondack lakes. There is no evidence, however, of any adverse effects of ambient rainfall on shade trees. For instance, no one has documented visible foliar symptoms caused by natural rain water. If the pH of rainfall continues to decrease, then acid precipitation may become an important problem on shade trees in the future.

Diagnosing pollutant injury

Diagnosing air pollution injury to trees is not easy because the injury can occur in many different forms depending on the pollutant, the tree species, and the environmental conditions under which the trees are growing. However, there are types of visible symptoms that are associated with specific air pollutants (see Table 1). These symptoms, along with a number of other factors described below, enable the arborist to make an accurate diagnosis of most air pollution problems on trees.

Diagnostic procedures—The Environmental Protection Agency's manual on diagnosing vegetation injury caused by air pollution (Applied Science Associates, 1978) lists six questions that are useful in attempting to diagnose air pollution injury:

1. What plant species are injured?
2. What are the injury symptoms and what plant parts are affected?
3. Is there a pollution source nearby capable of causing injury?
4. What is the distribution of affected plants?
5. Are biological agents (insects, diseases, nematodes) present?
6. What is the recent history of the affected area?

In contrast to insects or diseases which often are quite selective in the species they affect, air pollution often injures a wide range of plants, especially if the fumigation is severe. Knowing what plant species are injured also is useful because some plants are especially sensitive to certain pollutants and so make good bioindicators of the presence of that pollutant. Some common bioindicators are shown in Table 1.

Examining the types of symptoms present will also help in diagnosing air pollution injury. The color of the foliage injured, the pattern of injury on the leaves, the leaf surface affected, the state of maturity of the injured leaves, and the location of the plant where the injury occurred are all useful information to note.

If the injury symptoms appear to be caused by air pollution, then a source of the pollution problem must be identified. With the exception of long-distance transport of ozone, most pollutant injury to trees occurs within close proximity to the pollution sources. Air monitoring data from various local, state, or federal agencies can sometimes be found to verify the presence of a pollutant fumigation episode in an area with suspected air pollution injury.

The distribution of suspected pollutant injury on trees is another important diagnostic tool, especially when point sources of pollution are involved. Damage is usually most severe downwind from point sources. The distribution of injury can also be used to distinguish air pollution problems from those caused by insects or disease which often have distinct patterns of spread.

Any plants showing suspected pollutant injury should be examined carefully for biological agents that may have caused symptoms that mimic air pollution injury. Spider mites and leafhopper insects, for example, can cause upper leaf surface stipple on hardwood trees

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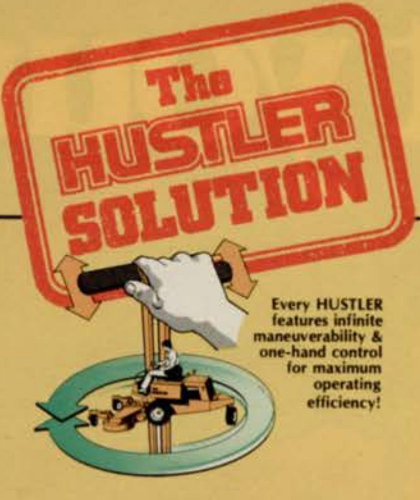

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Pollution *from page 42*

similar to ozone injury.

It is also important to be aware of any abiotic stresses such as water stress, frost, and nutrient deficiency that may be present at the site and may also cause symptoms similar to those caused by air pollution.

Obtaining information on the recent history of the affected area can sometimes help in making the diagnosis. In this way, information on factors such as soil fertility levels, pesticide applications, drought stress, or changes in drainage patterns can be obtained.

In addition to the abovementioned diagnostic procedures, it is often advisable to solicit the advice of trained forest pathologists or entomologists before making judgments on the cases that are more difficult to diagnose. It is often useful to have foliar analyses run to test for elevated levels of pollutants such as deicing salts, sulfur dioxide and hydrogen fluoride.

Field evaluations—In responding to requests to evaluate suspected air pollution problems on trees, the senior author has found it advisable to be properly equipped so the field time is spent most efficiently.

Some useful items that can be taken along in a pick-up truck, van, or station wagon include a field notebook (preferably with some preprinted data evaluation sheets showing the information you wish to collect), a camera (with closeup and telephoto lens), a book to press plant leaves for eventual preparation as herbarium specimens; plastic bags; ice cooler; hand lens; binoculars; pole pruners; soil sampling auger; books with good descriptions and photos of common insect, disease, and air pollution problems; and backpack.

It is especially useful to document suspected air pollution injury by taking extensive field notes and photographs and by collecting some foliar samples for herbarium mounting and others for preservation by freezing in plastic bags. Field notes, color photographs, and foliar samples are especially useful in discussing your findings with experts in tree problems diagnosis and also in serving as evidence in any possible litigation that might result.

To ensure that good herbarium specimens are prepared, leaves should be pressed flat as soon as possible after they are collected. Plastic bags are useful in collecting leaf samples but also for taking samples of insects or disease that might be found on the affected trees. A pole pruner is essential for collecting foliar samples from the upper or middle crowns of trees where air pollution injury is likely to occur, especially if the trees are growing close to one another. A good field guide to carry for diagnosing air pollution injury is Jacobson and Hill's (1970) book entitled "Recognition of air pollution injury to vegetation: A pictorial atlas."

Correcting air pollution problems

In the companion article, the authors will discuss ways to reduce air pollution injury to trees such as cleaning up the source of air pollution and planting pollution-tolerant trees. Some corrective measures such as adding gypsum to reduce toxic effects of deicing salts and fertilizing eastern white pine to reduce ozone and/or sulfur dioxide injury will be discussed.

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CONSTRUCTION

RESIST TEMPTATION TO CUT CORNERS WITH TIE WALLS

BY JOHN ALEXOPOULOS

Railroad ties have been utilized for many years in landscape design. Their popularity has been particularly great in comparison to other materials due to a variety of reasons, but primarily for their low cost and desired "old and weathered look".

The genuine railroad tie also has been treated through and through with preservative, seeming to last forever. In addition, the ties are easily transported, easily handled by two workers and can be cut to various lengths. Ties have therefore been used as curbing, walls, steps or planters.

This versatility in use has been a notable characteristic, and combined with the usual very low price, presented contractors and homeowners with a cheap and effective way out of using more expensive materials. In recent years, however, this surplus railroad material has become scarce and the prices for them has risen tremendously.

Timber selection

The timbers utilized for railbeds are generally pressure treated and vary in their dimensions. A typical tie might be considered as six inches by eight inches thick and eight feet long.

There are, however, numerous exceptions to these dimensions, with larger thicknesses, and lengths as long as thirteen feet being found. The type of wood used is often a hardwood and primarily oak. In any event, all the timbers are pressure treated with creosote. This treatment usually preserves the ties for many years though they may be greatly affected by weathering, wear, wood quality and by the material surrounding the wood.

In any batch of used railroad ties the quality varies widely as some pieces are found in very poor condition. Ties with wide cracks, splits made by spikes, internal decay, deformed or rounded edges are inadequate for landscape use. These defects are especially a problem where ties are used for steps in which case a very smooth tread and sharp edges are a necessity. The price for old ties is quite high, and wasted pieces become costly.

> The temptation to use less expensive and rapidly constructed material for railroad tie walls is always great. Concern must be given not only to strength and durability, but to appropriate use as well.

As a result of the need for top quality timbers and the scarcity of old and usable ties, new ones have become the predominantly available material. These new timbers vary in dimensions much as the older ones do, but usually are sold six inches by eight inches by eight feet. Most recently, landscape timbers have become available at garden centers and lumber yards which are even smaller in dimension. The new landscape timbers or new railroad ties also consist of various kinds of wood, both hardwood and softwood.

In selecting new landscape timbers, the designer or contractor must keep in mind the use for the timbers. In stair construction for instance, a sharp edge must be present for safety and appearance. Softwood timbers, such as cedar, hemlock or pine, should not be used for they wear too easily, creating a rounded and dangerous step. A better choice would be a well cut oak timber. Softwood timbers, on the other hand, if properly preserved, will serve well for walls and posts. Their light weight makes wall making all the easier and makes drilling for pin placement much easier than in hardwoods.

In selection of the kind of wood used, the designer should attempt to obtain the most naturally decay resistant species available. This is particularly important in wall construction where posts and wall courses are in constant contact with the soil. A problem exists here in that these wood species are no longer readily available and are more costly than the less resistant species.

The best naturally resistant woods are red cedar, redwood, cypress and black locust. The least resistant ones are primarily softwood species such as pine, spruce and hemlock.

No tree species, however, can be relied upon to last for many years if not treated with preservative. Even the best species, if available, will eventually decay especially if the wood is in direct contact with moist soil.

Preservatives

Preservatives must be utilized in order to extend the life of the railroad tie. It must be also kept in

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John Alexopoulos is Assistant Professor of Landscape Architecture, University of Connecticut, Storrs.

mind that most wooden walls, in contact with the soil, will not be permanent, lasting for far less time than masonry or concrete ones.

The best preservative treatment by far is pressure treatment. In this process the chemical is driven into every part of the timber. This complete dispersal throughout the timber prevents decay which occurs within the wood when it splits or within the holes drilled to receive joining spikes or rods. Creosoting is by far the most popular treatment, adding many years to the life of any wood species used. A drawback to the use of creosote treated timber is that the creosote tars can ooze from the wood and can therefore be messy in appearance and sticky to the touch. Designed areas such as playgrounds utilizing these timbers should be planned so as to avoid placing them where contact by people might occur. Creosoted ties are best used as underground posts in areas where contact with the timber would not be a problem.

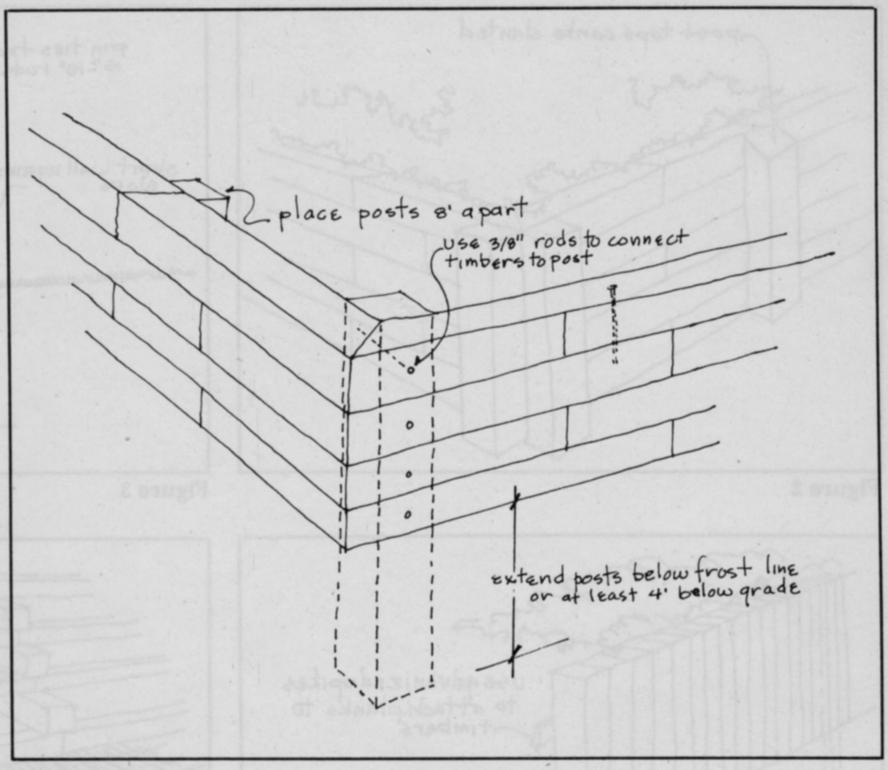

Figure 1

Pentachlorophenol, or Penta, is another fine, long lasting preservative and one which is not liable to be sticky to the touch. A real problem with this chemical and with creosote as well, is the toxic effect their fumes have on plants. New, fresh timbers should be allowed time to weather before placement to minimize damage to nearby plants. If, however, the plantings are open to breezes in a well exposed area, then the problem of damage will be lessened. The designer or contractor should use proper judgement as to the use of these kinds of treated timbers.

A preservative which is relatively safe near plantings and which is also an effective decay retardant is copper naphthenate. It generally is of a green color, but is now found in numerous colors from clear to dark brown.

A second treatment for preserving landscape timbers is the soaking method. The timbers are soaked in the preservative from a few hours to a few days. However, the chemical will penetrate only one eighth to one quarter of an inch into most woods. This is fine for the outer surface of the timber, but has no effect on decay organisms which will invade the interior of the timber, especially when it splits.

A final method of application of preservative is by brush application. Brushing on the chemical is generally done on the site and is applied after all cuts are made. The problem with this method is simply that the chemical penetrates so little into the timber. Annual painting can help in extending the life of the wood, with care taken to allow the preservative to flow into cracks.

Construction design

The design of railroad tie retaining walls must be done with consideration of the factors which affect all retaining walls.

The particular factor which is by far the most important one is the pressure exerted on the wall by the soil behind it. Tremendous and steady pressures constantly push against the back of a retaining wall and can topple it if the wall isn't designed correctly.

A primary error in design which leads to wall failure is that too often supporting posts, or "deadmen", are not employed. All the courses of a railroad tie wall should be tied together and attached to posts that not only hold each tie, but extends below the wall into the ground. The extension of the posts into the ground counteracts the natural tendency of a wall to topple and eliminates the effects of frost heaving. The depth of the post below the lowest grade should always extend below the frost depth in the particular region of the country (Fig. 1). The higher the wall is to be, the deeper the post must be placed.

A designer should consult an engineer for walls exceeding five or six feet high, because the higher the wall, the greater is the need for support. In a four or five foot high wall the posts should extend below the bottom wall course at least four feet and should be anchored in concrete. The use of a concrete footing should not be omitted, especially where the ground continues to slope above the top of the wall.

A batter or receding upward slope in the wall should be used in these situations so that the wall resists the pressures of the slope. If posts are omitted where the soil is not stable or is newly filled the danger of the wall sliding out from its bottom is increased.

Galvanized spikes should be used to pin individual wall courses

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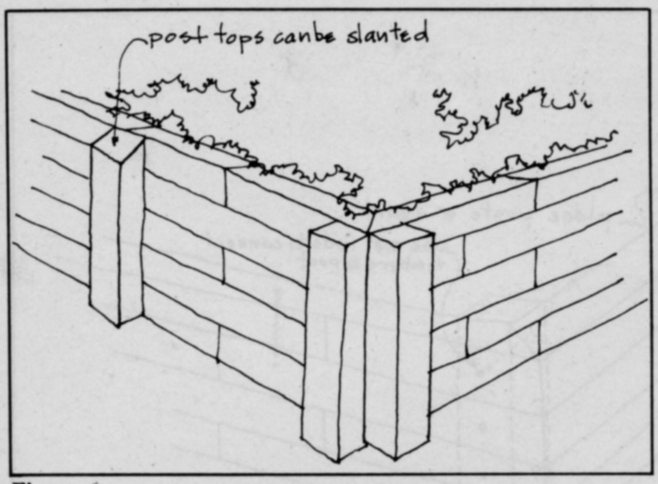
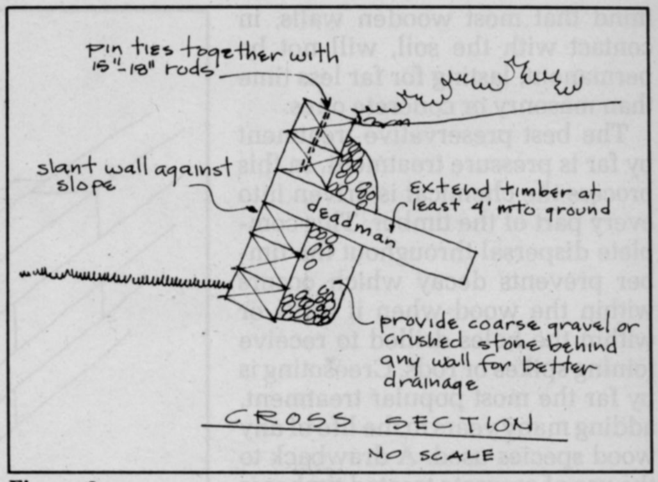


Figure 2



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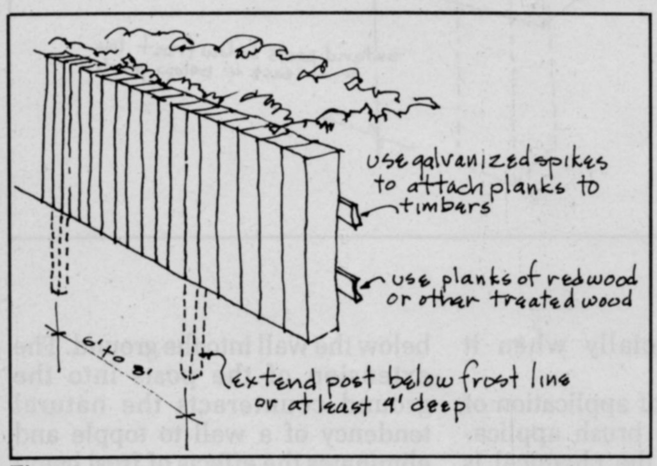

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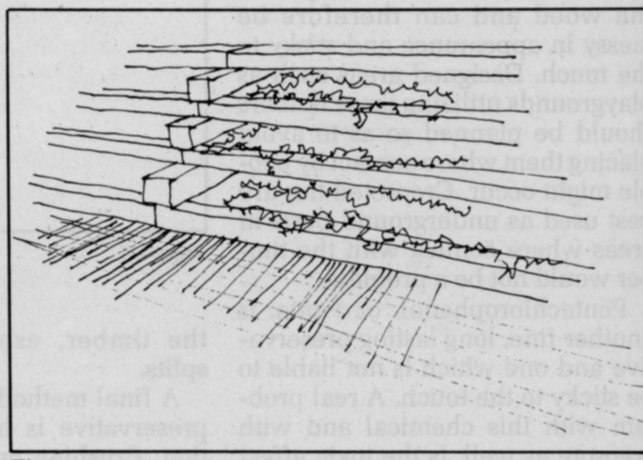

Figure 5

together or for joining the wall to posts. Rods of three-eighth-inch diameter by fifteen inches long can be used also. A galvanized coating will prevent rusting and subsequent failure where moisture is present. Metal straps or angle iron should be avoided as well and can be substituted with strips of redwood or pressure treated woods.

In considering the appearance of retaining walls, the designer can utilize the supporting posts by introducing them as part of the design (Fig. 2). Posts can be placed in front of the wall at intervals of from six to eight feet. The post edges can be cut at angles (champfered) for appearance and the post top cut at angles. The wall courses should alternate so that no joint is above another. The butt end of a tie can be placed between horizontal ties for added interest as well.

In short walls or in walls that are in front of stable soil the posts can be eliminated (Fig. 3). Where this is done, the use of "deadmen" or ties which extend perpendicularly into the slope should be utilized. These timbers will serve as counter drags to the natural pressures behind the wall. These "deadmen" can be located in patterns to create a better designed wall and should be extended at least four feet into the soil.

Another wall design is created by placing the ties vertically instead of horizontally. This style reveals no posts for support as the post found every six feet in wall length are extended into the ground for support (Fig. 4). The timbers are all joined together with a treated plank or redwood strip behind the wall.

Another design style for railroad tie walls is one which is most suitable for utilitarian purposes. This wall allows for spaces in which plants can be grown. Every other course of timbers is eliminated (Fig. 5). The "deadmen" serve not only as support for this wall but also serve as the points to which all the timbers are connected. The pressures caused by water behind walls is not as great in this type as others because excess soil water merely flows through the spaces. These walls are especially appropriate for garden use.

In conclusion, in the design of retaining walls, concern should be given not only to strength and durability, but to appropriate use as well. Landscape timbers or used railroad ties simply don't belong in some design situations while fitting perfectly into others. In general they are best used in residential and utilitarian situations, lacking the appearance of permanence and grandeur often necessary in most commercial or institutional landscapes. The temptation to use this less expensive and rapidly constructed material is always great, so the designer must consider these walls carefully. **WTT**