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Mulches for Landscapes

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Mulches are materials that are applied to the soil surface, but not tilled, mixed, or combined with underlying soil. Mulches can be composed of anything that is suitable as a soil covering for landscape use. Landscape mulches are typically plant residues (organic mulches) or rock, sand, and stone (inorganic mulches). We do not consider weed-control fabrics, erosion control nets, plastics, artificial turfgrass, or other manufactured surfaces designed for soil stabilization as landscape mulches, as many of these lead to increases in landscape trash and may impede mulch aesthetic or plant benefits.

While stone or rock are sometimes used, organic mulches provide the greatest range of benefits to planted landscapes. Organic mulch applications mimic litterfall, a natural process in forest ecosystems. Litterfall recycles mineral nutrients from fallen organic matter back into the trees, shrubs, and other plants. In highly weathered soils, as found in areas with high rainfall, macronutrients (such as phosphorus, potassium, and calcium) may be deficient, so trees are reliant on litterfall for acquiring their macronutrients (Vitousek 1984). Residence times of forest litter vary from 8 to 15 weeks in a tropical ecosystem and up to 17 to 32 years in various Mediterranean climate forests (Kawadias et al. 2001; Wafar et al. 1994). Gaudinski et al. (2004) make the point that carbon contained in recognizable litter can last for 2 to 5 years but may reside in living plants in the system or as organic residues for anywhere from 40 to nearly 100 years (Gaudinski et al. 2004). Plant litter is a natural mulch and occurs in all forests and even in desert woodland ecosystems. Perennial plants evolved to form litter layers under their canopies and are often reliant on the benefits conferred by decaying organic matter (table 1).

Figure 1. Litterfall is a natural mulch in forest ecosystems.

WHY APPLY MULCHES IN LANDSCAPES?

There are several reasons to apply mulch. Immediately after application, mulches prevent weeds from germinating and reduce evaporative loss from soil surfaces. Over time, mulches provide the following benefits (Robinson 1988; Chalker-Scott 2007):

- increase soil moisture content by modifying soil structure
- increase porosity of soil
- decrease salt build-up in the plant root zone
- add organic matter to soils, thereby increasing their nutrient content
- decrease soilborne diseases
- increase the growth of trees and other woody perennials planted under them

Table 1. Benefits and problems associated with various mulch materials used in landscapes

Mulch material	Benefit	Problem
Barks: pine, red cedar, redwood, etc.	• long lasting, slows breakdown, mitigates soil temperatures, and can prevent compaction • decorative when uniform size • good weed suppression • slows evaporation from soil surface	• slow breakdown does not allow soil microbial activity and other benefits • will not add significant nutrients to soil
Saw dusts or finely ground wood products	• uniform cover easily applied in thin layers • good weed suppression	• can become mixed with soil and immobilize nitrogen • can prevent water movement into soils • may not slow evaporation from soil surface
Shredded wood products, shredded lumber	• provides good mulch qualities • long lasting • breaks down into compounds that will feed the microbial community • provides excellent erosion control	• particles can be very sharp and splintery • if previously used lumber, paint can be toxic or contain lead
Recycled greenwastes	• long lasting • good weed control • adds n, p, k, and micronutrients to soil • provides substrate for soil microbial activity • increases water penetration and infiltration rates • slows evaporation from soil surface • can modify soil texture, increasing soil porosity	• can be a source of pests that are disposed of in the greenwaste recycling stream • may contain significant amounts of trash (plastic, glass, or metal) • may contain poorly ground or undesirable content such as palm wastes, weeds, or grass wastes • variable composition can make spreading difficult; varies with season • may have strong odor • may not be aesthetically pleasing
Fresh tree trimmings	• long lasting • good weed control • adds n, p, k, and micronutrients to soil • provides substrate for soil microbial activity • increases water penetration and infiltration rates • slows evaporation from soil surface • can modify soil texture, increasing soil porosity	• when locally sourced, few problems are observed • requires annual or biannual replenishment
Compost	• high mineral nutrient content • dark color is aesthetically appealing • fine texture is aesthetically pleasing • uniform ease of spreading	• often too fine in texture • will support weed growth • can provide a barrier to water movement into soil • may contain weed seeds • may support weed growth due to fine texture • not a good carbon source for soil microbial activity • can be moved by water or wind, easily making it a pollutant source • may not decrease evaporation from underlying soils • cost is high • may have high enough n-content to burn young or sensitive plants
Stone, rock, or gravel	• can be very aesthetically pleasing • permanent; will not break down; will not require replenishment • slows evaporation of water from soil surface • can prevent weed growth • no chance of rockborne plant diseases	• does not contribute significant amounts of plant mineral nutrients on breakdown • does not provide carbon for microbial activity • does not modify soil texture, microbial activity, or chemistry • may become quite hot, depending on type of rock

Figure 2. Weed germination in plots mulched with and without eucalyptus chips.

The most widely cited reasons for mulching are weed control and moisture conservation (Robinson 1988). There are also several mulch-associated problems. Mulches can exacerbate planting problems, increase root disease, increase frost injury, introduce pests and trash into plantings, and some mulches are costly to apply and maintain at working depths.

BENEFITS OF MULCHING

Many studies of mulched trees measure growth benefits, especially in young trees. Organic mulches often promote tree growth increases (Downer and Faber 2005; Greenly and Rakow 1995; Foshee et al. 1996; Green and Watson 1989). Some evidence suggests that benefits of mulching are not entirely generated by organic substrates. Iles and Dosmann (1999) found that various stone or mineral mulches had the same levels of growth promotion as bark and wood chip mulches; they assert that biological effects of mulches are less significant than temperature and moisture effects conferred by mulches in some settings. Others find inorganic mulches less effective than organic mulches in promoting growth or establishment of trees (Balvinder et al. 1988; Seckler and Tejwani 1983).

Mulching prevents the germination and growth of other plants (weeds) that compete with desirable plantings. Weeds also remove soil water as they grow larger, adding competition to desired plantings. Gilman and Grabosky (2004) found that mulched oaks grew better not because mulch was present but due to a lack of competition from turfgrass—a version of weed control by mulch. Mulches suppress weeds by preventing light from stimulating their germination (Chalker-Scott 2007). Mulch source does not seem to regulate germination; rather, low-nutrient organic mulch in thick layers with a coarse texture are more important factors—at times providing better control than herbicides (Cahill et al. 2005; Froment et al. 2000). Coarse mulches applied at least 4 inches deep control most annual weeds (Faber et al. 2007; Downer 2009). Nutrient-rich, fine-textured composts are not suitable soil covers for weed control because weed seeds will easily germinate when blown onto compost surfaces (Chalker-Scott 2007). As mulch decomposes, its weed suppression activity also disappears.

Mulching increases the nutrient content of underlying soils, and most of the nutrients in plants (including toxic ions) tend to accumulate in soils under organic mulches (Pickering and Shepherd 2000). When soil nutrients are not limiting to plant growth, organic

Figure 3. Fresh tree trimming chips or "arborist chips" are a good source of available carbon for soil microorganisms.

mulches still stimulate growth increases, again suggesting that nutrient additions can be less important to plant growth responses than other possible mulch benefits (Foshee et al. 1999). While Faber et al. (2000) found that nutrients accumulated in soils underlying yard waste-mulched avocado and citrus trees, their tissue nutrient contents were not increased. They associated growth increases with other known mulching phenomena, increased rooting, and root development. Many horticulturists erroneously believe that application of fresh (not composted) mulches of high carbon to nitrogen ratio will deplete nitrogen from underlying soil (Chalker-Scott and Downer 2018). Borland (1988) made the point that this is not supported in the literature. There is still no published evidence of nitrogen draft from mulches. Use of freshly chopped eucalyptus tree branches did not cause any nitrogen loss from soils or symptoms of nutrient deficiency in trees growing under them (Downer 1998; Downer and Hodel 2001; Downer and Faber 2005).

Figure 4. Stone mulches provide benefits, such as weed control and decrease of evaporation from the soil surface, but will not contribute carbon to the soil microbial community because they are not a carbon source.

Mulching with a layer of coarse stone or organic chips reduces evaporative loss from soils, thus preventing moisture loss to the atmosphere (Tejedor et al. 2003). Mulch-conserved soil moisture is especially useful to shallow-rooted trees such as avocado. Mulched trees can often skip every other irrigation compared to nonmulched trees (Downer 1998; Downer and Hodel 2001; Downer and Faber 2005). For moisture savings, mulch must be coarser than the underlying soil. Mulches that are texturally finer than the soil underneath them will conduct water to the surface and can lead to increased moisture loss and drying (Svenson and Witte 1989). Moisture savings by mulches is highest when there is maximum exposure of soil to the sun before complete canopy cover occurs. As soils become shaded, mulch-mediated and moisture-savings effects decrease. However, as mulches modify soils over time and at greater depths, the amount of available water in mulched soils increases, thus further extending irrigation intervals in a given soil type.

Figure 5. Organic mulches support fungal growth, sometimes of mycorrhizal fungi, that can access the nutrients contained in decaying mulch and bring them back to roots growing nearby. As fresh mulches age, they may become colonized with fungi that break down their cellulose. Cordons and mycelium of fungi release enzymes that suppress some root-disease-causing organisms such as Phytophthora.

Mulching has been associated with root rot disease control for many years and was notably documented by Broadbent and Baker (1974) in Australia. They observed that mulched avocado orchards could become suppressive to the avocado root rot organism *Phytophthora cinnamomi*. Later work in California avocado orchards established that cellulase and other enzymes produced by fungi growing in mulches play a role in control of diseases caused by *Phytophthora cinnamomi* (Downer et al. 2001a and 2001b). Freshly chipped mulches of tree branches provide labile carbon to soil microflora and fauna, thereby increasing soil microbial activity. Composts have very little labile carbon and do not produce the same degree of microbial activity increases. Fresh mulches are also a carbon source for many ectomycorrhizal fungi that are symbiotic with trees. Thus fresh, undecomposed organic materials are the most effective mulches for stimulating soil microbial activity and biocontrol of fungi, which in turn promote active soil pathogen suppression.

Mulches provide a place in landscapes to apply trimmings and other organic "waste" products. As landfills reached capacity, legislation was developed to divert green materials from the waste stream. Still, there are costs for picking up, recycling, and reusing green materials (yardwaste). Fuel and labor are necessary to collect and process these materials. A better solution is to process greenwaste at its source and reutilize it as mulch in landscapes. Several advantages of local mulch processing include the following:

- It provides a known mulch source without pests or pathogens.
- Fresh mulch has all its nutrients and carbon for microbial activity.
- On-site greenwaste recycling uses less fuel and contributes less carbon to the atmosphere.

DELETERIOUS EFFECTS OF MULCHING

Mulching can have negative effects on the plants growing under mulching conditions. Mulching does not allow observation of the soil surface, and thus awareness of underlying soil moisture status is reduced. Mulch may interfere with moisture penetration to underlying soil layers. In landscapes with frequent, light irrigations, mulch may be wetted but underlying soils may not obtain enough water for plants growing on these mulched soils. Gilman and Grabosky (2004) found that mulching increased tree stress in lightly irrigated landscape trees. Some mulches absorb considerable amounts of water and thus can prevent irrigation water from reaching the soil (Shaw and Pittenger 2005). These water issues are usually most common when mulches are new, and the irrigations are not properly scheduled. When mulches cover irrigation lines, it may be hard to see damage to them until plants start to show symptoms.

Mulching can accentuate the ill effects of improper planting. Arnold and others (2007) showed that green ash planted with its root collars below grade were less likely to survive when mulched than when unmulched. Trees are long-lived, and the effects of mulching can be short-term, especially if mulch layers are not maintained as they decompose. It usually takes years for long-term soil benefits to result from mulching, and benefits may not be seen if mulch layers are not consistently replenished (Downer 2009).

Figure 6. This oak has been planted too deeply, and mulch is placed in a thick layer near its stem. This can predispose the tree to root collar disease.

Mulches change the way that radiation is absorbed and then reradiated around trees, having potential positive or negative effects on trees and other plants growing around them. Mulched trees are generally cooler and have cooler stem temperatures (Downer and Faber 2005). Organic mulches better insulate landscape soils from intense solar radiation than decomposed granite or rock, which tend to transfer heat to soil (Singer and Martin 2008). The insulation properties of organic mulches help plants resist intense soil heating in arid climates; however, these same properties reduce night-time radiation from soil and tend to cool orchards at night, increasing the number of nights that trees are exposed to freezing temperatures during winter months. The slow release of nutrients by microbial decomposition may also keep plants growing longer into winter and predispose them to more frost damage.

Some authors claim mulches made from eucalyptus, walnut, and acacia are allelopathic. This is incorrect, since allelopathy is the interference of growth, germination, or reproduction of one living plant by another. Once plants are chopped and made into mulch, some allelochemicals may remain, but these are rapidly leached and broken down. Still, growth retardation, especially of seedlings, has been documented with eucalyptus, pine, and acacia (Schuman et al. 1995). Studies using fresh, coarse eucalyptus chips only showed growth benefits to young sycamore and avocado trees (Downer and Faber 2005; Downer 1998).

Mulching is an obvious way to spread pests and pathogens. The main concern is that diseased trees or parts of them when chipped and immediately applied may transfer disease pathogens or pests to soils or trees elsewhere. *Verticillium dahlieae* was found to survive several weeks outside in wood chips (Foreman et al. 2002). The canker fungus *Thyronectria austroamericana* from an infected host remained viable outside in mulch for over 2 years (Koski and Jacobi 2004).

Survival of pests and pathogens in chips or mulch does not imply that the infection or infestation process will continue or start new diseases, only that some pathogens can remain viable for a time. Jacobs (2005) showed that mulch infested with *Sphaeropteris sapinea* caused blight in Austrian pine, yet mulches with *Armillaria gallica* and *Botrysphaeria ribis* failed to initiate disease from their presence in mulch (Jacobs 2005). When mulches are composted before use, it is generally accepted that most pests are destroyed. However, pathogens, weeds, and insect pests can escape in yardwaste processing systems used by municipalities, and they can survive the holding process in stockpiles (Daugovish et al. 2007; Crohn et al. 2007; Downer et al. 2008). Yellow nutsedge was one of the most persistent weeds, surviving up to 8 weeks in stockpiles that reached composting temperatures, and the fungal pathogen *Sclerotinia sclerotiorum* survived for a similar duration. Weed seeds (common Malva or cheeseweed) can also persist for weeks in stockpiles and survive limited composting.

Figure 7. Bags containing pests are covered in yardwaste to make a "static" pile (Downer et al. 2008).

While mulches are not usually sources of inoculum, they can change growing conditions around perennial plants, sometimes making them more susceptible to resident pathogens. Mulch decreases evaporative loss from soil, so soils can remain wet longer, predisposing some plants to root rot pathogens such as *Armillaria* and *Phytophthora* spp. Monitoring irrigation and adjusting irrigation schedules for the presence of mulch will lessen these predispositions. Freshly chipped, healthy branches will stimulate the growth and development of fungal hyperparasites, which can compete with or destroy pathogenic fungi residing in dead or cankered branches. In wet weather, it may be necessary to move mulch away from perennials so that soil can dry, reducing conditions for root rots.

Recent invasions of wood-boring beetles such as *Euwallacea* (invasive shot hole borers), *Phoracantha* (eucalyptus Longhorned borer), *Ips* (various pine borers), and *Agrilus auroguttaus* (goldspotted oak borer) raise concerns that invasive insect pests can be spread in greenwaste or firewood that will be processed into mulch products. Paine and Eatough-Jones (2015) found that chipping infested branches to a bit less than 2 inches in length controlled 98 percent of invasive shot hole beetle emergence.

Infested wood products that are chipped before shipping or on-site before mulching pose less threat of pest spread than logs of green materials that are moved intact.

Mulches are a useful horticultural tool; their best use is by informed and observant arborists, landscapers, and gardeners that can monitor their plants, understand soil moisture relations, and are alert to the development of diseases and other pests. If used in an informed way, mulches can save water; add aesthetic benefits to plantings; improve soil qualities; retard diseases, weeds, and other pests; and reduce fertilizer requirements while stimulating growth of landscape plants.

Figure 8. Even small mulch rings around young trees will provide benefits to their growth and establishment.

MULCH APPLICATION RECOMMENDATIONS

To derive the most benefits from landscape mulches, follow these guidelines:

- Apply mulches as freshly chipped products containing wood and leaves for maximum benefits.
- Use coarse mulch with greater than 1-inch-size particles.
- Use landscape trimmings, especially tree trimmings, from on-site plantings.
- Apply up to 6 to 12 inches of fresh mulch for maximum weed suppression and other mulch-related benefits.
- Keep mulch away from tree stems to avoid predisposing them to collar rots.
- Do not apply composts as mulch.
- Monitor soil moisture under mulches to apply the appropriate amount of irrigation.
- When mulching, reduce or eliminate applied fertilizers.
- When mulching on slopes, use a shredded product that will adhere to the surface well; avoid barks and fine-textured products.
- Avoid applying mulches in narrow median strips, where they are easily moved off-site.

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