AAAIA Work Group Report

Landscape Plant Selection Criteria for the Allergic Patient

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Patients with pollen-related allergies are concerned about the species within their landscape that provoke their symptoms. Allergists are often asked for guidance but few information sources are available to aid patients in the recognition of allergenic plants and strategies to avoid personal exposure to them. Landscaping and horticultural workers also have few reliable guidance references, and what is available usually extols the virtues of the plants rather than their negative features. The aim of this article was to provide the results of the Landscape Allergen Working Group that was formed by the AAAIA Aerobiology Committee, which aimed to fill these existing knowledge gaps and develop guidance on producing a low-allergenic landscape. Within the context that complete pollen avoidance is unrealistic, the workgroup introduces selection criteria, avoidance strategies, and guidance on low-allergenic plants that could be selected by patients to reduce the overall pollen burden in their landscape environment. Specific focus is placed on entomophilous plants, which require insects as dispersal vectors and generally produce lower quantities of pollen, compared with anemophilous (wind-pollinated) species. Other biological hazards that can be encountered while performing landscaping activities are additionally reviewed and avoidance methods presented with the aim of protecting gardeners, and workers in the landscape and horticulture industries. The guidance presented in this article will ultimately be a helpful resource for the allergist and assist in engaging patients who are seeking to reduce the burden of allergen in their landscape environment.

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BACKGROUND

Plants produce reproductive propagules termed pollen that are aerosolized into local air masses. Although pollen deposition generally occurs in proximity to the source,1 there are examples of pollen transportation across regions, states, and even entire countries.2-8 Personal pollen exposure occurs in both urban and rural settings, and airborne levels vary among species, with highest concentrations usually reported during the spring (trees), summer (weeds and grass), and fall (weeds). The lowest concentrations occur during winter. Personal exposure to pollen grains, their associated fragments, and allergen released into the air can result in allergic sensitization, which can cause allergic rhinoconjunctivitis, and allergic asthma.

Many allergic patients often seek guidance from allergists to assist in plant identification or enquire about avoidance strategies to minimize personal exposure. In response to questions and concerns that were voiced to the AAAIA Aerobiology Committee, the Landscape Allergen Working Group was formed and consisted of clinicians and researchers with expertise in allergy, occupational health, aerobiology, and botany. The aim of the workgroup was to address the existing knowledge gaps and provide guidance on strategies that patients and workers could use to reduce the burden of pollen exposure within their personal landscape or workplace. This approach focused on design strategies that would result in the selection of candidate plants with a low pollen yield. These design characteristics will ultimately assist the patient and the worker but also provide a new resource that clinicians could use to assist patients during the design phases of a low-allergenic landscape.

Although eliminating personal pollen exposure is not completely feasible given regional and background sources, the guidelines and avoidance strategies developed by the workgroup that are outlined in this article could assist in the local reduction of pollen exposure and associated plant hazards. It is important to note that the design and production phases of a low-allergenic landscape require a basic understanding of plant biology concepts and botany. Understanding these concepts will further enhance the patient’s ability to participate in the selection of plant species that produce the least amount of pollen but are able to grow and persist in their landscape environment. An algorithm and selection guidelines that are intended to assist the patient in the selection of a nonallergenic plant landscape are also included in this article. Methods to reduce exposure to other plant-related hazards are additionally discussed.
POLLEN BIOLOGY

Many land plants disperse reproductive propagules through the air. Mosses and ferns produce spores that are spread by air currents, although in small amounts and usually over limited areas. In contrast, conifers and some flowering plants can produce large quantities of pollen that can reach high local concentrations1,9 and can travel in air masses over regional and continental distances.2-8 Pollen from both conifers and flowering plants may be of allergenic clinical relevance at the community level.

Conifers are gymnosperms, or plants that produce naked seeds that are not enclosed in a fruit. The pine, spruce, and fir cones are seed-bearing (female or megasporangial) strobili. These cones are aggregates of scales, with each scale, or bract, bearing 2 naked seeds on the axial surface. The smaller, more ephemeral-male (microsporangial) cones of pine, juniper, spruce, and fir are also aggregates of scales but bear pollen sacs on the axial surface of each scale. The male cones drop as soon as the pollen sheds, whereas the female cones are retained for the season to allow maturation of the seeds. Figure 1 shows the megasporangial and microsporangial arrangements of Loblolly pine (Figure 1, A) and microsporangial cones of mountain cedar (Figure 1, B), respectively.

Flowering plants, or angiosperms, produce seeds from ovules encased in an ovary (fruit) rather than naked on a scale. Flowering plants include those with the ancestral “magnolia-type” flowers, inconspicuous flowers such as those produced by grasses,
ragweed, and maple as well as the morphologically complex flowers of orchids and sunflowers. Examples of these flowering structures are depicted in Figure 1, C, D, E, F, and G. All flowering plants produce pollen and ovaries although there is a large array of variability in how this is achieved. For example, tulip, poppy, orchid, and magnolia flowers include all the reproductive and accessory parts in one flower called a “perfect” flower. These parts are arranged in concentric whorls. The outermost are the sepals, inside these are the petals, next is a whorl of stamens, and in the center are 1 or more carpels containing the ovaries and stigmas. The stamens produce pollen, and the stigmas receive pollen through a deposition process.

In contrast, other angiosperms have separate male and female flowers containing only stamens or carpels, respectively. These are known as “imperfect” (and incomplete) flowers. Staminate and carpellate flowers may occur on the same plant, which is called dioecious, or on separate plants, which are known as dioecious. Among wind-pollinated plants, petals and sepals usually are vestigial or absent, and many species are monoecious. Showy perfect flowers are almost always entomophilous (Figure 1), whereas imperfect, and inconspicuous flowers like grasses (Figure 1) and ragweed are typically anemophilous.

In many anemophilous plants, the flowers occur in inflorescences (clusters of small flowers) rather than as solitary flowers. There are many different types of inflorescences, based on the arrangement of the flowers in the cluster. Many wind-pollinated trees including oaks, birches, and mulberries produce male catkins; each catkin is a long, slender inflorescence (Figure 1) and ragweed are typically anemophilous.

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Much information has appeared recently and continues to appear on this topic. In addition to using plants with showy, insect-pollinated flowers, a patient’s allergen reactivity profile and potential sources of cross-reactivity should be considered.

## LOW-ALLERGENIC PLANTS

### Selection of low-allergenic plants for landscaping

Selecting plants for landscaping can be a challenging task. Lists of recommended plants are included in gardening magazines and for every category or planting. There are recommended lists for ground covers, annual and perennial flowers, trees, shrubs, and turf grass species, sometimes considering particular purposes, for example, swimming pool plantings and landscaping. These lists are driven by popularity and influenced by what is new and available at garden centers. However, considerations about hardness and floristic zones are important parameters in the selection of the most appropriate landscape plants for a particular location. Climate gradients and microclimates exist in particular zones, and often the same botanical species grow in different geographic locations under natural conditions. The United States Department of Agriculture, Agricultural Research Service has published a selection of plant hardiness zone maps that date back to 1960 and are freely available online to the public. In addition, anthropogenic alterations associated with landscaping are important elements to consider when designing a low-allergenic landscape. Regardless of whether or not plants are allergenic or can grow within a particular hardiness or floristic zone, those considered invasive or toxic should not be planted. The United States Department of Agriculture has prepared a list of noxious plants, which should be used as a reference for plants to avoid.

In addition to the aesthetic value of candidate plant species and the general landscape design, the allergic patient should evaluate plants for reduced allergenicity. Because of the climatic

<table>
<thead>
<tr>
<th>Type</th>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Hardiness zone</th>
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<tr>
<td>Tree</td>
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<td>Cercis canadensis</td>
<td>Eastern redbud</td>
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<tr>
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<td>Chionanthus virginicus</td>
<td>Fringe tree</td>
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<tr>
<td></td>
<td>Cornus florida</td>
<td>Flowering dogwood</td>
<td>Cornaceae</td>
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</tr>
<tr>
<td></td>
<td>Crataegus phaenopyrum</td>
<td>Washington hawthorn</td>
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<tr>
<td></td>
<td>Diospyros virginiana</td>
<td>Persimmon</td>
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<td></td>
<td>Ilex opaca</td>
<td>American holly</td>
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<td></td>
<td>Kalanchoe latifolia</td>
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<td>Saucer magnolia</td>
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<td>Sophora japonica</td>
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<td>Deciduous shrubs</td>
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<td>Baptisia australis</td>
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<td>Echinacea purpure</td>
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<td>Helleborus orientalis</td>
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<td>Ranunculaceae</td>
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<tr>
<td></td>
<td>Heucher a micrantha var. diversifolia “Palace Purple”</td>
<td>Coral bells</td>
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<tr>
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<td>Phlox divaricate</td>
<td>Wild sweet William</td>
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<td>Polygonatum odoratum var. pluriflorum</td>
<td>Solomon’s seal</td>
<td>Asparagaceae</td>
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<tr>
<td></td>
<td>Rudbeckia fulgida var. sullivantii “Goldstrum”</td>
<td>Black-eyed Susan</td>
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<tr>
<td></td>
<td>Sedum termatum</td>
<td>Three-leaved stonecrop</td>
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<tr>
<td></td>
<td>Symphyotrichum novae-angliae</td>
<td>New England aster</td>
<td>Asteraceae</td>
<td>4-8</td>
</tr>
</tbody>
</table>

*This list presents candidate nonallergenic plants that can grow within a broad range of hardiness zones. This list was adapted from several online and peer-reviewed sources and is intended to be a guide of candidate plants that could be used in the design of a nonallergenic plant landscape.

†Reference to plant hardiness zones presented by the United States Department of Agriculture, Agricultural Research Service.
A combination of native and ornamental anemophilous species typically make up the vegetation profiles of urban environments. In many cities, the selection of uniform species and dioecious male trees has eliminated fruit and litter production. This approach has resulted in homogeneous pollen profiles with a high community prevalence of allergy. In the United States, examples of common anemophilous plants planted in urban environments include maples (Acer rubrum and A. saccharum), American sweetgum (Liquidambar styraciflua), pine (Pinus taeda and P. ponderosa), beech (Fagus grandifolia), aspens and poplars (Populus species), Douglas-fir and fir (Pseudotsuga menziesii and Abies balsamea), white oak (Quercus alba), and sycamore (Platanus species).

The selection and design phases of a low-allergenic plant landscape should avoid anemophilous species, as shown in the algorithm presented in Figure 2. Minimizing personal pollen exposure to allergenic plant species should also be a major aim to select appropriate plants in a landscape setting. However, eliminating seasonal pollen exposure is not completely feasible and can present some landscape design challenges. Although removal of anemophilous species from an existing landscape should ultimately reduce but not eliminate pollen exposure, this option is not always possible due to cost-benefit considerations. Although the removal of existing anemophilous species should reduce the immediate pollen load, pollen sources from surrounding areas cannot be eliminated. Reducing the pollen concentration in the immediate vicinity to the level of the regional background would likely reduce allergic symptoms in sensitized subjects. Other challenges may arise depending on the sensitization profile of the patient. Individuals sensitized to grass species may need to evaluate other low-allergenic plant species or hardscaping alternatives. The selection of alternate species also depends on geographic, meteorological, and soil-related variables that determine the ability of a species to grow at a specific site, as described in the preceding section.

A low-allergenic landscape should ultimately consist of entomophilous plant species. Examples of common entomophilous plants in the United States are presented in Table II and include the flowering dogwood (Cornus florida), various magnolias (Magnolia species), and the tulip poplar (Liriodendron tulipifera). Entomophilous species can be mistakenly identified as causes of allergic rhinoconjunctivitis due to the emergence of their flowers at the same time and location as anemophilous allergenic species such as goldenrod intermixed with ragweed. Selection of female plants from dioecious species can reduce the pollen burden further in a landscaped environment but could result in the production of unwanted fruits and/or seeds. Selecting a broad diversity of plant species not known to cross-react may also be a strategy to reduce the pollen burden for a low-allergenic landscape. Using this plant selection approach could have occupational health implications and reduce work-related pollen exposures for landscape and arborist workers.

The preliminary landscape design phase should consist of the selection of entomophilous species with no documented history of allergy, if possible. However, this approximation may be challenging because the allergenicity for many pollen species has not been studied, and allergen extracts have not been prepared or tested on patients. For example, allergic sensitization to Indian bean (Catalpa speciosa) and horse chestnut (Aesculus hippocastanum) demonstrate that allergen cross-reactivity can occur among entomophilous species. The suggestion that allergen

![Figure 2](image-url)
cross-reactivity is a relevant selection factor requires further evaluation as proposed for horse chestnut. Understanding the taxonomic and phylogenetic relationships of various plant species is critical for the selection of a low-allergenic landscape.

To avoid selecting plant species that could exacerbate seasonal allergies in individuals sensitized to them, the following selection criteria/guidelines should be considered during the design stages of a low-allergenic landscape.

- Eliminate existing anemophilous species from your landscape if possible.
- Reduce grass pollen exposure and consider placement of shrubs or hardscaping. Grass allergens may also become aerosolized in the absence of pollen with mowing, in combination or not with rainfall episodes.
- Select a broad diversity of entomophilous, low-allergen producing species with little seasonal pollen production.
- Consider planting female plants derived from dioecious species.
- Ensure that selected species do not cross-react with other characterized allergenic plant species to the best possible extent.
- Select noninvasive plant species capable of growing in the specific geographic area.

OTHER BIOLOGICAL HAZARDS

In addition to pollen exposures, the gardener or landscape worker may encounter other biological hazards. A few examples include insect stings, exposure to microbial bioaerosols, and other plant-derived products (eg, trichomes, sap, bark, and leaves). Exposure to these other hazards may result in co-exacerbations of allergic symptoms and other adverse health effects. Awareness of these hazards may assist in the development of avoidance programs when working in a low-allergenic landscape.

Many of the plants listed in Table II are insect pollinated. Flowers produced by these species attract various insects that forage for pollen and nectar. Flying stinging insects from the order Hymenoptera (bees, wasps, yellow jackets, and hornets) may increase in frequency during flowering intervals and present opportunities for the gardener or landscape worker to be stung. Insect stings can cause adverse health effects ranging from large local allergic reaction to anaphylaxis. The preventative steps that can be taken to minimize exposure to stinging insects include wearing protective clothing such as long sleeves, hat, safety glasses, and gloves. If there is a risk of a systemic allergic reaction, self-injectable epinephrine should be carried at all times. Allergy/immunology evaluation and prescribing of venom immunotherapy for patients with IgE-mediated (anaphylactic) potential to hymenoptera venom should also be considered.

Handling plants that contain thorns, spines, glochids, trichomes, and sharp-edged leaves can result in skin injuries (scratches, lacerations). These can occur when handling plants without protective equipment. In most cases, the individual resolves these injuries; however, it may result in infection by pathogenic microorganisms such as the dimorphic fungal pathogen, *Sporothrix schenckii*, that can grow on sphagnum moss or thorned plants. Leaves and flowering structures of trees such as the London Plane tree (*Platanus acerifolia*) also produce microscopic leaf hairs called trichomes that can detach and aerosolize following disturbance. Inhalation of trichomes may result in upper respiratory tract irritation.

Plants can produce products that can lead to various forms of dermatitis following cutaneous exposure. For example, stinging nettle (*Urtica*), poison ivy (*Toxicodendron radicans*), and other urushiol-producing species such as poison oak (*T. diversilobum* or *T. pubescens*) and poison sumac (*T. vernix*) are representative examples. In addition to *Toxicodendron* species, more than 180 species included in the Asteraceae family have been reported to cause allergic contact dermatitis following cutaneous exposure. Examples include Chrysanthemum (*Chrysanthemum* species), Dahlia (*Dahlia* species), and several weed species, including ragweed. Plants in the Apiaceae family are also frequent sources of furocoumarins and causal agents of phytophotodermatitis. Gardeners and landscapers in direct contact with plants that produce these products are at highest risk for developing allergic dermatitis. Fisher’s Contact Dermatitis (6th edition) is a helpful resource that reviews and lists plant species known to cause dermatitis.

Personal exposure to microorganisms that colonize dried leaves, mulch, wood chips, and compost may also be encountered, often in high concentrations during disturbance events such as shoveling or raking mulch or woodchips. Similarly, workers can be exposed to arthropods such as the red spider mite (*Tetranychus urticae*) and other parasites of plants cultivated in occupational settings (greenhouses and farms). These exposures can exacerbate preexisting adverse health conditions including allergic sensitization, asthma and hypersensitivity pneumonitis, work-related cough symptoms as well as decreases in work-shift lung function. Additional botanically derived allergens such as grass pollen and respirable particles containing grass allergen may also disperse into the environment following disturbance. For example, Rowe et al showed that lawn mowing resulted in increased nasal and ocular symptoms in patients with high serum concentrations of total IgE and specific IgE to grass pollens but not fungi or grass leaf extract. It was hypothesized that grass pollen settles within the lawn and becomes airborne again during mowing activities. In a subsequent study, grass allergen concentrations increased 8-fold during mowing activities and quickly decreased following the completion of this activity.

Health and safety precautions used in the landscape industry can be used by gardeners, landscapers, and arborists to reduce or eliminate exposure to these other biological hazards. There are several helpful resources available from the United States Occupational Safety and Health Administration and the Canadian Centre for Occupational Health and Safety. Precautionary steps to minimize exposure to these agents include the following:

- Wear protective clothing and equipment including long-sleeved shirts, long pants, gloves, and head and eye protection.
- Apply insect repellent to prevent insect exposure and stings.
- Wear respiratory protection during disturbance activities such as digging soil, distributing mulch or compost, and mowing.
- Carry self-injectable epinephrine for those susceptible to anaphylaxis following an insect sting.
- Be aware of the season and potential exposure to pollen from neighboring areas.
- Remove poison ivy (*Toxicodendron radicans*) or other plants identified to cause skin injuries and toxic reactions.

Ensure that selected species do not cross-react with other characterized allergenic plant species to the best possible extent.

Select noninvasive plant species capable of growing in the specific geographic area.
• Landscaping employers should educate workers about pollen exposure and other biological hazards.

CONCLUSIONS AND RECOMMENDATIONS FOR THE CLINICIAN

This article described the basic biology of plants and the main principles that should be considered in designing a low-allergenic landscape, including the selection of entomophilous plants instead of anemophilous plants. These basic plant biology concepts can guide us to safer plant selections.

Many allergenic plants are already characterized with numerous references appearing in the scientific literature. These plants should be avoided when designing landscapes. However, it is difficult to avoid pollen entirely because under ideal circumstances, pollen may eventually be dispersed for hundreds or thousands of miles from their sources. Therefore, total avoidance in the landscape environment of the patient is not possible. Rather, the use of known low-allergic entomophilous plants (Table II) is recommended whenever possible. The algorithm in Figure 2 guides the selection of plants on a general basis using the basic information contained in this article augmented with the knowledge of plants that are suitable for the specific location. This article also provides selection criteria and guidelines when designing a low-allergenic landscape. Once it is determined what plants are generally safe to grow, then reasonable decisions can be made as to what plants to use in the patient’s landscape to minimize the likelihood of provoking allergic reactions. Although a completely allergy-free garden space outdoors is unrealistic, a reduced allergen or low-allergen landscape is feasible to design using the information and principles described in this article.

Allergic patients should work closely with their local allergist who would determine specific clinical sensitization to outdoor allergens by in vivo and/or in vitro tests. Knowing the outdoor allergens that sensitize individuals along with the information provided in this reference article will assist the clinician in providing patients with useful recommendations to design their landscapes.

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REFERENCES