Garry Oak Ecosystems Recovery Team

Annotated Bibliography on the Ecology and Management of Invasive Species:

Butterfly bush (*Buddleja davidii* Franchet)

(synonym *Buddleia davidii* Franchet)

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May 2005

Funds for this project were provided in part by the Parks Canada Species at Risk Recovery Action and Education Fund, a program supported by the National Strategy for the Protection of Species at Risk

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Annotated Bibliography on the Ecology and Management of Invasive Species: Butterfly bush (*Buddleja davidii* Franchet) (synonym *Buddleia davidii* Franchet)

References outlining the horticultural uses, techniques and management of *Buddleja* (i.e., how to grow *Buddleja*) are not included in this review.

Peer-reviewed Journal Articles

Anisko, T., and U. Im. 2001. Beware of butterfly bush. American Nurseryman 194 (2): 46-49.

This article describes the weed capabilities of *Buddleia davidii*, which was introduced into Great Britain at the end of the 19th century. By the middle of the 20th century it had thoroughly naturalized the wastelands of southern England. *B. davidii* is now listed among the top 20 invasive weeds in England. Seed production of a number of *Buddleia* taxa were studied at Longwood Gardens in southern Pennsylvania. Large differences in the amount of viable seed produced by *B. davidii* cultivars were found. Cultivars 'Summer Rose' and 'Orchid Beauty' produced 20 times fewer viable seeds than 'Potter's Purple' and 'Border Beauty.' A single flower cluster of 'Potter's Purple' was found to produce over 40,000 seeds. Some *Buddleia* species and hybrids produced fewer viable seeds than *B. davidii* and likely have lower potential for escaping gardens and colonizing natural areas. Gardeners are encouraged to deadhead or prune plants in the fall to eliminate the chance of seed dispersal.

Bellingham, P. J., D. A. Peltzer, and L. R. Walker. 2005. Contrasting impacts of a native and an invasive exotic shrub on flood-plain succession. Journal of Vegetation Science 16 (1): 135-142.

Authors' abstract: How do *Coriaria arborea*, an N-fixing native shrub, and *Buddleja davidii*, a non-N-fixing exotic shrub, affect N:P stoichiometry in plants and soils during early stages of primary succession on a flood-plain? In the Kowhai River valley, northeast South Island, New Zealand, we measured soil and foliar nutrient concentrations, light levels, plant community composition and the above-ground biomass of *Coriaria* and *Buddleja* in four successional stages: open, young, vigorous and mature. *Coriaria* occurred at low density but dominated above-ground biomass by the vigorous stage. *Buddleja* occurred at 5.3 ± 1.0 stems/m^2 in the young stage and reached a maximum biomass of 520–535 g.m^{-2} during the young and vigorous stages. Mineral soil N increased with above-ground *Coriaria* biomass (r^2 = 0.45), but did not vary with *Buddleja* biomass. In contrast, soil P increased with *Buddleja* biomass (r^2 = 0.35), but not with *Coriaria* biomass. In early successional stages, 70–80% of the species present were exotic, but this declined to about 15% by the mature stage. Exotic plant species richness declined with increasing *Coriaria* biomass, but no other measures of diversity varied with either *Coriaria* or *Buddleja* biomass. These results demonstrate that *Buddleja* dominates early succession and accumulates P whereas *Coriaria* dominates later succession and

accumulates N. A key ecosystem effect of the invasive exotic *Buddleja* is alteration of soil N:P stoichiometry.

Froude, V. A. 2002. Biological control options for invasive weeds of New Zealand protected areas. Science for Conservation 199. 68 pp. Also online: http://www.doc.govt.nz/Publications/004~Science-and-Research/Science-for-Conservation/PDF/sfc199.pdf

More than 240 invasive weed species adversely affect indigenous biota and ecosystems of lands and waterbodies managed by the New Zealand Department of Conservation. Potentially high establishment costs limit biological control programmes to a few species of concern, although there may be opportunities for joint programmes with other agencies. Biological control may be most useful ecologically where relatively few invasive species proliferate and their removal would bring significant conservation gains (e.g. *Salix cinerea*, *S. fragilis*, *Pinus contorta*). It may, however, be difficult to pursue biological control programmes for species that are valued in other contexts such as soil conservation. Programme outcomes cannot be reliably predicted and it may take many years before these are known. Biological control works best as part of a comprehensive weed management programme. If successful it may eventually reduce or remove the need for conventional control. This review on the potential contribution of biological control to the Department's weed management strategy addresses: weed impacts; benefits, risks and measuring biological control outcomes; international programmes and their outcomes for biological control of weeds in natural areas; New Zealand investigations for each invasive weed species affecting New Zealand protected areas; and an assessment process for prioritising biological control investigations.

[Biological control feasibility investigations are proceeding for *Buddleja davidii* in New Zealand.]

Humphries, R. N., and L. Guarino. 1987. Soil nitrogen and the growth of birch and buddleia in abandoned chalk quarries. Reclamation and Revegetation Research 6: 55-61.

Authors' abstract: Birch and buddleia (*Betula pendula; Buddleia davidii*) are amongst the earliest woody species to colonise abandoned chalk quarries in south-east Britain. The development of birch scrub is slow, whereas that of buddleia is rapid. The possibility of a differential response to soil nitrogen level and form was tested in a pot experiment. At low soil nitrogen, buddleia had an ability to maintain leaf area irrespective of form, whereas birch did not. This may explain the more rapid growth of buddleia. Maintenance of leaf area is proposed as a means whereby some pioneer species are able to grow faster than other species on soils and spoils with low nitrogen level.

Humphries, R. N., M. A. Jordan, and L. Guarino. 1982. The effect of water stress on the mortality of *Betula pendula* Roth. and *Buddleia davidii* Franch. seedlings. Plant and Soil 64: 273-276.

Authors' abstract: A simple container is described whereby small seedlings may be grown at controlled levels of water stress. The water stress was induced in the soil by an osmoticum which is separated from the soil by a semi-permeable membrane. The mortality of *B. pendula* seedlings was markedly increased at a matric potential of -1.6 bar whereas the mortality of *B. davidii* was only affected below -2.8 bar. This difference in tolerance to water stress at the seedling stage might not be reflected in the distribution of the species in the colonization of chalk and sand pits in England unless there is a dry spring.

McFadyen, R. E. C. 1998. Biological control of weeds. Annual Review of Entomology 43: 369-393.

Author's abstract: Classical biological control, i.e. the introduction and release of exotic insects, mites, or pathogens to give permanent control, is the predominant method in weed biocontrol. Inundative releases of predators and integrated pest management are less widely used. The United States, Australia, South Africa, Canada, and New Zealand use biocontrol the most. Weeds in natural ecosystems are increasingly becoming targets for biocontrol. Discussion continues on agent selection, but host-specificity testing is well developed and reliable. Post-release evaluation of impact is increasing, both on the target weed and on non-target plants. Control of aquatic weeds has been a notable success. Alien plant problems are increasing worldwide, and biocontrol offers the only safe, economic, and environmentally sustainable solution.

[*Buddleja davidii* is not specifically mentioned. However, the article does say that "the nursery trade is another problem; most pernicious weed species in the United Kingdom were deliberately introduced as garden ornamentals, as were 85% of woody plants invading natural areas in the United States."]

Owen, D. F., and W. R. Whiteway. 1980. *Buddleja davidii* in Britain: history and development of an associated fauna. Biological Conservation 17: 149-156.

Authors' abstract: *Buddleja davidii* was introduced to Britain in the 1890s and began to colonize waste land and building sites in the 1930s. It now occurs in almost every town, especially on Ca-rich soil to which it is highly tolerant. No native or introduced plant produces flowers that are so attractive to butterflies and other insects. Eleven species of Lepidoptera caterpillars (*Celastrina argiolus, Orgyia antiqua, Melanchra persicariae, Lacanobia oleracea, Orthosia stabilis, Cucullia verbasci, Phlogophora meticulosa, Polymixis flavicincta, Gymnoscelis rufifasciata, Odontopera bidentata* and *Biston betularia*) feed on buddleia leaves or flowers, among them *C. verbasci*, previously restricted to the Scrophulariaceae. The shrub is in every sense a useful introduction, exploiting a previously unfilled niche, and its development of an associated fauna as well as the attractiveness of its flowers to nectar-feeding insects makes it a welcome addition to the British flora.

Reichard, S. H., and C. W. Hamilton. 1997. Predicting invasions of woody plants introduced into North America. Conservation Biology 11: 193-203.

Authors' abstract: Plant species continue to be introduced in North America for various purposes. If the trend continues, it is probable that some will escape cultivation and become invasive in native ecosystems. We present a retrospective analysis of several structural, life history, and biogeographical attributes of woody plants introduced in North America to determine which traits characterize species that have and have not invaded. Predictive models derived from discriminant analysis correctly classified 86.2% of the species in cross-validation whereas those derived from classification and regression trees classified 76% correctly. From these models we created a hierarchical predictive tree that allows the user to divide species into three categories: admit (low risk of invasiveness), deny admission (high risk of invasiveness), or delay admission for further analyses and/or monitor intensively (risk cannot adequately be assessed based on only the included attributes). We recommend that species that are highly invasive elsewhere not be allowed into the US and that a more conservative introduction policy using a hierarchical predictive method be employed.

[Although *Buddleja davidii* is not specifically mentioned, the authors analyzed the traits of woody plant species known to have been introduced into North America prior to 1930, which probably includes *B. davidii*.]

Richardson, B. 1993. Vegetation management practices in Australia and New Zealand. Canadian Journal of Forest Research 23 (10): 1989-2005.

Authors' abstract: Radiata pine (*Pinus radiata* D. Don) is the predominant species in plantation forests of Australia and New Zealand. Removal or suppression of noncrop vegetation is often carried out to enhance crop growth and survival by reducing competition for water, light, and nutrients. Other reasons for vegetation removal include microclimate modification, providing access into stands, and fire hazard reduction. Many studies have demonstrated large increases in crop growth from removing noncrop vegetation. Vegetation management can also mean introducing noncrop species to improve site quality, to suppress unwanted species, or to provide fodder for grazing. While herbicides are still the most widely used weed control tool, nonchemical methods are of increasing importance. The role of machinery is likely to increase in both countries as the use of fire for vegetation management and general site preparation declines. To calculate the long-term cost-benefit of vegetation management, a better understanding of the crop growth response to these treatments is essential. This requires experiments that focus on the role of both crop and noncrop species in hydrological and nutrient cycles. Personal computer based decision support systems are likely to play an increasing role as an aid to cost-effective vegetation management decision making.

[*Buddleja davidii* is discussed as a common weed species in the *Pinus radiata* plantation forests of New Zealand. See also Richardson et al., 1999.]

Richardson, B., M. O. Kimberley, J. W. Ray, and G. W. Coker. 1999. Indices of interspecific plant competition for *Pinus radiata* in the central North Island of New Zealand. Canadian Journal of Forest Research 29 (7): 898-905.

Authors' abstract: *Pinus radiata* D. Don was grown on its own and with a range of densities of either buddleia (*Buddleja davidii* Franchet) or broom (*Cytisus scoparius* L.), two important forest weed species, in a field trial at Rotorua, New Zealand. Tree growth from the time of planting to age 3 was modelled as a function of tree size and a competition modifier. The competition modifier is, in effect, a multiplier that reduces tree growth according to the degree of competition defined by a competition index (CI). A range of CIs, with some sensitivity to both weed and tree growth and development over time, were individually incorporated into the modifier and evaluated. The "best" CI combined measures of weed height relative to tree height, proximity of the weed to the tree, and weed abundance, and was negatively correlated with an index of light availability. For a given value of CI, the effect on tree growth was independent of weed species. For diameter growth, the effect of CI was independent of tree age. However, for height growth the negative effect of a given CI value was much higher in year 3 than in years 1 and 2. This suggests that competition has an immediate effect on diameter but a delayed effect on height growth.

Richardson, B., A. Vanner, J. Ray, N. Davenhill, and G. Coker. 1996. Mechanisms of *Pinus radiata* growth suppression by some common forest weed species. New Zealand Journal of Forestry Science 26 (3): 421-437.

Authors' abstract: In a trial carried out adjacent to the New Zealand Forest Research Institute nursery at Rotorua, which was designed to quantify the reduction in *Pinus radiata* growth

caused by a range of weed species, tree seedlings were grown in weed-free plots (treated by mechanical cultivation and herbicide application), or with herbaceous broadleaves (a volunteer mixture of species from which grasses were excluded), *Cytisus scoparius* (broom), *Ulex europaeus* (gorse), *Buddleja davidii* (buddleia), *Holcus lanatus* (Yorkshire fog) with *Lolium multiflorum* (Italian ryegrass)—the "grass" treatment, *Lotus uliginosus* (lotus), or *Cortaderia selloana* (pampas). Water and nutrient levels were varied by factorial irrigation and fertilizer treatment (a regime including NPK fertilizer and other treatments pre- and post-planting). After 3 years tree stem volume was greatest in weed-free, lotus, gorse, and grass treatments and least with buddleia and pampas. The effect of herbaceous broadleaves and broom was intermediate. It was concluded that tall, fast-growing weed species reduced *P. radiata* growth by restricting light availability to tree crowns. No convincing evidence was found to link the large growth losses with interference in water or nutrient supply.

Smale, M. C. 1990. Ecological role of buddleia (*Buddleia davidii*) in streambeds in Te Urewera National Park. New Zealand Journal of Ecology 14: 1-6.

Author's abstract: Replacement patterns under buddleia (*Buddleja davidii*) groves aged between 2 and 17 years were studied in streambeds in the western Ikawhenua Range and in the upper Waioeka catchment, Te Urewera National Park. Height and basal diameter growth followed an exponential pattern, with rapid early growth (0.5 m/year and 1 cm/year respectively), levelling off after 15 years or more. Intense self-thinning occurred in younger stands. Typical forest floor vegetation was developing within 15 years of colonisation by buddleia. Seedlings of ten indigenous trees and shrubs were widespread under buddleia, with primary colonising species (e.g. *Hebe stricta, Kunzea ericoides*) more common under young stands, and other seral species (e.g. *Pseudopanax arboreus, Melicytus ramiflorus, Aristotelia serrata*) more common under older stands. Buddleia quickly displaces primary native colonisers, herbaceous and woody, where it occurs en masse, accelerating successions to forest on fresh alluvium by replacing longer-lived species such as *K. ericoides*. It is a very effective coloniser of new surfaces, and is likely to continue spreading in the Park and persist indefinitely in lowland catchments subject to frequent flooding and alluviation.

Timmins, S. M., and P. A. Williams. 1991. Weed numbers in New Zealand's forest and scrub reserves. New Zealand Journal of Ecology 15 (2): 153-162. Also available online: http://www.nzes.org.nz/nzje/free_issues/NZJEcol15_2_153.pdf

Authors' abstract: New Zealand's protected natural areas are being increasingly threatened by weeds as the natural landscape is fragmented and surrounding land use intensifies. To assist in designing management to reduce the threat, we attempted to determine the most important reserve characteristics influencing the presence of problem weeds in forest and scrub reserves. Data on 15 reserve characteristics were derived from surveys of 234 reserves. From correlation analysis, analysis of variance and consideration of several multivariate models, it appears that the most important characteristics influencing the number of problem weeds in reserves are proximity to towns, distance from roads and railway lines, human use, reserve shape, and habitat diversity. These factors reflect principally increased proximity to source of propagules associated with intensifying land use, including urbanisation. Reserves with the most weeds are narrow remnants on fertile soils with clearings and a history of modification, and those close to towns or sites of high human activity. If these reserves are to continue to protect natural values, they will require regular attention to prevent the establishment of further weeds. Accidental spread of weeds and disturbance in reserves should be minimised.

[*Buddleja davidii* was among the species studied.]

Other Published Sources

Brockerhoff, E. G., T. M. Withers, M. Kay, and W. Faulds. 1999. Impact of the defoliator *Cleopus japonicus* (Coleoptera: Curculionidae) on *Buddleja davidii* in the laboratory. Proceedings of the 52nd New Zealand Plant Protection Conference 113-118.
http://www.hortnet.co.nz/publications/nzpps/proceedings/99/99_113.pdf

Authors' abstract: *Cleopus japonicus* Wingelmüller (Coleoptera: Curculionidae) has been investigated as a potential biocontrol agent against *Buddleja davidii* Franchet (Buddlejaceae), an invasive weed of exotic and indigenous forests in New Zealand. The impact of feeding damage by *C. japonicus*, at densities of 0, 3, 10 or 20 larvae per plant (from 2nd instar), on the growth of buddleia plants was assessed in a quarantine laboratory. Matured larvae were replaced every 11 days until, after seven weeks, the effects of defoliation were assessed. Grazing damage increased with larval density and in the high density treatment (20 larvae per plant), 83% of expanded leaves had more than 50% of the leaf area grazed. One third of the plants in the high density treatment died, presumably as a result of grazing, whereas there was no mortality in the control and light grazing (3 larvae per plant) treatments. Grazing resulted in a significant reduction in main stem height, total stem and branch length, and dry weight of roots and shoots, primarily in the medium and high density treatments. The results suggest that, following permission to release and successful establishment, *C. japonicus* should successfully suppress buddleia growth.

Csurhes, S., and R. Edwards. 1998. Potential Environmental Weeds in Australia: Candidate Species for Preventative Control. Biodiversity Group, Canberra, ACT. Also online:
http://www.deh.gov.au/biodiversity/invasive/publications/weeds-potential/appendix-c-b.html

The appendix of this report contains a section for buddleja and states, "Although there are five species of *Buddleja* naturalised in New Zealand, only *B. davidii* is considered a major management problem. … It is naturalised on both the North and South Island of New Zealand and has invaded streambeds, roadsides and land slips (Smale 1990). Seedlings can occur at densities of several million plants per hectare but will self-thin to populations of about 2 500 plants per hectare by 10 years of age. In New Zealand, it appears to be a pioneer species and is eventually replaced by native species if disturbance is not continuous (Smale 1990). In Australia, *Buddleja davidii* has not reached its full potential and represents a threat to many vegetation communities (Blood *pers. comm.*). Damp sclerophyll forests are particularly vulnerable … Riparian communities also support infestations, particularly in association with disturbance in the urban area."

Douglas, G. W., G. B. Straley, D. V. Meidinger, and J. Pojar (eds.). 1998. Illustrated Flora of British Columbia, Volume 2: Dicotyledons (Balsaminaceae through Cuscutaceae). BC Ministry of Environment, Lands and Parks and BC Ministry of Forests, Victoria, BC. 401 pp.

This comprehensive reference has excellent identification keys and detailed technical descriptions of vegetative and sexual morphology. This flora is the taxonomic authority for the invasive species fact sheets (unless otherwise indicated). Douglas et al. describe the habitat of *Buddleja davidii* Franch. as mesic to dry disturbed areas and rocky slopes in the lowland zone; frequent in SW BC; introduced from China.

Moller, D. 2003. Characterizing potential invasiveness of fourteen *Buddleja* cultivars in South Florida. Journal of Undergraduate Research 5 (2). University of Florida, Gainesville, FL. http://www.clas.ufl.edu/CLAS/jur/1103/papers/paper_moller.html

Author's abstract: Plant growth, visual quality, flowering, and seed production were determined for 14 *Buddleja* species. *Buddleja davidii* x *B. lindleyana* and *B*. x *weyeriana* 'Honeycomb' had the greatest growth index and shoot dry weight of all cultivars. Each of the 14 cultivars evaluated produced seed. The shape and number of seed pods per infructescence varied with cultivar. The influence of light and temperature on germination were determined for 6 *Buddleja* davidii cultivars. Regardless of temperature or cultivar, light was required for germination. With or without light, less than 2% germination occurred at 33°C for each cultivar. At 15 or 24°C in light, germination was greatest for 'Nanho Purple' followed by 'Dartmoor.' Germination of 'Black Knight' and 'White Profusion' was consistently lower than that of other cultivars, regardless of temperature.

Paterson, J. P. H., and A. Cooper. 1997. Colonisation of an urban motorway embankment by *Buddleja davidii* Franch in Northern Ireland. Poster presented at 4th International Conference on the Ecology of Invasive Plants (October 1-4, 1997), Technische Universität, Berlin, Germany. Also online: http://www.lboro.ac.uk/research/cens/invasives/4iceap_poster.htm

Author's abstract: An elevated motorway with steep embankments consisting of crushed graywacke quarry stone (grizzly) has been constructed in Belfast (Northern Ireland). The embankments, which are moisture deficient during the summer months, have recently been planted with tree species, most of which are native to Ireland. *Buddleja davidii*, a native of China, is colonising the embankments. Its spread appears to be influenced by the location of an established seed source associated with a derelict urban site, the direction of traffic flow (slipstream effect) and prevailing wind direction. The age (time since construction) of the embankments does not appear to have an effect on the establishment success of *B. davidii*, which has higher growth rates (1-2 m yr -1) than planted tree species (0.05-0.5 m yr -1).

Reichard, S. 1996. *Buddleia davidii* Butterfly Bush. Page 48 *in* Randall, J. M., and J. Marinelli (eds.). Invasive Plants: Weeds of the Global Garden. Brooklyn Botanic Garden Publications, Brooklyn, NY. 112 pp.

Butterfly bush is sometimes called the "summer lilac" because its fragrant flowers look a lot like those of lilac and because it flowers in midsummer rather than spring. The flowers are a nectar source for butterflies. Originally from China, the shrub has been grown in the US since about 1900 and has escaped from cultivation along the eastern seaboard from Pennsylvania to North Carolina, and along the West Coast in California, Oregon and Washington. It generally colonizes disturbed areas such as roadsides and riparian zones. Other members of this genus (for example, *B. madagascarensis, B. lindleyana* and *B. asiatica*) have also shown strong invasive ability while others (such as *B. globosa*) have not. Therefore, unidentified members of this genus should be observed and removed from the garden if they show signs of spreading. Butterfly bush does not yet present a serious problem but is spreading rapidly. The species does not vegetatively reproduce via underground parts, so it is fairly easy to remove established plants. Be sure to remove the stump or treat it with a glyphosate herbicide, as the plant can regenerate from the roots if cut.

Sukopp, H., and A. Wurzel. 2003. The effects of climate change on the vegetation of central European cities. Urban Habitats 1 (1): 3-26.
http://www.urbanhabitats.org/v01n01/climatechange_pdf.pdf

Authors' abstract: Since the 1850s the effects of global warming have been anticipated by the rise of temperature in many big cities. In addition, vegetation changes in central European cities have been well documented. This paper explores the changing urban distribution of some ruderal herbaceous species and discusses changes in distribution and physiological changes in tree and shrub species in response to this rise in temperature. Examples of affected species covered here include *Acer negundo*, *Ailanthus altissima*, *Amelanchier spicata*, *Berberis julianae*, *Buddleia davidii*, *Colutea arborescens*, *Cornus alba*, *C. stolonifera*, *Cotoneaster bullatus*, *Cytisus multiflorus*, *C. striatus*, *Juglans regia*, *Laburnum anagyroides*, *Ligustrum vulgare*, *Mahonia aquifolium*, *Paulownia tomentosa*, *Philadelphus coronarius*, *Platanus* x *hispanica*, *Populus* x *canadensis*, *Prunus armeniaca*, *P. laurocerasus*, *P. mahaleb*, *P. persica*, *P. serotina*, *Pyrus communis*, *Quercus cerris*, *Q. rubra*, *Q. robur*, *Ribes aureum*, *Robinia pseudacacia*, *Sambucus spp.*, *Sorbus intermedia* agg., *Symphoricarpos albus*, and *Syringa vulgaris*. The responses of some woody scramblers and creepers are also examined. For many of these species, there was a long lag time between introduction and invasion in the wild. We briefly review phenological investigations, including studies of *Aesculus hippocastanum* and *Tilia euchlora*. Finally, we consider the extent to which cities can act as simulators of global climate change. We conclude that although other ecological and socioeconomic factors are affecting the vegetation in urban areas, many of the nonnative invasive species found colonizing cities (or naturalizing within them) originate in warmer areas and are benefiting from the more favorable climate.

[*Buddleja davidii* is included in the table entitled "Distribution of Some Nonnative Plant Species in Central Europe."]

Unpublished Sources and Websites

Butler, T. 2004. Popular Butterfly Bush Added to Noxious Weed List. Oregon Department of Agriculture, Salem, OR.
http://www.oda.state.or.us/information/news/2004/040227weed.html

This news bulletin announces that *Buddleja davidii* was added to the State Noxious Weed List in Oregon in 2004.

Calflora. No date. *Buddleja davidii* L. Albany, CA.

http://www.calflora.org/cgi-bin/species_query.cgi?where-taxon=Buddleja+davidii

This website contains information about the distribution of *Buddleja davidii* in California and links to other information sources.

Department of Conservation. 2003. Te Urewera National Park Management Plan. East Coast Hawke's Bay Conservancy, New Zealand.

http://www.doc.govt.nz/Explore/001~National-Parks/Te-Urewera-National-Park/Te-Urewera-National-Park-Management-Plan/008~2.7-Introduced-Plants.asp

This report lists *Buddleja davidii* as a significant invasive weed in the park, and states that "Buddleia displaces early successional species (grasses, herbs, shrubs) and allows early entry of later successional species."

Dole, C. H. 1997. Buddleia: Butterfly Bush Extraordinaire. Butterfly Gardeners' Quarterly #12, Seattle, WA.
http://butterflywebsite.com/articles/bgq/buddleia.htm
http://users.bestweb.net/~habitat/Butterfly%20Bush.htm

These websites, designed primarily for gardeners, provide information on the history of *Buddleja davidii*, and on alternative species (notably *B. globosa*) that are not as invasive.

ERMA New Zealand. 2004. Biological Control Agents NOR 02001—Buddleia. Environmental Risk Management Authority, Wellington, New Zealand.

http://www.ermanz.govt.nz/news-events/focus/biocontrol-agents.asp#buddleia

Author's notes: An application received from the Forest Research Institute to release a weevil for the control of the weed pest Buddleia (*Buddleja davidii*) is currently under consideration by the Authority. Buddleia is considered by some to be a weed of both the environment and forestry plantations, mainly in eastern central North Island. The applicant is concerned that the weed pest is displacing valued native species and is reported to be costing the forestry industry $0.5 to 2.9 million annually in control and lost production. Forest Research wish to release from containment an insect biological control agent *Cleopus japonicus*, or buddleia leaf weevil, the effects of which they have been studying for over ten years. The small (5mm) brown weevil produces slug-like larvae of a similar size that feed on the leaves reducing growth rate, and killing small plants. A hearing to consider this application was held in Rotorua on the 7th of April 2004 and was well attended by a number of interested parties. As a result of information obtained at this hearing and subsequent considerations the Authority has requested that Forest Research conduct further host-specificity testing to determine any potential detrimental effects of approving the release of this weevil. A final decision on this application is due 31st March 2005, once the Authority has considered the results of this further testing.

Forman, J. 2003. Access of Weevil. Invasive Species Weblog. December 23, 2003.
http://invasivespecies.blogspot.com/2003_12_21_invasivespecies_archive.html

HortNews is reporting that forestry researchers in New Zealand are seeking permission to import *Cleopus japonicus*, a weevil that defoliates the invasive butterfly bush (*Buddleja davidii*, sometimes known horticulturally as *Buddleia*). This is in spite of the fact that evidence has shown that the weevils also feed on some of the other species in the genus that are present in New Zealand, albeit non-native. Butterfly bush is quite popular among gardeners worldwide, with many cultivars showcasing an array of brilliantly colored flowers. The weevil in question, native to Asia, has also been shown to attack native hebes (*Hebe* spp.), but scientists believe the negative impacts of the butterfly bush invasion outweigh the potential weevil risk to native plant species.

Global Invasive Species Database. No date. *Buddleja davidii* (Shrub). Conservatoire Botanique National Mediterraneen do Porquerolles.
http://www.issg.org/database/species/ecology.asp?si=650&fr=1&sts=sss

This website provides general global information about *Buddleja davidii* and states that this species is originally from China and has invaded Australia, New Zealand, the Pacific, Europe and the US. A profile is given for this species, including a description and information on the habitat, impacts, uses, geographic range, dispersal methods, management, reproduction and life cycle. Impacts listed include that dense infestations of *B. davidii* compete with indigenous vegetation of rivers and impede the growth and reproduction of other species of trees and shrubs. Monospecific stands of *B. davidii* impede access to rivers. Seedlings, which have superficial rooting, are easily carried away in floods and may form blockages, causing erosion of banks.

Goodwin, K. 2002. Plant Species, Sargeant Bay Provincial Park.
http://www.sargbay.ca/PlantList.pdf

This document notes that *Buddleja davidii* is present in Sargeant Bay Provincial Park, north of Sechelt, BC.

Hawaiian Ecosystems at Risk Project. 2001. *Buddleja davidii*. A Global Compendium of Weeds.
http://www.hear.org/gcw/html/autogend/species/3189.HTM

This website includes very basic information on *Buddleja davidii*, and crosslinks to related references from around the world.

Hood, I. 2003. Buddleia Biocontrol? Modelling Its Potential Value. Forest Health News No. 132, Rotorua, New Zealand.
http://www.forestresearch.co.nz/PDF/No132-2003Aug.pdf

This research note describes a computer model designed to predict the effectiveness of the bioagent *Cleopus japonicus* as a defoliator for *Buddleja davidii*.

Karori Wildlife Sanctuary. 2004. Giving Our Forest Room to Regenerate. Wellington, New Zealand.
http://www.sanctuary.org.nz/whatsnew/news/pdf/WeedControl.pdf

Excerpt from “Control methods” (for *Buddleja davidii*): Hand-pull seedlings and smaller plants. Cut trunks of larger plants near ground level and spray stumps *immediately* with 1 part glyphosate (ask for this at any garden centre) to 4 parts water. Alternatively, place thick black plastic over stumps to exclude all sunlight, and remove any shoots until plants die. Dispose of seeds carefully. Do not leave stems on the ground.

Kay, N. 2002. Variety in Buddleia Biocontrol. CABI Biocontrol News and Information 23 (3).
http://pest.cabweb.org/Journals/BNI/Bni23-3/Gennews.htm

Author’s notes: Here, we report on approaches being taken to manage buddleia on opposite sides of the world that differ, not because the nature of the problem varies, but because of stakeholder priorities and attitudes. New Zealanders are familiar with the concept of classical biological control as a weed management tool; Landcare Research, for example, actively includes landowners and other members of the public in weed biocontrol implementation, engaging them in redistribution of biocontrol agents, and monitoring of their spread and impact. New Zealand is hoping to adopt this same approach for buddleia control. In the UK, however, classical weed biocontrol in something of a novelty and it has only recently begun its first

weed biological control programme (against Japanese knotweed *Fallopia japonica*). This conservatism, combined with a dense population of avid gardeners and armchair naturalists, makes it unlikely that permission would be given for the importation of buddleia natural enemies to the UK. Therefore, CABI Bioscience, funded by Railtrack, is pursuing the development of a stump treatment approach based on naturally occurring fungi already present in the wild.

Klinkenberg, B. 2004. E-Flora BC: Atlas of the Plants of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver, BC. http://www.eflora.bc.ca/

This site provides information on the distribution of *Buddleja davidii* in BC as well as information on identification, ecology, habitat and nomenclature, with links to other relevant websites.

Native Plant Society of Oregon. 2002. Invasive Gardening and Landscaping Plants of the Southern Willamette Valley. Emerald Chapter, Eugene, OR. http://www.emeraldnpso.org/PDFs/Invas_Orn.pdf

In this document, *Buddleja davidii* is described as a high impact species. Impacts include "forming riparian monocultures along Salmon Cr. (Oakridge), and in many other areas in western Oregon and Washington. Displaces native willows which are essential host plants for native butterflies."

Natural Resources Conservation Service. No date. Plants Profile: *Buddleja davidii* Franch. Orange Eye Butterfly Bush. United States Department of Agriculture Plants Database, Washington, DC. http://plants.usda.gov/index.html

This website provides excellent information including an illustrated description of *Buddleja davidii*, alternative nomenclature, distribution by state, the classification system for this species and the invasiveness and noxious status for each state. The site also provides links to other US websites.

NatureServe. 2005. Invasive Species Impact Ranks for the United States. Arlington, VA. http://www.natureserve.org/getData/plantData.jsp

NatureServe is assessing all of the estimated 3500 non-native plant species that have escaped from cultivation in the US using a new methodology called "Invasive Species Assessment Protocol." This system, developed by NatureServe, the Nature Conservancy and the National Park Service, creates a prioritized list of non-native plants and their impact on biodiversity. The site also includes citations and references used in assessing the species. According to this matrix (January 10, 2005), *Buddleja davidii* has a national impact rank of high/low.

Pacific Island Ecosystems at Risk (PIER). 2004. *Buddleja davidii* Franch., Buddlejaceae. http://www.hear.org/pier/species/buddleja_davidii.htm

This website describes ecology, synonyms, common names, distributions (Pacific as well as global), management and impact information for *Buddleja davidii*.

Paterson, J. P. H. 2000. *Buddleja davidii* Franchet (Loganiaceae). Woody Plant Ecology, United Kingdom.
http://members.lycos.co.uk/WoodyPlantEcology/docs/web-bud.htm

This comprehensive overview includes species characteristics, status in native range, status in invaded regions and the ecological differences between the two.

Plants for a Future Database. No date. *Buddleja davidii*. Plants for a Future, Chapel Hill, NC.
http://www.ibiblio.org/pfaf/cgi-bin/arr_html?Buddleia+davidii

This database provides information on physical characteristics, habitats and locations, edible and medicinal uses, cultivation and propagation. There are also links to numerous other sites.

Roja, D. 1998. Exotic Plant Management: Redwood National and State Parks. California.
http://www.nps.gov/redw/exot1998.doc

Buddleja davidii is only briefly mentioned in this report, but for removal they winched plants out of a sandbar.

Starr, F., K. Starr, and L. Loope. 2003. *Buddleja davidii*. United States Geological Survey—Biological Resources Division, Haleakala Field Station, Maui, Hawai'i.
http://www.hear.org/starr/hiplants/reports/html/buddleia_davidii.htm

Authors' overview: *Buddleja davidii*, native to China, is a large shrub with colorful fragrant flowers that is cultivated as an ornamental garden plant in temperate regions of the world, and is often planted to attract wildlife, such as butterflies and hummingbirds, which readily sip nectar from flowers. *B. davidii* is known to spread from gardens and has become invasive in Europe, New Zealand, Australia, and parts of the United States… *B. davidii* spreads in disturbed areas by numerous wind and water dispersed seeds from plants that can reach maturity in less than one year… . In invaded areas, such as New Zealand, *B. davidii* quickly colonizes riversides, facilitates succession, and has aggressive growth that out-competes colonization by native vegetation. Studies of *B. davidii* infestations in New Zealand have found that *B. davidii* is relatively short lived with the greatest infestation densities occurring in the first 10 years (Smale 1990). By the time the stand is about 15 years old, densities of infestations lessen. As this happens, native tree species eventually become dominant again. Because of this, along with widespread distribution that gives high re-invasion potential, New Zealanders have taken a strategy of ongoing management focussing control in natural areas where new infestations are found. In cool regions of the United States, including states in the northeast and Pacific northwest, *B. davidii* is increasingly being recognized as a potential pest plant and is currently on several invasive plant watch lists…

Though known to spread in several states, the full pest potential of *B. davidii* in natural areas of the United States is not yet known. In Hawai'i, *B. davidii* is commonly cultivated and has occasionally escaped from gardens in cool upland areas of Kaua'i and Maui…. The full invasive potential in Hawai'i is also not yet known, though from what has been gathered from known invaded ranges elsewhere, it is presumed that on Maui, this attractive shrub could potentially invade disturbed areas of mid elevation shrubland, roadsides, pastures, gulches, open areas, and perhaps some woodlands. Due to the plant's popularity in landscaping and widespread distribution on Maui, island wide eradication would take large amounts of resources. However, *B. davidii* will only become more widespread and costlier to control in the

future. Perhaps the best strategy at this time for *B. davidii* on Maui would be similar to that of New Zealand, where *B. davidii* is discouraged in landscaping and detected and controlled in newly invaded natural areas as early as possible.

Tasman District Council. 2001. Tasman-Nelson Regional Pest Management Strategy. Nelson, New Zealand.
http://www.nelsoncitycouncil.co.nz/environment/downloads/Regional%20Pest%20Management.pdf

This weed management strategy includes a section on *Buddleja davidii*. The objective is "to control the spread of Buddleia from adjacent properties to land clear of Buddleia, or being cleared of Buddleia." The method of achieving this objective will be to "enforce rules requiring land occupiers to destroy Buddleia where there is a reasonable complaint."

Washington State Noxious Weed Control Board. 2004. Written Findings of the Noxious Weed State Control Board. Olympia, WA.
http://www.nwcb.wa.gov/weed_info/Written_findings/buddleja_davidii.htm

A well-referenced overview of *Buddleia davidii*, including description, economic importance, habitat, geographic distribution and control methods (particularly from New Zealand).

Weed Risk Assessment for Hawaii and Pacific Islands. No date. Hawaii.
http://www.botany.hawaii.edu/faculty/daehler/wra/wra_table2.asp

This website outlines the predicted invasiveness of *Buddleja davidii* in Hawaii and the Pacific Islands. Predictions are based on field observations and information from the USDA Forest Service and from the Hawaii Division of Forestry and Wildlife Urban and Community Forestry program.

General summaries of basic information, or fact sheets:

- http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200017825
- http://www.deh.gov.au/biodiversity/invasive/publications/weeds-potential/appendix-c-b.html
- http://138.253.199.114/IAAP%20Web/IAAPwebsite/plantintro.asp?ID=7 (under construction)
- http://www.enature.com/fieldguide/showSpeciesLSH.asp?curGroupID=10&lshapeID=24&curPageNum=46&recnum=TS1177
- http://www.co.stevens.wa.us/weedboard/htm_weed/butterfly%20bush.htm
- http://www.co.whatcom.wa.us/publicworks/pdf/weeds/butterfly_bush.pdf
- http://www.orc.govt.nz/html/details.html?details=6&articleID=224
- http://www.protectnz.org.nz/downloads/nppa/nppa_110.pdf
- http://www.habitas.org.uk/flora/species.asp?item=3948
- http://www.cnr.vt.edu/dendro/dendrology/syllabus/bdavidii.htm

Personal Communications

Betts, Michael. 2005. *Personal communication*. Weed Specialist, Ministry of Agriculture, Food and Fisheries, Victoria, BC. March 22, 2005.

Betts has observed butterfly bush only as a garden ornamental, not in wild situations. He notes that this species has never looked very aggressive, as it did not seem to be a plant that causes serious problems.

Ceska, Adolf. 2005. *Personal communication*. Botanist, Victoria, BC. March 16, 2005.

Ceska has observed butterfly bush in the moister *Arbutus* zone, such as around Vancouver and in Nanaimo. He suggests that it could potentially be invasive but lack of moisture in summer would be a limiting factor.

Costanzo, Brenda. 2005. *Personal communication*. Plant Species at Risk Biologist, Ministry of Water, Land and Air Protection, Victoria, BC. February 28, 2005.

Costanzo has observed that if you clip back butterfly bush too far during winter, or prune it too early in the spring, you can kill the plant. This information may be useful in controlling this species where it is potentially invasive.

Fairbarns, Matt. 2005. *Personal communication*. Plant Ecologist, Aruncus Consulting, Victoria, BC. February 22, 2005.

Fairbarns describes butterfly bush as being mildly invasive, and infesting primarily where there is a large seed source, deep soils and mineral soil exposure. This species prefers moderate to high nutrient levels, is moderately drought tolerant, yet avoids shallow soils. He has noticed that butterfly bush does not do well with prolonged severe moisture deficits. Fairbarns has rarely observed butterfly bush in natural communities, and has seen it only in Garry oak ecosystems that are highly disturbed and in urban areas. He has not seen much impact by this species but has noted that on suitable sites it can grow quite large (5-7 m high) and sprawling, so it has the potential for greater impact. The main issue with this species is its prolific seed production.

Hebda, Richard. 2005. *Personal communication*. Curator of Botany and Earth History, Royal BC Museum, Victoria, BC. March 16, 2005.

Hebda has observed butterfly bush on the south end of Vancouver Island (particularly Saanichton), and the north shore of Vancouver (North and West Vancouver). This species tends to invade rocky outcrops and roadsides. He has observed it becoming more weedy in the past few years, although it hasn't invaded natural ecosystems. He predicts that it could invade Garry oak ecosystems, particularly on rocky outcrops. He has noticed that butterfly bush is becoming more widely available in the trades, and predicts that the issue of it invading will become greater. As with other weed species, Hebda cautions against disturbing the soil, which provides a new seed bed for invasive species.

Lomer, Frank. 2005. *Personal communication*. Naturalist. New Westminster, BC. March 8, 2005.

Lomer states that butterfly bush is not a threat in Garry oak ecosystems. This species seems to prefer a gravelly, rocky habitat and would not be invasive even in a rocky meadow. This species is abundant in Horseshoe Bay, which is the largest infestation in BC that he is aware of. He has noticed that butterfly bush does not invade the meadow habitats of native species that are present in the north shore area. There is a also a large population of butterfly bush along the Chilliwack River at Cultus Lake and it is growing in the river bed. He has also seen it growing on dredged sand. Infestations have come from gardens. It can impact habitats by taking up space and producing shade, but it is not a very aggressive species (unlike Scotch broom). Lomer doesn't feel that this species is enough of a threat to ban it from gardens (like purple loosestrife).

Polster, Dave. 2005. *Personal communication*. Plant Ecologist, Polster Environmental Services Ltd., Victoria, BC. February 21, 2005.

Polster has observed butterfly bush scattered around Vancouver Island, and more extensively on the Upper Levels highway in West and North Vancouver (probably because of the length of time it has been cultivated in North Shore gardens). He has not seen this species in Garry oak ecosystems, but recognizes the potential for it to invade in the future. He believes that this species can outcompete most native species, and certainly Garry oak ecosystem plants. Polster describes this species as a prolific seed producer, with seeds eaten and spread by birds.

Like most invasive species, butterfly bush tends to be in disturbed ecosystems, and in Garry oak ecosystems, *not* burning is a disturbance. Polster has not tried controlling this species, but predicts that methods that are successful for broom would be effective on butterfly bush, such as hand-pulling plants if they are smaller than a pencil during winter when the soil is wet. For larger plants, Polster recommends cutting it when it is just coming into flower, but before it is in seed, and then covering the cut stump with moss or something that causes shade and therefore prevents growth. A preventative measure for butterfly bush that Polster recommends is not to plant it in gardens.

Roemer, Hans. 2005. *Personal communication*. Botanist, Victoria, BC. March 17, 2005.

Roemer has never observed butterfly bush in Garry oak ecosystems. Given that this species is native to China, where there is high precipitation during the summer, and given that Garry oak ecosystems have drought during the summer, he predicts that this species is not a threat to Garry oak ecosystems. He has seen this species at Horseshoe Bay, the Nanaimo ferry terminal and other sites with deeper soils. Since Garry oak ecosystems typically have shallow soils, he does not suspect that there is high potential for infestations.

Turner, Nancy. 2005. *Personal communication*. Ethnobotanist, University of Victoria, Victoria, BC. February 18, 2005.

Turner notes that butterfly bush is still being sold in garden shops. The plants can grow from cuttings, and she has seen this species as an extremely pervasive escapee in other parts of the world. She suspects it requires a little more moisture than the driest Garry oak sites, and therefore would not occupy these areas.