

**Final Report to
The Agricultural Research Foundation
and the
Nursery Regulatory Committee**

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Accomplishments

During 2005 I hosted 4 research interns: Julie Ream (Oregon State University), Gilda Medina (Ecuador), Magdalena Zazirska (Poland), and Vyacheslav Dolbrik (Ukraine).

The interns worked on many projects throughout the spring and summer. The students visited many nurseries along with me to identify important problems and research directions. They helped plan experiments, set them up, collected data, and then summarized data with statistical analyses, charts, and tables. This report would be endless if I included all of their work. So instead, I will try to highlight the major projects each student worked on and include any major publications.

Julie studied the invasiveness of butterfly bush (*Buddleja davidii*). In response to recent listing of this plant as an invasive weed by the Oregon Department of Agriculture, Julie and I set out to document several invaded sites and determine the similarities among

these sites. Julie traveled all over the state of Oregon to document invaded sites where she measured chemical properties of the soil, she recorded surrounding vegetation, and she described the topography and hydrology of the sites. Julie presented the results of her research at the Northeast Weed Science Society in Washington DC in January 6, 2005. Her presentation was so good that professors from two other universities in the audience offered her a graduate assistantship on the spot. As a sophomore working on her B.S. degree, she was not prepared to think about a M.S., but those offers were flattering nonetheless and they speak volumes of her research and presentation skills. A summary of her research is attached to this report under Appendix 1.

Gilda worked on many projects, and was my primary aid in collecting data. Her own specific research focused on water loss from 15 gallon pot-in-pot containers. She presented her research at the Southern Nursery Association Research Conference in Atlanta, GA in August 10, 2005. I was extremely proud in how she represented myself and Oregon State University. In conjunction with her presentation (in front of almost 200 scientists), she also wrote an abstract which will be printed in the annual proceedings. Her paper is attached to the end of this report and labeled as Appendix 2.

Magdalena started her internship in June, 2005. She has been here only a short time, but is already involved in many projects. One of her projects is investigating biological weed control in container crops. Her greatest asset is her attention to detail and laboratory technique. She oversees most of our lab research on the physical properties of Douglas fir bark and pumice. She is involved in determining the particle size distribution, water holding capacity, air space, pore space, and moisture release curves of the bark substrates. She will attend the Northeast Weed Science Society

meeting in January to present research on postemergence control of butterfly bush. Her abstract is listed as Appendix 3.

Vyacheslav focused primarily on determining the cause of marginal chlorosis in boxwoods and the injection of acids through drip tape for red maple production. His experience in actual production nurseries was very useful, and thus he also handled most of our tractor and pruning maintenance. Because he was here for only 6 months, I was not able to prepare him for a presentation in a national science meeting.

Appendix 1.

PRODUCTION AND INVASION OF BUTTERFLY BUSH
J. Ream and J. Altland, Oregon State University, Corvallis

ABSTRACT

Butterfly bush (*Buddleja davidii*) is an ornamental crop commonly grown in nurseries, but is showing signs of invasiveness in Oregon's natural areas. The Oregon State Weed Board has placed *Buddleja davidii* on the noxious weed list; however, it may be years before quarantine status is assigned that would prohibit its production and sale. Even if production was prohibited, current plantings in home landscapes are so numerous that complete eradication is unlikely, and thus there will always be abundant seed source to cause further infestations.

Little is known about site characteristics that favor butterfly bush invasion. Butterfly bush is a perennial shrub native to river margins in central and west China. Literature from England suggests *Buddleja* inhabits soils with specific chemical properties (high pH) where other plants won't grow or only grow poorly. Its presence in the British Isles has been described as a colonist of disturbed and compacted sites, specifically areas such as railway beds, unused industrial areas, hard-rock quarries, and on old walls and buildings. Research in New Zealand indicates that butterfly bush is competitive in areas prone to frequent flooding and alluviation. Other conditions such as soil disturbances, soil hydrology, and/or soil biology may select for butterfly bush invasion.

The objective of this research was to determine and describe site conditions that favor butterfly bush invasion. Plant, soil, and climate characteristics of current invaded areas was documented. Soil samples were collected to determine chemical properties of soils in which plants invade. Three sub-samples (each 1 pint) of soil were collected from each site and analyzed for potassium, calcium, magnesium, and soil pH. Physical characteristics of the soil were assessed by classifying the soil by its history of disturbance, flood history, hydrology and soil texture class (sand, silt, or clay). Nursery producers and retailers of butterfly bush were also surveyed and visited. Nursery production practices were documented, and if present, escaped seedlings from these production sites were collected.

Butterfly bush was found growing in a wide variety of sites, from flood plains to mountain slopes. Areas of densest invasion were on burn sites in reforestation areas, and sites that receive frequent disturbance such as flood plains. Density of seedling occurrence was approximately 4 times higher in riparian areas (0.23 plants/m²) than other natural sites, industrial sites, or roadsides. Density of seedlings at all sites tended to decrease with increased groundcover (living plants or dead plant debris).

Few escaped seedlings were found at production or retail nurseries. Production nurseries frequently cut plants back to encourage branching and more dense plant form. In the process, flowers are removed and not allowed to produce seed. Escaped seedlings were found at production nurseries that allowed plants in production or nearby landscape plantings to retain flowers over the winter.

Retail nurseries typically sell their stock before the end of the growing season. Plants not sold are cut back prior to over-wintering. Research from the United Kingdom reported that seed from butterfly bush are not released from the plant until the following spring. Because flower heads are almost always removed for one or more reasons throughout the growing season in both production and retail nurseries, the occurrence of escaped seedlings from these sites was low. It is not likely that production and retail sites are a source of escaped butterfly bush plants, although they might be a source of escaped seedlings once they are installed in home landscapes.

Appendix 2.

Evapotranspiration Rates from Trees Grown in Pot-In-Pot Culture

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Index Words: water, evaporation, transpiration.

Significance to the Nursery Industry: Water supply for agriculture in many parts of the U.S. is becoming limited. This mandates more efficient use of irrigation in container production.

Producers of large containers that utilize irrigation emitters placed directly in containers are capable of applying uniform and precise irrigation amounts that would limit excess leaching of water and nutrients. Data herein indicate large specie differences in evapotranspiration (ET) rates from 15 gallon tree crops. ET rates seemed to be dependent on canopy shape and structure. This research provides container producers an indication of the relative amount of water lost from ET in ten different tree species. This research indicates how some species might be grouped together in irrigation zones to simplify and increase irrigation efficiency.

Nature of Work: Irrigation efficiency is dependent primarily on irrigation uniformity and application of precise water amounts to satisfy crop needs. Most producers of large container crops, both above ground and pot-in-pot (PIP) are currently using some form of micro-irrigation with emitters positioned in each container, which allows for uniform irrigation. Applying proper water amounts without over-irrigating to the point of excessive leaching requires knowledge of crop ET rates.

Deficient irrigation rates cause plant stress and limit plant growth. Several studies have reported the reduction of plant height, leaf area, plant weight and physiological processes due to water-stress conditions (1). Most nurseries err on the side of over-watering to prevent water stress. However, excess watering causes poor aeration of the root medium, increases root diseases,

leaches nitrogen and reduces plant quality (2). Water requirements for plants can be estimated by summing the water lost from evaporation and transpiration, collectively referred to as ET. It has been shown that the degree of shading of the crop canopy and the amount of water available at the evaporating surface are factors that affect evaporation rates (3). According to Rajapakse (1988), stomatal and cuticular factors that affect transpiration rates vary with the plant species. Nursery pruning practices would also affect canopy shape and total leaf area, thus drastically affecting ET rates. ET rates can be determined for crops by measuring the weight (and thus volume) of water loss over a set period of time. An easier, farm-ready method for estimating ET from large containers would be preferable to weighing containers throughout the growing season.

The following study was initially proposed by Daniel Struve at Ohio State University to determine if ET of container grown trees can be generalized across geographical regions of the US. Furthermore, there was an attempt to correlate tree caliper to ET rates. The experiment described in this paper was repeated at seven sites throughout the US. Due to space limitations, only data collected in Oregon will be discussed here. The specific objective of our experiment was to determine relative evaporation and transpiration rates throughout the summer growing season of shade trees grown in a PIP system.

This experiment was conducted in 15 gallon containers grown PIP at a local nursery. On July 2, August 12, and September 22, 2004, trees were weighed at approximately 9 am and again at 3 pm to determine water loss (ET) over a 6 hour period. Ten species listed in Table 1 were evaluated. Caliper was measured prior to weighing, and percent canopy shading of the soil surface was estimated (data not shown). To determine the relative amount of evaporation to transpiration of each species, five containers of each were covered with a black plastic bag after the initial weight was recorded in the morning in order to prevent evaporation from the container surface. Five additional pots were left uncovered.

Results and Discussion: Across and within all species, there were no difference in water loss between containers covered and those uncovered (Chart 1, data not shown within species). This indicates little or inconsequential evaporation from containers grown in PIP systems. It is possible that traditional container production (above ground) would have higher levels of evaporation since they would be exposed to sunlight and thus heated to higher temperatures. It is also possible that containers spaced further apart with more of the container surface exposed to sunlight could lose more water to evaporation.

Within each species, tree caliper and ET were not correlated (Table 1). It is possible that using more replications would have yielded significant correlations. Transpiration rates seemed more correlated to canopy size and structure. Plants with larger canopies tended to lose greater amounts of water. Canopy size of each species was estimated as a group and not individually, thus correlation calculations were not possible. While all tree species were a similar age (recently potted bare root whips) and similar size (1.25 to 1.75 inch caliper), they had drastically different canopy structures. Differences in canopy size and structure may have been due in part to species, but more likely they were a result of nursery pruning practices that vary drastically among different species.

While there appears to be no reliable predictor of ET across the 10 tree species in this experiment, these data demonstrate that some plants have similar enough ET rates that they can be grouped in common irrigation zones. This allows for plants with similar ET rates to be irrigated together. Based on results listed in Table 1, this nursery might consider placing maple, ash, crabapple, and pear in the same irrigation zone. Likewise, oak and honeylocust could be grouped together with linden and cherry in yet another group. As a note of caution, because of the strong influence canopy size and shape has on transpiration rates, different pruning practices at a different nursery could make observations in this experiment irrelevant for another nursery.

Literature Cited

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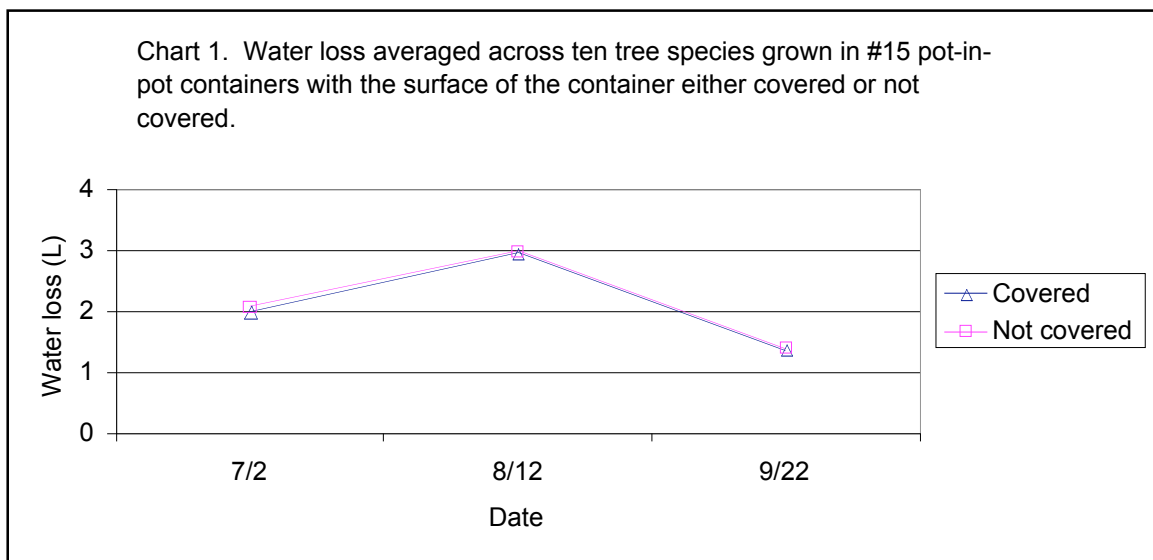


Table 1. Evapotranspiration (ET) rates from 9 am to 3 pm for ten tree species grown pot-in-pot in 15 gallon containers.

Species	July 22		August 12	
	Caliper (in)	ET (L)	Caliper (in)	ET (L)
<i>Acer rubrum</i> 'Red Sunset'	1.33	3.7 a ^z	1.46	4.5 a
<i>Acer xfreemanii</i> 'Autumn Blaze'	1.55	2.5 b	1.69	3.3 b
<i>Fraxinus pennsylvanica</i> 'Patmore'	1.54	2.8 b	1.67	3.3 b
<i>Gleditsia tricanthos</i> 'Shademaster'	1.45	1.5 c	1.49	1.9 cd
<i>Malus ioensis</i> 'Prariefire'	1.40	1.7 c	1.51	3.5 b
<i>Prunus cerasifera</i> 'Thundercloud'	1.37	2.8 b	1.52	4.2 a
<i>Prunus serrulata</i> 'Kwanzan'	1.35	1.8 c	1.51	2.3 c
<i>Pyrus calleryana</i> 'Cleveland Select'	1.46	1.3 cd	1.62	3.0 b
<i>Quercus rubra</i>	1.18	0.8 d	1.28	1.5 d
<i>Tilia cordata</i> 'Greenspire'	1.21	1.2 cd	1.44	2.2 c

^z Means within a column with different letters are significantly different according to Duncan's multiple range test ($\alpha = 0.05$).

Appendix 3.

HERBICIDAL CONTROL OF BUTTERFLY BUSH
M. Zazirska and J. Altland, Oregon State University, Corvallis

ABSTRACT

Butterfly bush (*Buddleja davidii*) is native to China but has been reported as an invasive weed in Europe, New Zealand, Australia, and parts of the United States. It was introduced to the United States as an ornamental and is now widely distributed in landscapes and gardens. Several factors lend to its invasive habits. Butterfly bush starts flowering and producing seed in its second year, although some panicles may be present within the first year. It has enormous reproductive potential with approximately 3 million seeds per mature plant (1). Seeds are small, lightweight and capable of being dispersed by multiple vectors such as wind, water, animals and human activities. Butterfly bush rapidly develops an extensive root system that allows it to survive on dry soils during periods of drought stress. In Oregon it has been documented to colonize industrial sites, road sides, and other waste areas. However, of greatest concern is its spread into natural riparian areas.

Due to increasing awareness of its invasiveness, there is greater need for control recommendations. The objective of this research is to determine which herbicides and application methods are most suitable for eradicating butterfly bush from natural or riparian areas.

Uniform plants in 4 inch pots of the cultivars 'Black Knight' and 'Ellen's Blue' were planted in a Willamette silt loam soil July 26, 2004. Eight single plant replications per cultivar were planted in a randomized complete block design. Herbicides were applied to butterfly bush on September 16, 2005 when plants were approximately 6 to 7 feet tall and wide, and all were flowering profusely. Sprayed herbicides were applied using a CO₂ backpack sprayer with a single 8004 flat fan nozzle at 35 psi. Painted herbicides were applied to recently cut stumps in the concentrated form using foam paint brushes. Herbicides and rates are listed in Table 1. Herbicides were applied so that the amount of active ingredient applied to plants in paint and spray treatments were the same. Plants were rated at 1, 2, and 4 weeks after treatment (WAT) for control. Plants were rated on a scale from 0 to 10 where 0 = no injury, 3 = slight injury, 5 = moderate injury, 7 = severe injury, and 10 = complete death.

At 1 and 4 WAT, control ratings were higher on 'Black Knight' compared to 'Ellen's Blue' for all treatments indicating cultivar differences in herbicide tolerance. By 4 WAT, sprayed Aquamaster (glyphosate) and Roundup Ultramax (glyphosate) provided better control than Arsenal (imazapyr) and Garlon 3A (triclopyr). Ratings were high among all painted treatments, however, because most of the plant was pruned off prior to application, these plants were difficult to rate accurately. Some branches remained at the base of the plant, by which control was rated. Because plants were large at the time of treatment, spraying was difficult and would be even more difficult in natural areas where preservation

of surrounding vegetation was desired. Painting herbicides appears to be an effective alternative to spraying, especially in sensitive ecosystems such as riparian areas.

1. Miller, A. 1984. The distribution and ecology of *Buddleia davidii* Franch. In Britain, with particular reference to conditions supporting germination and the establishment of seedlings. D. Phil. Theses, CNAA, Oxford Polytechnic.

Table 1. Postemergence butterfly bush control with selected herbicides and application methods.

Application method	Herbicide	Product	Rate	1 WAT ^z		4 WAT	
				'Black Knight'	'Ellen's Blue'	'Black Knight'	'Ellen's Blue'
Paint ^y	glyphosate	Aquamaster	10.0 ^x	6.5 a ^w	4.3 a	10.0 a	9.4 a
	glyphosate	Roundup	10.5	5.6 a	4.0 ab	10.0 a	9.0 ab
	imazapyr	Arsenal	7.5	2.6 c	1.9 d	9.3 b	6.9 c
	triclopyr	Garlon 3A	15.0	3.1 bc	3.0 bc	9.5 ab	7.4 c
Spray	glyphosate	Aquamaster	2.0 ^y	4.1 b	1.3 d	10.0 a	7.8 bc
	glyphosate	Roundup	2.1	3.6 bc	1.3 d	9.8 ab	8.1 abc
	imazapyr	Arsenal	1.5	1.1 d	0.0 e	6.5 d	2.6 d
	triclopyr	Garlon 3A	3.0	3.1 bc	2.1 cd	7.6 c	7.3 c

^z Weeks after treatment.

^y Herbicide concentrates were painted on fresh cut stumps.

^x The rate for painted plants is expressed as ml/plant, where rate was applied directly to cut stems of each plant.

^w Means with different letters within a column are significantly different according to Duncan's multiple range test ($\alpha = 0.05$).

^v The rate for sprayed plants is expressed as the % concentration in spray solution. All sprays were applied at a rate of 500 ml/plant.