

**WOODY MULCH RESEARCH REVIEW, PROFESSIONAL USERS AND PRODUCT AVAILABILITY SURVEYS**

**Project Goals**

Seattle Public Utilities contracted with Stenn Design to conduct a scientific literature review and a survey of selected local landscape professionals and mulch suppliers to determine the availability, horticultural value and recommended application rates of woody landscape mulch materials. The primary objective was to help develop informed recommendations for use of woody mulches—particularly commercially available alternatives to chipped tree trimming debris supplied by commercial arborists, which is inconvenient or unappealing for many customers’ uses. An additional purpose was to explore the validity of concerns about disease spread and nutrient tie-up resulting from use of arborist chips.

**Contents**

**I. Literature Review and Survey Topics and Sources .....2**  
**II. Summary of Findings .....4**  
**III. Recommended Mulch Product Specification and Application Rates. ....7**  
**IV. Bibliography & References .....8**  
**V. Landscape Professionals and Researchers Surveyed ..... 12**  
**VI. Mulch Suppliers Surveyed ..... 13**  
**VII. Tabular Summary of Woody Mulchers Research Survey Responses..... 14**  
**VIII. 2005 Seattle Area Woody Mulch Source Survey ..... 16**

**I. Literature Review and Survey Topics and Sources**

The chart below summarizes the primary questions posed and sources searched in the literature review and surveys. A bibliography and list of survey participants is included at the report end.

The literature review focused on published scientific studies, and in a few cases unpublished material such as Masters Theses from reliable sources, that provide sound data to support realistic analysis. Extension Bulletins and articles in popular garden publications or landscape trade magazines lacking research citations were reviewed but ignored in the final analysis. Exceptions were made for articles by reliable researchers (notably, compost researcher Harry Hoitink of Ohio State University), and are noted in the text as assertions or observations unsupported by specific cited research.

The professionals surveyed were selected based on a reputation for experimentation with sustainable practices and application of scientific principles in their management decisions. Their opinions are identified as such, with specific examples noted if provided.

| <b>Literature Review Questions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Sources</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1. Is there documentation of benefits or harm associated with use of various woody mulches <u>in landscapes</u>, including: Improved or inhibited plant growth, reduced water use; increased or reduced incidence of disease, rot, pests or weeds?</li> <li>2. How important is the issue of fine bark and other mulches forming impermeable, water-shedding barrier? Is it a textural issue or material specific?</li> <li>3. What would be an appropriate specification for woody mulch products to be included in Natural Lawn and Garden promotions?</li> </ol> | <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Scientific articles identified through searches of Agricola, Google and Google Scholar, Tree-CD, Searchlight, and references cited in the articles.</li> <li><input checked="" type="checkbox"/> Extension bulletins, utility and commercial websites identified through Google searches.</li> <li><input checked="" type="checkbox"/> Review of (2004 update of) Dr. Craig Cogger’s Organic Amendment Literature Review conducted for Snohomish County Soil Amendment Project</li> <li><input checked="" type="checkbox"/> Reexamination of mulch benefits literature review conducted by Stenn Design for Seattle Public Utility Conservation Potential Assessment (2004).</li> <li><input checked="" type="checkbox"/> Phone and e-mailed queries of extension researchers, private soil scientists (labs) and others.</li> <li><input checked="" type="checkbox"/> <b><i>Publications cited are listed in the Bibliography and References section at the conclusion of this report.</i></b></li> </ul> |
| <b>Professional Users and Researchers Survey Questions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Survey Method and Participation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ol style="list-style-type: none"> <li>1. Do you know of documented benefits or harm associated with use of various woody mulches <u>in landscapes</u>, including: Improved or inhibited plant growth, reduced water use; increased or reduced incidence of disease, rot, pests or weeds?</li> <li>2. What woody mulches do you have experience with? At what rates?</li> <li>3. What benefits or problems have you</li> </ol>                                                                                                                                                                             | <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> E-mailed survey and phone interviews of 20 (of 31 queried) select landscape professional and field researchers.</li> <li><input checked="" type="checkbox"/> <b><i>A complete list of survey participants and respondents is included in the Bibliography and References section at the conclusion of this report.</i></b></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

|                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>observed from mulching: Improved or inhibited plant growth, reduced water use; increased or reduced incidence of disease, rot, pests or weeds?</p> <p>4. How important is the issue of fine bark and other mulches forming impermeable, water-shedding barrier? Is it a textural issue or material specific?</p> <p>5. What are the practical life spans of these products and their benefits?</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Survey of Landscape Material Suppliers</b>                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p>1. What woody mulches (including composted bark or sawdust) do you carry?</p> <p>2. Do you have specifications or performance information on these products?</p> <p>3. Can you recommend any professionals who can tell us about experience with these products?</p>                                                                                                                               | <p><input checked="" type="checkbox"/> Phone Survey of Bulk Suppliers.</p> <p><input checked="" type="checkbox"/> Phone Survey of Bagged Product Suppliers.</p> <p><input checked="" type="checkbox"/> <i>A complete list of suppliers surveyed is included in the Bibliography and References section at the conclusion of this report, and complete information is provided on the Product Availability Spreadsheet.</i></p> |

## II. Summary of Findings

There is a large body of research and local practical experience supporting the benefits of using woody mulches on landscape plantings. Benefits of mulching including weed suppression, soil moisture retention and improved soil structure are widely reported in both professional experience and scientific literature and. (Friedrich and Ham, 1982. Green and Watson 1989. Greenly and Rakow, Hart, 2002. ). However there is both contradictory and incomplete scientific evidence, and conflicting practical experience regarding some critical questions related to use of specific mulches, including: The concerns of nitrogen immobilization from use of fresh woody materials, growth inhibition related to acidifying or allelopathic effects of bark mulches, and the transmission of pathogens through chipped prunings from diseased plants.

Many of the contradictions may be explained by variability in the composition of arborist chips and to a lesser extent ground bark, and by differences in application rates or between common “real world” conditions versus experimental conditions. The paragraphs below attempt to summarize the best available research and experience, and explain commonly observed phenomena, such as bark mulch forming dense crusted layers that inhibit water penetration and plant growth, which are not corroborated by research

- ✓ **There is no evidence that use of fir, hemlock or pine barks inhibit growth of woody landscape plants due to an allelopathic effect or soil acidification.** The most relevant study, conducted at WSU’s Puyallup Research Station (ongoing since 2001) showed no significant difference in growth or appearance of a variety of native and ornamental plants grown with a 3” fir bark mulch and those grown in unmulched soil (with the exception of minor inhibition of one species, *Cornus sericea*, which recovered in subsequent years). When combined with compost amendment incorporated or surface applied, a 3” bark mulch improved the growth of most plants compared to unmulched compost applications. (Hart, 2002).

Other studies have found conifer bark mulches to improve woody plant growth compared to controls (Pickering and Shepherd, 2000. Greenly and Rakow, 1995). Another study using bark mulch showed that it decreased first year growth compared to a control and other treatments, but was beneficial by the third year of a five year trial (Samjyn and De Vos, 2002) However, research with strawberries showed that bark mulch depleted soil and leaf nitrogen levels, and reduced yield. (Sonstebly, 2004).

**Conifer bark inhibition of plant growth associated with crusting, reported by many landscape professionals, may be due to over-application and/or use of material containing a high proportion of fine particles.** See discussion below.

**Bark from logs transported in salt water could be the cause of some plant growth inhibition and surface crusting associated with bark mulches.** However there is no documentation of how common saltwater bark is, or how often these problems are linked to it.

**There is conflicting evidence of soil acidification related to pine bark or needle mulches.** A number of studies find no soil acidification under pine bark or shredded pine needle mulches (Pickering and Shepherd, 2000. Greenly and Rakow, 1995). Pickering and

Shepherd found that pH of a variety of woody mulches did not affect the soil pH beneath them after one year. In one study where pine bark and needles acidified soil, other mulches from Cypress, Eucalyptus, Melaleuca and Oak bark also acidified the soil (to a lesser degree); suggesting that it may have been a temporary stage of decomposition. This is supported by one study that showed that pine bark and pine wood-chip mulches raised soil pH compared to an untreated control two years after application. (Iles and Dossman, 1999).

- ✓ **Surface crusting of mulches and related water-shedding conditions appears to be related to use of material with excessive fine particles, though fungal growth may cause matting and water shedding even in coarser mulches.** Several professional users (8 of 11 responding to this question) report this problem with fresh (uncomposted) fine bark and composted sawdust products. However, WSDOT practitioners and WSU researchers dispute that it is inherent problem to bark, based on their experiences. Both WSU and WSDOT use a material specified to include no more than 55% passing through a ¼ inch screen. This conclusion is supported by reports of similar crusting/hydrophobia in screened compost and composted sawdust products by all professionals reporting experience using them as mulches. In-Harmony Landscaping reports successful use of fresh bark, though encounters problems where excessive or repeated applications have been made in the past.

**Fungal matting may cause surface crusting and water shedding in woody mulches.** Hoitink and Krause (1998) suggest that fresh, undecomposed woody mulches applied deeper than 4 inches heat up due to microbial activity, dry out, and become colonized by fungi that create a water repelling mat. One professional user surveyed reported fungal matting in deep applications of fine bark mulches. A compost supplier reported numerous customer reports of such mats forming in both bark and composted wood chip mulches; which the supplier associated with over-irrigation (Gage). The author of this review has observed similar conditions in aging piles of arborist chips and in thick bark mulch applications.

- ✓ **Nitrogen immobilization by fresh wood chip appears to be a real problem in some situations.** While some studies have shown no growth inhibition or nitrogen immobilization from use of wood chip (Greenly and Rakow, 1995—pine chip and hardwood chip; Pickering and Shepherd, 2000—conifer bark and wood chips), a multi-year study of mulching with fresh wood chip from ground-up shipping pallets documented soil-nitrogen immobilization, and inhibition of growth and flowering of rhododendrons and river birches compared to an unmulched control and plots mulched with yard debris compost (Lloyd, Herms, Stinner and Hoitink, 2003). Nitrogen immobilization was documented at the soil surface and at 6 inch depth, which the authors attribute to nutrient scavenging by fungal hyphae, nutrient movement in soil water, and soil fauna cultivation. The mulch was removed and replaced with fresh wood chip annually, preventing breakdown and beneficial nitrogen release from the wood that would naturally occur in aging mulch. (Hoitink and Krause, 1998, suggest that removing particles smaller than 3/8 inch through screening prevents nitrogen immobilization problems).

Although nine of eleven professionals surveyed responding to this question reported no problems with using fresh arborist chips, two reported consistent problems. A Seattle Parks professional reports that fresh chips inhibit growth of herbaceous perennials, annuals and some non-native woody plants—particularly small specimens. A Certified Arborist reported

observing temporary growth inhibition in woody plants after application of arborist chips, particularly if applied too thick (recommends 2 to 4 inch application).

**Nitrogen immobilization has been documented with sawdust mulches on blueberries** (Strik, Penhallegon, DeFrancesco, and Mann. 1995), **and also with bark mulches on strawberries** (Sønsteby, 2004).

- ✓ **Disease transmission by arborist chips from diseased plants is not documented.** (Such direct infection would be very difficult to prove in a field setting, and probably not an accurate reflection of “real-life” if proven in a laboratory setting.). **However use of fine-textured mulches or over-application of arborist chips may exacerbate wet conditions that weaken plants and encourage infection by a pathogen that is already present.** All survey participants support the view that proper use of arborist chip (moderate rates, away from plant crowns) promotes healthy plants and soil life, and reduces summer moisture stress that weakens plants and makes them susceptible to disease. However two Certified Arborists surveyed and a plant laboratory diagnostician (Ribeiro, personal communication) report repeated observation of *Phytophthora* associated with wet conditions made worse by fine mulches. One arborist reports seeing many cases of disease where chips are applied too thick or piled against woody plant trunks (Cohen).

Hoitink and Krause (1998) assert that *Verticillium dahliae* can be transmitted to woody ornamentals, and that *Rhizoctonia solani* is stimulated by fresh mulches and may afflict herbaceous plants. Aside from plant pathogens, they also attribute a number of fungal problems to hardwood mulches, including growth of unattractive slime molds, shotgun fungi (*Sphaerobolus*) which can stain wood, and proliferation of mushrooms which may be considered ornamental except for species that are toxic to pets or people. They recommend supplying adequate nitrogen and water at time of mulch application to speed bacterial colonization and inhibit fungal growth. Conifer barks are apparently too ligninaceous to have these problems.

- ✓ **The practical life spans of these products and their benefits vary depending on** mulch composition (tree species, and percentage of bark and green material) particle size and application rate; site moisture levels, irrigation practices, sun exposure, soil fertility or fertilization. Based on survey responses, at the application rates recommended above ground bark mulch should be reapplied every 2 to 4 years, and wood chip mulch every 1 to 2 years.

### III. Recommended Mulch Product Specification and Application Rates.

- ✓ **Caution should be exercised in applying fresh arborist chip or other wood chip products around newly planted ornamental plants.** Aging for at least one month with adequate moisture is recommended in all cases by Hoitink and Krause, though local experience suggests that it is not necessary for mulching most established plants.
- ✓ **Recommended wood chip mulch depths around ornamental landscape plantings should be limited to 2 to 4 inches of arborist chips or ground wood waste. Screened materials with smaller, more uniform particle size should be limited to 2 to 3 inch depths.** These application rates are based on the most common recommendations of survey respondents, with consideration given to conclusions from the scientific literature. Hoitink and Krause claim without citing specific research that 1-2" deep mulches of fresh wood chip or compost promote establishment of beneficial mycorrhizal fungi in reforestation, but 4-6 inch deep mulches of the same material inhibits the development of beneficial myccorhizae. Greenly and Rakow found 7.5 cm. deep mulch of ground woody materials produced better growth than 15 or 25 cm. depths of the same mulch materials.
- ✓ **Recommended wood chip mulch depths around restoration plantings (native species, limited or no irrigation) are 6 to 10 inches of arborist chips or ground wood waste. Ground bark should not be applied at these rates, as it is likely to inhibit plant growth.** The WDOT specification tested at WSU-Puyallup (planting into a mulch of 3 inches of unincorporated compost topped by 3 inches of bark) is an alternative recommendation that produces good results in what are essentially restoration conditions.
- ✓ **Bark mulch and hardwood chips should contain limited fine particles to prevent hydrophobic crusting, and also to prevent nitrogen immobilization in non-bark woody material.** WDOT specifies bark that contains less than 55% material passing through a ¼ inch screen. The origin of this specification is an erosion control material specification developed for the US Composting Council, though the justification for this percentage is unclear. As the attached Woody Mulch Availability spreadsheet shows, a number of "Medium" grade bark products available both in bags and bulk likely meet this criteria, though no manufacturers were able to provide sieve analyses of products. Cedar Grove Compost reports that its 1-inch compost currently does not meet the WDOT mulch specification (though this may be a misinterpretation of the specification). Rainier Wood Recycling's Medium Chip and Medium Red Chip do meet the specification.
- ✓ **Application frequency should be based on observation of decomposition of old mulch layers, with a goal of not having more than 3 inches of undecomposed fine bark or woody material or 4 inches of undecomposed coarse chip.**

#### IV. Bibliography & References

\* *Indicates sources reviewed only in abstracted or summarized form. Other articles were reviewed in primary form.*

Abu-Awwad, A.M., Effect of mulch and irrigation water amounts on soil evaporation transpiration. *Journal of agronomy and crop science*. July 1998. v. 181 (1) p. 55-59.

Allen, R, L. S. Pereira, D. Raes, M. Smith. *FAO Crop Evapotranspiration - guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Food and Agriculture Organization of the United Nations. Rome, 1998

Appleton, B.L., J.F Derr, B.B. Ross. The effect of various landscape weed control measures on soil moisture and temperature, and tree root growth. *Journal of arboriculture*. Oct 1990. v. 16 (10) Pages 264-268.

\*Ashworth, S. and H. Harrison. 1983. Evaluation of mulches for use in the home garden. *HortScience* 18(2):180-182.

\*Billeaud, L.A. and J.M. Zajicek. 1989. Influence of mulches on weed control, soil pH, soil nitrogen content, and growth of *Ligustrum japonicum*. *J. Environ. Hort.* 7(4):155-157.

\* Borland, J. and G. Weinstein,. *Mulch: is it always beneficial?* *Grounds maintenance*. Feb 1989. v. 24 (2) p. 10-12, 14, 120-121.

Cogger, Craig. *Soil amendment literature review: detailed summations and citations of literature reviewed*. In, *Snohomish County Soil Amendment Project: Final Report. 2002*. Howard Stenn, editor.

Craul, P.J. 1999. *Urban soils: Applications and practices*. John Wiley and Sons, New York.

\*Davies, Jeffrey W., *Mulching effects on plant climate and yield*. World Meteorological Organization, 1975. ; no. 388 WMO (Series) no. 388v, 92 p.

Day, S. *Fresh wood chips as mulch*. *Virginia gardener newsletter* / July 1994. v. 13 (7). p. 1.

Duryea, M.L., J. English, A. Hermansen. 1999. A comparison of landscape mulches: Chemical, allelopathic and decomposition properties. *Journal arboriculture* 25(2): 88-

Foshee, W.G. W.D. Goff, M.G. Patterson, K.M. Tilt. Organic mulches affect on soil and leaf nutrient levels of young pecan trees. March 1999. *Journal of Arboriculture* 25(2).

Fraedrich, S.W. and D.M. Ham. 1982. Wood chip mulching around maples: Effect on tree growth and soil characteristics. *Journal of Arboriculture*. 8:85-89.

\*Gleason, M.L. and J.K Iles. 1998. Mulch matters. *Amer. Nurseryman* 182(4):24-31.

Gouin, F.R. 1992. Mulch mania. *American nurseryman*. 176(7):97-99.

- Green, T.L. and G.W. Watson. 1989. Effects of turfgrass and mulch on establishment and growth of bareroot sugar maples. *Journal Arboriculture*. 15(11):268-272.
- \*Greenly, K. and D Rakow,. 1995. The effects of mulch type and depth on weed and tree growth. *Journal Arboriculture* 21(5) 225-232
- Hart, Jennifer Lynn. 2002. Yard Debris Compost and Douglas Fir Bark Mulch Effects on the Establishment, Growth and Quality of Plants in the Landscape. Thesis (M.S.)—WSU.
- Hillel, D. Environmental soil physics. 1998. Academic Press, San Diego.
- Hoitink, H, Krause and Zondag. 1999. Soil Amendments and Mulch on Tree Health and Management, Ohio St. U. Extension Research Circular 173-00.
- Hoitink, H. and M.S. Krause. Control of Nuisance and Detrimental Molds (Fungi) in Mulches and Composts. Ohio State Univ. Ornamental Plants -- Annual Reports and Research Reviews 1998. Special Circular 165-99.
- \*Hundt, V. When a tree falls: the benefits of creating shredded wood mulch. *Arbor age*. 2004 Sept., v. 24, no. 9. p. 26-27.
- Iles J.K. and Dossmann M. S. 1999. Effect of Organic and Mineral Mulches on Soil Properties and Growth of Fairview Flame® Red Maple Trees. Iowa Turfgrass Research Report.
- Ji, S. 2001. Soil water accumulation under different precipitation, potential evaporation, and straw mulch conditions. *Soil Science Society of America Journal*. 65(2):442-448.
- \*Kettler, J.S. A pot study investigating the relationship between tree mulch decomposition and nutrient element availability. *Communications in soil science and plant analysis*. 1997. 28(15/16):1269-1284.
- Khaleel, R., K.R. Reddy, and M.R. Overcash. 1981. Changes in soil physical properties due to organic waste applications: A review. *J. Environ. Quality*. 10:133-141.
- Koski, R. and Jacobi. 1997. W.R. Tree pathogen survival in chipped wood mulch. *Journal of arboriculture*. May, 30, 2004. (3):165-171.
- \*Larson, L. and A. Bath. 1996. Evaluation of soil temperature moderating and moisture conserving effects of various mulches during a growing season. *Acta-Agriculturae..* 46(3): 153-160.
- \*Liskey, E. Research update: if some mulch is good, is more better? *Grounds maintenance*. Apr 1998. 33 (4):1.
- Lloyd, John E.; Herms, Daniel A.; Stinner Benjamin R.; Hoitink, Harry A.J. 2003. Organic Mulches Enhance Overall Plant Growth. *Turfgrass Trends Magazine* 08-11-03.

- \*Mirabello, Robert Allan. 1997. Nutrient availability in mulched landscape plantings. Thesis (M.S.)--University of Arkansas, Fayetteville, 1997.
- Neilsen, G.H. 2003. Surface application of mulches and biosolids affect orchard soil properties After 7 Years. *Canadian Journal of Soil Science*. 83(1):131-137.
- Niggli, U., F.P. Weibel, and W. Gut. 1990. Weed control with organic mulch materials in orchards. Results from 8 year field experiments. *Acta Horticulturae* 285:97-103.
- Olkowski, W., W Klitz, and D Miller. 1981. Mulching for Weed Control .
- \*Pickering, J.S. The suitability of composted green waste as an organic mulch: effects on soil moisture retention and surface temperature. *Acta Horticulturae*. 1998. (469):319-324.
- Pickering, J.S. and A. Shepherd. 2000. Evaluation of organic landscape mulches: composition and nutrient release characteristics. *Arboricultural Journal*. 2000. 23(2-3):175-187.
- Pinamonti, F. 1998. Compost mulch effects on soil fertility, nutritional status and performance of grapevine. *Nutrient Cycling in Agroecosystems*. 51:239
- \*Posey, May. 1954. Some effects of sawdust mulching of pine seedlings. Auburn, Ala. : Agricultural Experiment Station of the Alabama Polytechnic Institute, 1954. 4 p. : ill. ; 23 cm.
- \*Powell, Bilderbank and Skroch. 1989. Landscape Mulch Evaluation. *Proc. SNA Conf*. 32:345-47.
- \*Samyn J.; De Vos B. The assessment of mulch sheets to inhibit competitive vegetation in tree plantations in urban and natural environment. Urban Forestry & Urban Greening, August 2002, vol.
- Serra-Wittling, C. Modification of soil water retention and biological properties by municipal solid waste compost. *Compost Science & Utilization*. Winter 1996. 4(1):44-52.
- \*Skroch, W.A. Mulches: Durability, aesthetic value, weed control, and temperature. *Journal of Environmental Horticulture*. Mar 1992. v. 10 (1) Pages 43-45.
- \*Sønsteby; Nes; Måge. 2004. Effects of bark mulch and npk fertilizer on yield, leaf nutrient status and soil mineral nitrogen during three years of strawberry production. *Acta Agriculturae Scandinavica*, January 2004, 54(3): 128-134.
- Strik, B., R. Penhallegon, J. DeFrancesco, and J. Mann. 1995. Alternatives to sawdust mulch in blueberries. Oregon State University, North Willamette Research & Extension Center.
- Sweeten, J.M. Improving soils with livestock manure. *Journal of soil and water conservation*. Mar/Apr 1985. 40(2):206-210.
- USDA-NRCS. Soil quality resource concerns: available water capacity. Soil quality information sheet. January, 1998.

- Watson, G. and A. Tyznik. The benefits and beauty of mulch. Morton Arbor Quarterly. Summer 1993. v. 29 (2) p. 17-23.
- Watson, G.W. 1988. Organic mulch and grass competition influence tree root development. Journal of Arboriculture. 14:200-203.
- \*Watson, G.W. and G. Kupkowski. 1991. Effects of a deep layer of mulch on the soil environment and tree root growth. Journal of Arboriculture. 17(9):242-245.
- Wilkinson, K., S. Tymms, V. Hood, E. Tee: I. Porter. 1995. Green organics: risks, best practice and use in horticulture A report on the green organics research program, [ecorecycle.vic.gov.au](http://ecorecycle.vic.gov.au)

## V. Landscape Professionals and Researchers Surveyed

- = survey respondents.  
 = survey recipients who did not complete survey.

### **Practical Use Survey**

- Linda Chalker-Scott, WSU-Extension
- Craig Cogger, WSU-Extension
- Dan Sullivan, OSU-Extension
- Mark Maurer and Sandy Salisbury, WSDOT
- Mark Gile, In-Harmony Landscape
- Linelle Russ, Lake Washington VoTech.
- Phil Renfro, Seattle Parks
- Barbara Selemo, CUH
- David Zuckerman, Wash. Park Arboretum
- Becky Fenske, Supreme Landscape
- James Barbarinos, Certified Arborist
- Tina Cohen, Certified Arborist
- Kern Ewing, UW
- Jeff Gage, Compost Design Consultant
- Barb Decarro, Seattle Parks
- Robert Edmonds, University of Washington
- Rita Hummel, WSU-Extension
- Alexandra Stone, OSU-NSRC
- Darcy Peebles, Western Agricultural Lab
- EJ Hooks, Seattle Parks
- Dirk Muntean, Soil and Plant Lab
- Su Nicol, Center for Urban Horticulture
- Alan Burke, Classic Nursery and Landscape
- Joel Miller, Olympia Metro-Parks
- Hendrikus Schraven, Soil Dynamics
- Van Bobbitt, South Seattle Comm. College
- Bill Peregrine, Malone's Landscaping

### **Research / Technical Questions**

- Olaf Ribiero, Ribiero Plant Lab
- Linda Chalker-Scott, WSU-Extension
- Craig Cogger, WSU-Extension
- Ron Alexander, Alexander Associates
- Anna Thurston, City of Tacoma
- Cass Turnbull, Plant Amnesty
- Kern Ewing, UW

## VI. Mulch Suppliers Surveyed

**Bulk Suppliers Surveyed.** *Contact information included in product availability spreadsheet.*

- Sawdust Supply
- Cedar Grove
- Pacific Topsoil
- Sayers Fuel
- Sky Nursery
- E-green Landscaping & Materials

**Bagged Product Suppliers Surveyed.** *Contact information included in product availability spreadsheet*

- Home Depot
- Lowe's
- Fred Meyers
- Swanson's Nursery
- City People's Garden Center
- West Seattle Nursery
- Sky Nursery
- Molbak's Nursery
- Mountain West, LLC (wholesale supplier)
- Whitney Farms (wholesale supplier)
- Waupaca Materials (wholesale supplier)

**VII. Tabular Summary of Woody Mulchers Research Survey Responses**

|                                      | Mulch: <u>BARK</u>                                                                                                                                                                                                    | Mulch: <u>ARBORIST<br/>CHIP</u>                                                                                                                                                                                                    | Mulch: <u>SAWDUST<br/>or COMPOST</u>                                                                                                   |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Plant growth benefits or inhibition? | <b>2 Positive:</b> CC, WSDOT:<br><b>4 Negative:</b> LWVT, BDc, InH, BF<br><b>2 Positive with limitations:</b> LC-S, PR “natives only”                                                                                 | <b>7 Positive:</b> LCS, BS, DOT, LWVT, BDc, DZ, KE, JB<br><b>4 Positive with limitations:</b> LC-S, OR, PR “Only for large, woody plants, after composting”. TC (“Inhibits in short term—depth important”).<br><b>0 Negative:</b>  | <b>2 Positive:</b> Compost, unless too deep (TC)<br><b>Negative:</b><br><b>2 Positive with limitations</b> LC-S, InH (composted bark). |
| Water conservation?                  | <b>3 Positive:</b> CC, DOT, PR<br><b>2 Negative:</b> LWVT, JG<br><b>2 Positive with limitations:</b> LC-S, BDc                                                                                                        | <b>10 Positive:</b> LCS, BS, TC, KE, DOT, PR, LWVT, BDc, DZ, JB<br><b>0 Negative:</b>                                                                                                                                              | <b>2 Positive:</b> TC, KE,<br><b>Positive with limitations:</b> LC-S                                                                   |
| Surface crusting?                    | <b>8 Yes:</b> LCS, TC, BF, PR (fines-full sun), JG (fine bark or compost that is kept too wet gets fungal mats), LWVT, BDc, InH-thinks related to repeated layering.<br><b>2 Positive with limitations:</b> CC, WDOT, | Yes:<br>No: LCS, BS, DOT, TC, PR (“not typically”), BDc, LWVT,                                                                                                                                                                     | <b>5 Yes:</b> LCS, TC, DZ, JB, OR<br><b>1 No:</b> BF                                                                                   |
| Disease, pests or weed occurrence?   | <b>2 Benefits:</b> Weed control (DOT CC)<br><b>3 Problems:</b> Horsetail (LCS), weeds and moisture-related diseases if too fine (PR), weakens plants, increases disease (LWVT),                                       | <b>4 Benefits:</b> KE, BS, LCS, LWVT. Extend season, improve soil structure, suppress weed germination.<br><b>3 Problems:</b> Weeds over time (BS, DOT). Disease problem if used too deeply (TC), Weeds—disease hard to prove (PR) | <b>1 Benefits:</b> Weed control(LCS)<br><b>3 Problems:</b> TC, OR, JB. Promote fungal rots.                                            |
| Other benefits or problems?          | <b>2 Problems:</b> LCS, LWVT. Salt                                                                                                                                                                                    | <b>2 Problems:</b> BS “Birds strew about”, PR “best if composted, variable”                                                                                                                                                        |                                                                                                                                        |
| What is the                          | 4+ yrs (CC), 2-3 yrs                                                                                                                                                                                                  | 2 yrs (KE), 1+ (LCS), 6-                                                                                                                                                                                                           | 2 yrs (KE),                                                                                                                            |

Woody Mulches Research Review and Surveys

---

|                                            |                                                             |                                                                                                                                                                                             |                                       |
|--------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| practical life span of product / benefits? | (DOT), coarse fir-3 yrs, fine hemlock 1-yr (PR), 1-yr (BDc) | 12 mos. For weeds (BS), 3-4 yrs (DOT). 1-2 yr (PR), depends on C:N LWVT, 1-2 yr (BDc), 2 yrs DZ,                                                                                            |                                       |
| Recommended application rate?              | Landscape: 3-4" CC, 3" PR, 2-4" BDc<br>Conservation: 3" DOT | Landscape: 4" (LCS), 4-6" (BS), 2-4" (TC), 4" (PR), 2-4" LWVT, 2-4" BDc, 3-4" DZ,<br>Conservation/Invasive control: 6-12"(KE), up to 12" (LCS), 10"+ (BS), 3-6" (DOT), 8-10" (PR), 6" (DZ), | Landscape: 2-4" (TC)<br>Conservation: |

**VIII. 2005 Seattle Area Woody Mulch Source Survey**

Spreadsheet on following pages.