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ARBORICULTURE: INTEGRATED MANAGEMENT OF LANDSCAPING TREES, SHRUBS, CLIMBERS

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ABSTRACT

This review article examines the evolution of arboriculture from reactive maintenance to a holistic, science based "Plant Health Care" (PHC) framework for the integrated management of landscape trees, shrubs and climbers. The review details critical cultural practices, including precision pruning, the remediation of abiotic stressors like soil compaction and the mitigation of "volcano mulching" and girdling roots to ensure robust root zone development. Furthermore, it highlights the transformative role of technology, such as Sonic Tomography for internal decay detection and UAV based multispectral imagery for area wide risk management, as essential tools for data driven decision making. Ultimately, the article argues that integrating these diverse management strategies is vital for developing climate resilient urban forests that provide sustainable ecosystem services amidst densification and shifting precipitation patterns.

Keywords **:** Arboriculture, Integrated management of landscaping, Trees, Shrubs, Climbers

Introduction

Arboriculture is the science and practice of growing individual urban woody plants, such as trees, shrubs and climbers, to improve their health, safety and appearance (Dujesiefken *et al*., 2005; Frediani, 2024). Unlike forestry, which focuses on entire ecosystems, arboriculture takes care of individual trees that face urban challenges like pollution, limited root space and human activity (Dujesiefken *et al*., 2005). The field has changed from traditional "tree surgery" to a more holistic approach called Environmental Arboriculture. This approach treats trees as living organisms closely connected to their surroundings and sees decay as a natural process. This is managed through the Compartmentalization of Decay in Trees (CODIT) model, which helps support the trees natural defenses (Dujesiefken *et al*., 2005; Fay, 2002). Ultimately, the discipline promotes sustainable urban development by combining ecological practices, such as regulating temperature, capturing carbon and purifying air, with important psychological benefits that reduce stress and enhance cognitive focus (Falk & Balling, 2010; Townsend & Barton, 2018; Frediani, 2024).

Pre planting assessment and species selection ("Right Plant, Right Place")

Site analysis

Site assessment is the first step in arboriculture. Most tree deaths come from mistakes made in the planting site rather than from pests or diseases (Anon.1 2005). A thorough analysis should look at the natural and physical limits of the urban environment to promote long term health. Practitioners must first determine the geographic hardiness zone, considering both cold and heat tolerance. Microclimates, caused by heat reflecting pavement or wind tunnels between buildings, can differ greatly from regional averages. This means selecting species that can with stand drought or strong winds (Anon.1 2005). Urban soils often face severe compaction and inadequate drainage, which restricts oxygen flow to the roots. The assessment should include testing soil pH to understand nutrient availability and measuring

available soil volume. Limited rooting space is a major reason for stunted growth and weak structures (Watson, 2014; Moss *et al.,* 2019). It is essential to check the above ground space for overhead power lines and building setbacks to avoid future topping or excessive pruning (Anon.1 2005). Below ground, mapping the location of utilities such as gas, water and electricity is crucial. This helps avoid root interference and ensures safe excavation (NBC, 2023).

Selection criteria

Selecting woody plants requires careful evaluation of their biological traits in relation to the functional needs of a landscape. This helps reduce maintenance, protect infrastructure and enable plants to reach their genetic potential. When choosing trees, it is important to consider their mature sizes, root structures and canopy shapes, such as columnar, spreading, or weeping. This prevents damage to pavement and utilities. It also helps manage litter issues from unwanted fruit or sap, as seen with female *Ginkgo biloba*, which can create urban nuisances (Anon.1 2005). Shrubs are chosen based on their growth habits mounding, upright, or prostrate to fulfill specific design purposes like security screening or noise reduction, while minimizing the need for significant rejuvenation pruning (Watson, 2014). For climbers, it is necessary to evaluate their particular attachment methods, including twining, tendrils, or adhesive aerial roots. These factors directly impact structural load bearing needs and the risk of damaging masonry surfaces (Dujesiefken *et al*., 2005).

Important tree species in integrated landscape management:

Selecting the right trees requires a solid understanding of plant classification and structure. Knowing a tree's family and genus helps arborists forecast its growth, weaknesses to pests and ability to handle urban challenges. For reference, (Table 1).

Table 1 : List of trees used in arboriculture

S.No.	Common name	Scientific name	Family	Key characteristics & landscape use
1	Neem	*Azadirachta indica*	Meliaceae	Hardy, drought tolerant, dense evergreen canopy, medicinal value.
2	Gulmohar	*Delonix regia*	Caesalpiniaceae	Broad umbrella shape, intense orange flowers, fast growing shade tree.
3	Arjun	*Terminalia arjuna*	Combretaceae	Large size, buttressed trunk, excellent for soil stabilization and riverbanks.
4	Kachnar	*Bauhinia variegata*	Leguminosae	Ornamental "orchid like" blooms, medium size, ideal for small parks.
5	Amaltas	*Cassia fistula*	Leguminosae	Golden drooping flowers, drought resistant, used in narrow avenues.
6	Peepal	*Ficus religiosa*	Moraceae	Wide spreading, heart shaped leaves, long lived and ecologically significant.
7	Banyan	*Ficus benghalensis*	Moraceae	Massive spread with aerial roots, requires significant soil volume.
8	Mango	*Mangifera indica*	Anacardiaceae	Dense round canopy, evergreen, provides significant edible fruit yield.
9	Amla	*Phyllanthus emblica*	Phyllanthaceae	Feathery foliage, airy canopy, high nutrient rich fruit production.
10	Silver Oak	*Grevillea robusta*	Proteaceae	Pyramidal tall form, fern like leaves used as a windbreak or vertical focal point.
11	Scholar Tree	*Alstonia scholaris*	Apocynaceae	Distinct whorled branches, fragrant flowers, used for architectural symmetry.
12	Kadamb	*Neolamarckia cadamba*	Rubiaceae	Ball-shaped yellow flowers, broad leaves, fast growing ornamental.
13	Ashok	*Saraca asoca*	Fabaceae	Sacred tree, beautiful orange yellow clusters, used for cultural landscapes.
14	Mahaneem	*Ailanthus excelsa*	Simaroubaceae	Extremely fast growing, hardy in degraded soils, good for urban reforestation.
15	Indian Rosewood	*Dalbergia sissoo*	Leguminosae	Irregular crown, highly valued timber, nitrogen fixing properties.
16	Teak	*Tectona grandis*	Lamiaceae	Large deciduous leaves, very tall, primarily used in larger landscape stands.

17	Jacaranda	*Jacaranda mimosifolia*	Bignoniaceae	Vivid purple blooms, fine textured foliage, high aesthetic value.
18	Indian Tulip	*Thespesia populnea*	Malvaceae	Heart shaped leaves, salt tolerant, excellent for coastal landscaping.
19	Pilkhan	*Ficus virens*	Moraceae	Briefly deciduous, copper colored new leaves, provides dense bird habitat.
20	Silk Floss	*Ceiba speciosa*	Malvaceae	Thorny trunk, large pink flowers, striking specimen for large lawns.

Important shrub species in integrated landscape management

Within an integrated management system, shrubs are a key structural layer in urban vegetation. Choosing species based on their growth form, canopy density and maintenance needs ensures they can provide hedging, screening and soil stabilization without requiring too much care. Below, we detail a variety of representative shrub profiles and their specific roles in the landscape (Table 2).

Table 2 : List of shrubs used in arboriculture:

S. No.	Common name	Scientific name	Family	Key characteristics & landscape use
1	Crepe myrtle	*Lagerstroemia indica*	Lythraceae	Deciduous, sculptural bark, vibrant summer blooms, specimen use.
2	Yellow bells	*Tecoma stans*	Bignoniaceae	Upright growth, golden trumpet flowers, good for informal screening.
3	Hibiscus	*Hibiscus rosa-sinensis*	Malvaceae	Evergreen, wide color range, versatile for hedges or container planting.
4	Jangli Arandi	*Jatropha curcas*	Euphorbiaceae	Hardy and drought resistant, used as a “living fence” for security.
5	Oleander	*Nerium oleander*	Apocynaceae	Extremely tough, salt and pollution tolerant, used in highway medians.
6	Gardenia	*Gardenia jasminoides*	Rubiaceae	Mounding habit, intensely fragrant white flowers, high maintenance specimen.
7	Bougainvillea	*Bougainvillea glabra*	Nyctaginaceae	Thorny scrambling shrub, vibrant colorful bracts, used for security/color.
8	Duranta	*Duranta erecta*	Verbenaceae	Golden berries and purple flowers, commonly used for formal clipped hedges.
9	Ixora	*Ixora coccinea*	Rubiaceae	Compact mounding habit, star shaped flower clusters, ideal for borders.
10	Boxwood	*Buxus sempervirens*	Buxaceae	Slow growing, dense small leaves, the gold standard for formal topiary.
11	Cape Jasmine	*Tabernaemontana divaricata*	Apocynaceae	Waxy white flowers, pinwheel shape, low maintenance landscape filler.
12	Copperleaf	*Acalypha wilkesiana*	Euphorbiaceae	Large colorful foliage, upright habit, used for tropical color contrast.
13	Lantana	*Lantana camara*	Verbenaceae	Spreading habit, multi colored flowers, attracts butterflies, very hardy.
14	Night Jasmine	*Nyctanthes arbor-tristis*	Oleaceae	Small tree/large shrub, flowers bloom at night and fall by morning.

Important climber species in integrated landscape management

Climbers, often called woody vines, play an important role in adding vertical greenery to urban areas where space on the ground is limited. Choosing the right climbers mainly depends on how they attach to supports. This choice affects the type of structure needed, ranging from light trellises and wire frames to sturdy masonry surfaces. In an integrated management plan, it is vital to assess the strength and condition of the supporting structure, whether it’s a building or an old tree. This ensures that it can safely hold the climber’s full weight when it matures (Dujesiefken *et al.*, 2005). The following table lists a selection of climbers chosen for their ornamental value and their various methods of attachment (Table 3).

Table 3 : List of climbers used in arboriculture:

S.No.	Common name	Scientific name	Family	Attachment & landscape use
1	Akas Nim	*Mellingtonia hortensis*	Bignoniaceae	Often managed as a climber/tree, tall vertical fragrance.
2	Money Plant	*Epipremnum aureum*	Araceae	**Aerial Roots:** Ideal for green walls and masonry surfaces.
3	Railway Creeper	*Ipomoea cairica*	Convolvulaceae	**Twining Stems:** Aggressive growth for covering fences quickly.
4	Climbing Rose	*Rosa setigera*	Rosaceae	**Scrambling/Thorns:** Needs tying to a trellis, classic aesthetic.
5	Wisteria	*Wisteria sinensis*	Fabaceae	**Twining:** Heavy woody stems, requires high load bearing structures.
6	Trumpet Vine	*Campsis radicans*	Bignoniaceae	**Aerial Roots/Tendrils:** High-climbing, vigorous hummingbird attractant.
7	Star Jasmine	*Trachelospermum jasminoides*	Apocynaceae	**Twining:** Evergreen with fragrant white blooms, used for screening.
8	Passion Flower	*Passiflora edulis*	Passifloraceae	**Tendrils:** Intricate flowers and edible fruit, needs light wire mesh.
9	Bleeding Heart	*Clerodendrum thomsoniae*	Lamiaceae	**Twining:** Showy red and white flowers, ideal for patio trellises.
10	Garlic Vine	*Mansoa alliacea*	Bignoniaceae	**Tendrils:** Purple clusters, garlic-scented leaves when crushed, hardy.

Installation and establishment best practices

Soil preparation and modification

Urban site preparation must address the physical and chemical limitations that often hinder root development. The use of structural soils, which are engineered mixes of gap graded stone and soil, allows for the compaction needed for load bearing pavements while still keeping interconnected macropores for root growth and oxygen exchange (Watson, 2014). Similarly, suspended pavement systems, like soil cells, provide large amounts of uncompacted soil beneath hardscapes to support mature canopy growth (NBC, 2023). While older methods favored heavily amending backfill with organic matter, recent research suggests using mainly native soil for backfill helps prevent the "bathtub effect," where water accumulates in the hole. It also encourages roots to connect with the surrounding landscape (Watson, 2014; Moss *et al.*, 2019).

Planting techniques

The longevity of a woody plant mainly depends on how well it is installed.

The Root Flare: Recognizing the "trunk flare" or "root flare" which is where the trunk widens at the base, is the most important step. Planting too deep can lead to oxygen deprivation, trunk decay and the growth of stem girdling roots (SGRs) that might eventually strangle the tree (Anon.1 2005). The planting hole should be dug 2 to 3 times the width of the root ball but no deeper than the height of the root ball to avoid settling (Watson, 2014; Urban Forestry Manual). For Balled and Burlapped (B&B) trees, should remove the wire basket and burlap from at least the upper third of the root ball. For container grown shrubs and trees, must "tease out" or slice circling roots to ensure they can expand laterally (Watson, 2014; Urban Forestry Manual).

Establishment care

The establishment period, which is the time needed for the root system to regenerate enough to support the canopy without additional care, is a high risk phase for urban plants. Young trees and shrubs need consistent moisture. The watering schedule should consider site specific soil drainage and weather rather than fixed times. However, a general rule is to provide 2 to 3 gallons of water for every inch of trunk diameter during dry spells (Tree Council, 2005; Watson, 2014). Staking should be a temporary solution and used only if the tree cannot support itself or is in a high wind area. Flexible ties allow for "trunk sway," which helps develop trunk taper (Anon.1 2005). Stakes should generally be removed after one growing season to prevent girdling (Urban Forestry Manual). Pruning at planting should be minimal. Focus only on the "3 Ds" Dead, Damaged, or Diseased branches. Keeping as much leaf area as possible is vital for photosynthesis, which supports the root growth needed for establishment (Dujesiefken *et al.*, 2005; Tree Council, 2005).

Integrated pruning and structural management

Tree management

Structural pruning for young trees, the main goal is to create a strong structure, focusing on maintaining a single dominant leader. This includes identifying and subordinating "codominant" stems to prevent future structural problems (Gilman & Black, 1990).

Mature tree care

Caring for mature trees shifts towards crown cleaning by removing dead or diseased wood, thinning to reduce density for better light and wind penetration and reduction to decrease height or spread while keeping a natural shape (Arborist Standards, 2015; Tree Council, 2005). Alex Shigo developed the Compartmentalization of Decay in Trees (CODIT) model. It explains that trees do not "heal". Instead, they wall off decay using four biological barriers. Pruning cuts should be made just outside the branch bark ridge and collar to respect these natural boundaries. Poorly made "flush cuts" damage these barriers and can lead to significant decay (Fay, 2002; Dujesiefken *et al.,* 2005).

Shrub management

Shrubs need specific techniques to keep their functional and aesthetic roles:

This means cutting the entire shrub back to within inches of the ground to encourage new and vigorous growth, especially for those that have become overgrown. Arborists differentiate between natural form pruning, which thins branches to keep a plant's natural shape and formal hedging, which uses shearing to create geometric forms. It's important that formal hedges are pruned wider at the base than at the top so that sunlight reaches the lower foliage, preventing "bottom thinning" (Gilman & Black, 1990).

Climber Management

Climbers need active training to grow well in vertical systems without harming their hosts or structures

Training systems:

Early intervention is key to directing stems onto trellises or wires. In urban areas, it's important to manage the weight of the biomass. If not pruned, the weight of woody vines can lead to collapses of support structures or pull facades away from buildings (Dujesiefken *et al.,* 2005).

Facade protection:

For self-clinging species with aerial roots, regular pruning away from windows, gutters and roof tiles is necessary to prevent moisture buildup and structural damage (Arborist Standards, 2015).

Integrated Pest Management (IPM) and Plant Health Care (PHC)

Monitoring and Thresholds

Integrated Pest Management (IPM) has changed from a theory into a key practice in arboriculture. It now emphasizes biologically sound strategies instead of reactive "cover sprays" (Nielsen, 1989). Regular monitoring is central to this approach. This involves checking for "key plants" and "key pests" to spot issues before they become critical. A key part of this is figuring out action thresholds. These are the points at which pest damage becomes unacceptable. In landscape management, these thresholds typically depend on "aesthetic injury levels" because the main goal is to maintain the visual and functional quality of the specimen (Nielsen, 1989; Hudler & O'Brien, 2002).

Abiotic stressors (The primary cause)

Soil Compaction and De-icing Salts:

Compaction reduces the space in the soil, limiting oxygen and water access for roots. De-icing salts can also cause toxic sodium buildup and "physiological drought" by changing soil osmotic potential (Tree Council, 2005). Both drought and waterlogging can disrupt transpiration and root respiration. Extended drought makes trees more susceptible to secondary "stress linked" pests such as bark beetles and borers (Hudler & O'Brien, 2002). These often appear as chlorosis (yellowing of leaves). Deficiencies are commonly caused by high soil pH (alkalinity), which makes micronutrients like iron and manganese unavailable. Management includes adjusting soil pH or using chelated nutrient injections (Watson, 2014).

Biotic Stressors

Pests like borers (e.g., Bronze Birch Borer), scales and mites regularly invade urban areas. Fungal and bacterial diseases, such as *Verticillium* wilt or various rusts, need accurate diagnosis to avoid unnecessary chemical treatments (Hudler & O'Brien, 2002). This approach focuses on conserving or releasing beneficial organisms such as ladybugs, lacewings, or parasitic wasps to naturally reduce pest populations. This fits within the "Integrated Plant Management" framework (Nielsen, 1989). When pest thresholds are surpassed, choosing the right delivery method is crucial. Systemic injections (trunk or soil) are becoming more favored in urban settings to prevent chemical drift linked to foliar sprays. This protects bystanders and non target organisms (Nielsen, 1989).

Root Zone Management

Mulching

Mulching mimics the forest floor and is vital for healthy root zones. Best practices recommend using 2 to 3 inches (50 to 75 mm) of mulch for shrubs and up to 4 inches (100 mm) for mature trees. Keep mulch 25 to 75 mm away from the trunk to prevent rot. "Volcano mulching" encourages shallow roots and disease. Proper mulch helps control weeds, retains moisture, regulates soil temperature, and protects trunks from mower damage (Fech, 2014; Niemiera, 2018).

Root collar excavation and girdling roots

Trees suffer when the root flare is buried or constricted. Circling or girdling roots limit water and nutrient flow and weaken stability. For established trees, root collar excavation using air spades may be necessary (Moss *et al.,* 2019; USDA Forest Service, n.d.).

Fertilization and nutrition management

Fertilization should follow a prescription approach based on soil or leaf testing, not regular schedules. Too much fertilizer can harm roots, especially in dry conditions and is often unnecessary at planting. Ornamentals require much less fertilizer than turfgrass and slow release formulations are better to minimize root burn and nutrient loss (Fech, 2014; Niemiera, 2018).

Risk assessment and support systems

Tree Risk Assessment (TRAQ)

Tree risk assessment checks for dangers using the TRAQ framework. It looks at:

- The chance of failure, including structural problems like decay, cracks, or root damage.
- The chance of hitting a target, such as people, property, or infrastructure.
- The consequences of failure, focusing on how serious the damage could be based on the size of the damaged part and the value of the target.

Risk is rated from Low to Extreme:

This system helps managers decide how to act based on safety improvements (Fay, 2006; Koeser *et al.,* 2017; Klein *et al.,* 2019).

Decay Detection Technology

Special tools check for internal defects without harming the tree much:

- Resistance drilling, known as Resistograph, finds decay by measuring the wood's resistance.
- Sonic tomography shows the internal structure by detecting 'sound waves' speed differences. It creates color coded images of solid and decayed wood (Klein *et al.,* 2019).

Supplemental Support Systems

Support systems lower the risk of failure and help trees live longer:

- Cabling and bracing hold weak unions and split stems steady.
- Propping supports heavy, low limbs on mature trees.
- Climber support systems need strong, well-kept anchors to avoid collapse and damage as the vine biomass grows (Fay, 2006; Arborist Standards, 2015).

Future trends and technology in arboriculture

Urban arboriculture is moving from manual surveys to digital monitoring systems. GIS and geo mapping allow for detailed tree inventories with information on species, health and maintenance, using smartphone GPS for real time data collection (Dhawale *et al.,* 2022). LiDAR and remote sensing provide precise 3D measurements of canopy and biomass and help identify conflicts with infrastructure (Datta & Dash, 2024). UAVs equipped with multispectral sensors can detect tree stress early and machine learning from drone images can achieve 94.3% accuracy in identifying species (Ritter, 2018; Mazurek *et al.,* 2025).

Climate change adaptation

Tree selection now prioritizes climate resilient species that are suitable for future conditions from 2050 to 2080 instead of focusing on historical hardiness zones. There is a strong emphasis on drought and heat tolerant species to manage urban heat islands (Datta & Dash, 2024). Increasing species diversity is critical to lower the risks from pests and diseases driven by climate change, such as Hemlock Woolly Adelgid (Hudler & O'Brien, 2002).

Green walls and vertical forests

Vertical forests need careful management that includes automated irrigation and fertigation systems. These systems provide 0.5 to 20 liters of nutrient solution per square meter daily through sensor based control (Singh & Kumar, 2023). Regular pruning and structural assessments of supports are required because of the high biomass and limited root space, which helps prevent structural damage (Dujesiefken *et al.,* 2005; Singh & Kumar, 2023).

Conclusion

In conclusion, the integrated management of landscape trees, shrubs and climbers has evolved into a proactive, science based discipline known as Plant Health Care, which is essential for the survival of green infrastructure in densifying urban environments. By prioritizing structural integrity through biological principles like CODIT and focusing on root health with structural soils and proper mulching, arborists can ensure long term stability and vigor. The synergy between traditional arboricultural skills and modern technologies, such as sonic tomography and UAV based multispectral monitoring, enables data driven decision making that enhances public safety and maximizes ecological services. Ultimately, adhering to international technical standards and implementing Integrated Pest Management (IPM) transforms these plantings from mere aesthetic elements into a vital urban utility capable of providing critical climate resilience and ecosystem benefits for decades to come.

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