Garry oak ecosystems recovery team

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Bibliographic summary of the Ecology and Management of Invasive Species:

Hypericum perforatum L. *and H. calycinum* L.

Common St. Johnswort & Aaron's Beard

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Briese, D.T. 1996. Biological control of weeds and fire management in protected natural areas: are they compatible strategies? Biological Conservation, Vol. 77, Issue 2-3, pp. 135–141.

Author's abstract: Biological control of weeds has been traditionally associated with pastoral or cultivated land-use systems. Recently though, there has been increasing discussion of the possibility of biological control of weeds that have invaded national parks and native forests. However, a completely different set of management strategies applies in such land-use systems, the aims of which may conflict with those of classical biological control. In Australia, one such practice is the use of regular prescription burning to control the incidence and severity of wild fires. This paper reports data collected between 1981 and 1987 on an infestation of St John's wort (*Hypericum perforatum*), and its biological control agent, *Chrysolina quadrigemina*, in eucalypt forest that was burnt twice during the study period. The fires both promoted development of the weed population and retarded that of the control agent. However, a subsequent indirect effect of fire was to favour population build-ups of *C. quadrigemina* and a recently released agent, *Aphis chloris*, through increased plant nutrient levels. This indicates that the compatibility of biological control with existing management strategies must be considered when it is proposed as an option for the control of invasive weeds in protected natural areas.

Buckley, Y.M., D.T. Briese, and M. Rees. 2003. Demography and Management of the Invasive Plant Species *Hypericum perforatum*. I. Using Multi-Level Mixed-Effects Models For Characterizing Growth, Survival and Fecundity in a Long-Term Data Set. J Applied Ecol, Vol. 40, No. 3, pp. 481-493.

Authors' abstract: 1. *Hypericum perforatum* , St John's wort, is an invasive perennial herb that is especially problematic on waste ground, roadsides, pastures and open woodland in south-eastern Australia. We use detailed data from a long-term observational study to develop quantitative models of the factors affecting growth, survival and fecundity of *H. perforatum* individuals. 2. Multi-level or hierarchical mixed-effects statistical models are used to analyse how environmental and intrinsic plant variables affect growth and reproduction within a complex nested spatial and temporal context. These techniques are relatively underused in ecology, despite the prevalence of multi-level and repeated-measures data generated from ecological studies. 3. We found that plant size (rosette or flowering stems) was strongly correlated with all life stages studied (growth, probability of flowering, asexual reproduction, survival and fruit production). Environmental variables such as herbivory, ground cover and rainfall had significant effects on several life stages. 4. Significant spatial variation at the quadrat level was found in the probability of flowering, flowering stem growth and fruit production models; variation at all other spatial levels in all models was non-significant. Yearly temporal variation was significant in all models where multi-year data were available. 5. Plants in shaded habitats were smaller but had higher survival probabilities than plants in open habitats. They are therefore likely to have slightly different population dynamics. 6. Synthesis and applications. Analysis of these models for *H. perforatum* has provided insights into which plant traits and environmental factors determine how populations increase and persist in exotic ecosystems, enabling population management strategies to be most effectively targeted. Spatially and temporally correlated data are often collected in long-term ecological studies and multi-level models are a way in which we can fully exploit the wealth of data available.

Without these tools data are either underexploited or crucial assumptions of independence on which many statistics are based are contravened.

Clark, D.L., and M.V. Wilson. 2001. Fire, mowing, and hand-removal of woody species in restoring a native wetland prairie in the Willamette Valley of Oregon. Wetlands, Vol. 21, No. 1, pp. 135-144.

Authors' abstract: The invasion of prairies by woody species is a worldwide conservation concern. Fire is frequently used to inhibit this invasion. However, there is little documentation of the effect of fire in wetland prairies, which are also threatened with encroachment of woody species. The present study investigated wetland species responses to experimental burning, hand-removal of woody species, and mowing with removal of cut material. The possible ecological mechanisms responsible for individualistic responses of species, including direct mortality, ability to resprout, and release from competition are considered. We also evaluated these treatments as tools for meeting restoration objectives of reducing the abundance of woody species, reducing or preventing spread of non-native pest species, and increasing or at least maintaining native species' abundance. After two years of treatments (1994 and 1996) three patterns emerged. 1) Woody species: Burning and hand-removal caused the greatest reductions in cover of woody species. Mowing with removal of cut material, however, did not reduce the cover of woody species compared to controls. As woody plant cover decreased, plant mortality increased, indicating that treatments influenced woody plant cover at least partially through mortality. 2) Native herbaceous species: Burning significantly decreased inflorescence production of *Deschampsia cespitosa*, the dominant wetland prairie grass. In contrast, burning, along with mowing, significantly increased flowering of *Juncus tenuis*. Flowering and cover of all native graminoids combined, however, showed no significant responses to treatments. Burning and hand-removal significantly promoted the cover of native forbs as a group, with *Lotus purshiana* and *Veronica scutellata* showing the greatest increases. 3) Non-native herbaceous species: Burning and hand-removal significantly reduced the cover of non-native forbs as a group and particularly reduced the cover of *Hypericum perforatum*. The number of inflorescences of nonnative grasses (*Holcus lanatus* and *Anthoxanthum odoratum*) increased with hand-removal and mowing. Overall, no treatment was clearly superior in fulfilling the restoration objectives. Burning was effective in reducing woody cover and did not promote abundance of non-native herbaceous species. Burning, however, reduced the flowering of the key native grass, *Deschampsia cespitosa*. Hand-removal of woody species was also effective at reducing woody cover and promoted the abundance of some native species, but it sometimes increased the cover of non-native herbaceous species. Because mowing with removal of cm material was ineffective in reducing woody cover and tended to promote non-native herbaceous species, this treatment is not recommended as a management tool.

Clark, N. 1953. The biology of *Hypericum perforatum* L. var. *angustifolium* DC (St. John's wort) in the Ovens Valley, Victoria, with particular reference to entomological control. Australian Journal of Botany. Vol. , pp. 95-120.

Author's abstract: A study of the biology of *Hypericum perforatum* L. var. *angustifolium* DC in the Ovens Valley, Victoria, has shown that the weed possesses characteristics that make it a difficult species for effective entomological control. They include the ability to prosper under a diversity of environmental conditions after successful establishment from seed; a great capacity for vegetative reproduction by suckering; and the delayed germination of a proportion of the seed for at least 6 years, probably owing to the presence of an inhibitor in the sticky exudate of the seed capsule. The problem of control is made more difficult by the unfavourableness of a large part of the area for the growth of other herbaceous plants capable of competing effectively with either mature *Hypericum* or its seedlings.

The leaf-eating beetles *Chysomela gemellata* Rossi and C. *hyperici* Forst. differ greatly in their ability to destroy well-established stands of the weed. The susceptibility of mature *Hypericum* to defoliation depends on environmental conditions, e.g. the physical condition of the soil, which determine the life span of the individual crown and the rate and amount of vegetative reproduction. *C. hyperici* is highly destructive only in stands characterized by large crowns and limited vegetative reproduction; whereas *C. gemellata* can eliminate any type of stand occurring in treeless areas. The difference between the insects is due to the fact that *C. gemellata* can sustain the process of defoliation much longer than *C. hyperici*.

It so happens that environmental conditions most favourable for the initial multiplication of both insects occur in the very sites in which the weed is most readily controlled, i.e, where the established plants are of the type most susceptible to insect attack, and where seedling regeneration is most likely to be suppressed by the associated flora.

The stands of *Hypericum* that occur in areas less favourable for the initial colonization by the insects are genaally more resistant to defoliation. Some of these stands, e.g. those present in eucalypt forest, cannot be destroyed by hand defoliation sustained for longer periods than the insects can maintain the process. Frequently, plants capable of ousting mature wort damaged by insect attacks or of suppressing seedling regeneration are scarce or absent, e.g. many areas of gold dredgings. Consequently, if the insects do succeed in destroying the original stands in such sites, the weed has a good chance of successful regeneration from seed. In many such areas in which the weed was destroyed in 1946 or 1948 St. John's wort is already re-established as the predominant plant. It has either achieved its former density or is well on the way towards doing so.

Crompton, C.W., I. V. Hall, K.I.N. Jensen, and P.D. Hildebrand. 1988. The biology of Canadian weeds. 83. *Hypericum perforatum* L. Can. J. Plant Sci. 68, pp 149-162.

Authors' abstract: *Hypericum perforatum* L., St. John's-wort is an introduced weed growing in waste places, roadsides, rangelands, pastures and similar habitats of Eastern Canada and British Columbia. It is poisonous to livestock causing a photosensitization in grazing animals with light-coloured hair. In Canada, two introduced leaf-feeding beetles, *Chrysolina quadrigemina* and *C. hyperici* have provided effective control. In Nova Scotia an endemic host-specific "strain" of *Colletotrichum gloeosporioides* generally maintained this weed at low levels, particularly in lowbush blueberry fields. It spreads both by seeds and vegetatively by rhizomes. Details related to its morphology, reproductive biology, responses to human manipulation, parasites and control measures are summarized.

Maron, J. L., M. Vilà, R. Bommarco, S. Elmendorf, and P. Beardsley. 2004. Rapid evolution of an invasive plant. Ecological Monographs Vol. 74, No. 2, pp. 261–280.

Authors' abstract: Exotic plants often face different conditions from those experienced where they are native. The general issue of how exotics respond to unfamiliar environments within their new range is not well understood. Phenotypic plasticity has historically been seen as the primary mechanism enabling exotics to colonize large, environmentally diverse areas. However, new work indicates that exotics can evolve quickly, suggesting that contemporary evolution may be more important in invasion ecology than previously appreciated. To determine the influence of contemporary evolution, phenotypic plasticity, and founder effects in affecting phenotypic variation among introduced plants, we compared the size, fecundity, and leaf area of St. John's wort (*Hypericum perforatum*) collected from native European and introduced western and central North American populations in common gardens in Washington, California, Spain, and Sweden. We also determined genetic relationships among these plants by examining variation in amplified fragment length polymorphism (AFLP) markers. There was substantial genetic variation among introduced populations and evidence for multiple introductions of *H. perforatum* into North America. Across common gardens introduced plants were neither universally larger nor more fecund than natives. However, within common gardens, both introduced and native populations exhibited significant latitudinally-based clines in size and fecundity. Clines among introduced populations broadly converged with those among native populations. Introduced and native plants originating from northern latitudes generally outperformed those originating from southern latitudes when grown in northern latitude gardens of Washington and Sweden. Conversely, plants from southern latitudes performed best in southern gardens in Spain and California. Clinal patterns in leaf area, however, did not change between gardens; European and central North American plants from northern latitudes had larger leaves than plants from southern latitudes within these regions in both Washington and California, the two gardens where this trait was measured. Introduced plants did not always occur at similar latitudes as their most closely related native progenitor, indicating that pre-adaptation (i.e., climate matching) is unlikely to be the sole explanation for clinal patterns among introduced populations. Instead, results suggest that introduced plants are evolving adaptations to broad-scale environmental conditions in their introduced range.

Tisdale, E.W., M. Hironaka, and W.L. Pringle. 1959. Observations on the Autecology of *Hypericum perforatum.* Ecology, Vol. 40, No., 1, pp 54-62.

Authors' abstract: *Hypericum perforatum*, an introduced perennial forb, has become a major weed on ranges of the Pacific Northwest and California. In Idaho, it is confined largely to the northern part of the state, and has become most abundant on depleted areas of former perennial grassland now occupied by annual grasses and forbs, particularly *Bromus* spp. Studies were made of several features of the autecology of the species, including seed production and germination, seedling behavior, vegetative propagation, root development and phenology. The studies were conducted mainly during the period 1951-1954 as part of a larger project on the ecology and control of *Hypericum*. Seed production during a 2-year study averaged 69 seeds per capsule, and 23,350 seeds per plant. Germination in the laboratory at temperatures of 70 to 78 Fahrenheit averaged 65 percent for a large number of samples. Seed stored indoors for 15 years gave 50 percent germination, while seed buried at depths of 1 and 3 inches retained similar viability after 3 years in the soil. *Hypericum* seedlings were found only spottily in the field and seedling mortality approached 100 percent in most cases. Germination occurred principally in May and the normal seasonal drought period of late July and August proved to be the critical period for seedling survival. The distribution pattern of the plant suggests occasional large scale establishment of seedlings under particularly favorable conditions. Vegetative propagation by root offshoots accounts for much of the local spread. The root system of *Hypericum* seedlings commonly attains a depth of about 1 foot during its first growing season. The mature plant possesses an extensive root system which extends 4 to 5 feet in depth and about 3 feet laterally. Considerable absorption of soil moisture from depths of 30 inches or more appears to occur. The phenology of Hypericum indicates a high degree of suitability to the habitat of the study area. In Idaho, spring growth begins in April, and proceeds rapidly during May and early June, when both moisture and temperature conditions are favorable. Flowering occurs in June and continues into July. Seed begins to form late in July, ripens by mid-September and is disseminated throughout October and November. Most plants are largely dried out by mid-August, but development of fresh fall basal growth occurred in 4 years out of 7 observed. This basal growth survives through the winter with only slight damage in most years and becomes active in spring 1 to 2 weeks before upright shoots begin to show.

Vilà, M., A. J.L. Maron, and L. Marco. 2005. Evidence for the enemy release hypothesis in *Hypericum perforatum.* Oecologia, Vol. 142, pp. 474-479.

Authors' abstract: The enemy release hypothesis (ERH), which has been the theoretical basis for classic biological control, predicts that the success of invaders in the introduced range is due to their release from co-evolved natural enemies (i.e. herbivores, pathogens and predators) left behind in the native range. We tested this prediction by comparing herbivore pressure on native European and introduced North American populations of *Hypericum perforatum* (St Johnr's Wort). We found that introduced populations occur at larger densities, are less damaged by insect herbivory and suffer less mortality than populations in the native range. However, overall population size was not significantly different between ranges. Moreover, on average plants were significantly smaller in the introduced range than in the native range. Our survey supports the contention that plants from the introduced range experience less herbivore damage than plants from the native range. While this may lead to denser populations, it does not result in larger plant size in the introduced versus native range as postulated by the ERH.

Vilà, M., A. Gómez, and J.L. Maron. 2003. Are alien plants more competitive than their native conspecifics? A test using *Hypericum perforatum* L. Oecologia, Vol. 137, pp. 211-215.

Authors' abstract: The evolution of increased competitive ability hypothesis predicts that introduced plants that are long liberated from their natural enemies may lose costly herbivore defense, enabling them to reallocate resources previously spent on defense to traits that increase competitive superiority. We tested this prediction by comparing the competitive ability of native St John's wort (*Hypericum perforatum*) from Europe with introduced St John's wort from central North America where plants have long grown free of specialist herbivores, and introduced plants from western North America where plants have been subjected to over 57 years of biological control. Plants were grown in a greenhouse with and without competition with Italian ryegrass (*Lolium multiflorum*). St John's wort from the introduced range were not better interspecific competitors than plants from the native range. The magnitude of the effect of ryegrass on St John's wort was similar for introduced and native genotypes. Furthermore, introduced plants were not uniformly larger than natives; rather, within each region of origin there was a high variability in size between populations. Competition with ryegrass reduced the growth of St John's wort by >90%. In contrast, St John's wort reduced ryegrass growth <10%. These results do not support the contention that plants from the introduced range evolve greater competitive ability in the absence of natural enemies.

Wapshere, A.J. 1984. Recent work in Europe on biological control of *Hypericum perforatum* [Guttiferae] for Australia. Biocontrol, Vol. 29, No. 2, pp. 14-156.

Author's abstract: Additional climatically adapted strains of the chrysomelids *Chrysolina hyperici* Suffrian and *C. quadrigemina* Förster, the geometrid, *Anaitis efformata* Guenée, and the buprestid *Agrilus hyperici* Greutzer from submediterranean regions of France have been introduced into Australia for release in regions where *Hypericum perforatum* L. is still insufficiently controlled biologically. Further safety testing of the noctuid, *Actinotia hyperici* Schiffermeyer revealed that additional testing against *Eucalyptus* spp. would be necessary. The eriophyid, *Phyllocoptes hyperici* Liro, was found to be a major controlling agent for *H. perforatum* in France and preliminary safety testing strongly suggests it could be safe to introduce into Australia. In France the combined effect of *P. hyperici* and *Ag. hyperici* causes the decline of *H. perforatum* populations to low levels within 10 years in aging stands of the weed. The importance of these organisms and others in regulating populations of *H. perforatum* is discussed.

Other published sources

Booker, R. 2002. Effects of *Hypericum perforatum* (St. John's wort) on the metabolism and uptake of γ–aminobutyric acid (GABA). MSc Thesis, Dept. of Psychiatry, University of Alberta, 122 pp.

Douglas, G.W., G.B. Straley, D.V. Meidinger, and J. Pojar (editors). 1998. Illustrated Flora of British Columbia. Volume 2: Dicotyledons (Balsaminaceae Through Cucurbitaceae). B.C. Ministry of Environment, Lands & Parks and B.C. Ministry of Forests. Victoria. 401 pp.

Fitch, W.H., W. G. Smith, and G. Bentham. 1880. Illustrations of the British Flora. 328 pp.

Harris, J.A. & Gill, A.M. 1997. History of the introduction and spread of St John's wort (*Hypericum perforatum* L.) in Australia. Plant Protection Quarterly, Vol. 12, 52–56.

> Authors' abstract: *Hypericum perforatum* has been introduced into Australia a number of times, the first being more than 100 years ago. It was cultivated in the Melbourne and Adelaide Botanic Gardens in 1858 and 1859, respectively, for potential use in home gardens. The earliest recorded outbreak of the wort was in 1880 at Bright, Victoria; i.e. escaped from a local garden where it was planted for medicinal purposes. Another outbreak occurred at Coromandel Valley in the Adelaide hills, possibly as early as 1881, and certainly by 1886. The earliest outbreak in New South Wales seems to have occurred at Mudgee in 1890 from either horse fodder or as a 'garden escape'. It now occurs in all States. Herbarium records suggest that its range was still increasing in the 1980s. Today it is still abundant in some localities, particularly in south-eastern Australia. For example, in 1986, 200 000ha of the Tablelands of New South Wales were heavily infested with the wort. The pattern of spread of St. John's wort has consisted of increasing numbers of isolated occurrences from which expansion has occurred until they coalesced. Spread rate was most rapid, perhaps through the accidental movement of seed associated with the movement of stock and their fodder, as well as through 'garden escapes' following deliberate plantings for horticultural use. Initially an agricultural problem, it is now more of a problem along roadsides and easements and in non-agricultural land, generally. Low levels of disturbance, such as mowing-burning-scarifying increased populations whereas frequent, intensive disturbance such as repeated ploughing used in tobacco cultivation, eliminated it. Population explosions could well be attributed to a changed disturbance regime in a locality, and/or seed longevity. That seeds may lie dormant in the soil for many decades underscores the ability of the species to 'return' to a site after a prolonged absence (such as under pine plantations) and to some extent independent of the cause of that absence.

Jacobs, J. 2007. Ecology and Management of Common St. Johnswort (*Hypericum perforatum* L.). United States Department of Agriculture, Natural Resources Conservation Service, Invasive Species Technical Note No. MT-14, 11 pp.

> Author's abstract: Common St. Johnswort is a perennial weed accidentally and intentionally introduced to North America from Europe. It is a member of the Clusiaceae family and also bares the common names St. John's wort, goatweed, and Klamath weed. Common St. Johnswort is perennial, relatively long-lived, and reproduces by short rhizomes that initiate from the stem base and by seed. Seeds can survive in the soil for ten years. Herbarium records indicate that populations of common St. Johnswort in Montana were first reported from Gallatin County in 1905 and as of 2007 have been reported from 26 of Montana's 56 counties infesting an estimated 68,065 acres. It is recognized as an economically important pest in temperate regions world-wide and has a long and storied history as a medicinal plant. It invades foothill rangeland, pastures, and open forest sites where it reduces available forage to livestock and wildlife and poses a threat of poisoning. It also occurs in riparian areas, along roadsides, and along railroad rights-of-way. Common St. Johnswort can be controlled using picloram (one to two quarts Tordon® per acre) or metsulfuron (one ounce Escort® or Cimarron® per acre) applied to actively growing plants before bloom. Grazing management of common St. Johnswort with all species of livestock is risky because it contains hypericin which causes blistering of skin of grazing animals that consume it and are exposed to the sun. In extreme cases, affected parts of the mouth may prevent animals from drinking and foraging. Five insects are available for biological control of common St. Johnswort. The release of two foliar feeding beetles in 1945 and 1946, *Chrysolina hyperici* and *C. quadrigemina*, were the first attempt at biological control using insects in the

United States and were very successful in reducing St. Johnswort populations in California.

Rutledge, C. R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. Jamestown, ND: Northern Prairie Wildlife Research Center Online. www.npwrc.usgs.gov/resource/plants/explant/index.htm

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Fact sheets, websites, and databases

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BC Ministry of Agriculture, Field Guide to Noxious and Other Selected Weeds of British Columbia: St. John's-Wort (*Hypericum perforatum*). www.agf.gov.bc.ca/cropprot/weedguid/stjohnsw.htm

BC Ministry of Forests, Lands and Natural Resource Operations, Biocontrol Agents Available for Redistribution. www.for.gov.bc.ca/hra/Plants/biocontrol/bioagents_available.htm#CHQU

BC Ministry of Forests, Lands and Natural Resource Operations. Invasive Plants with Biocontrol: St. John's Wort (*Hypericum perforatum*). www.for.gov.bc.ca/hra/Plants/biocontrol/bcmatrix.htm#SJ

Canadian Biodiversity Information Facility. Notes on poisoning: *Hypericum perforatum*. www.cbif.gc.ca/pls/pp/ppack.info?p_psn=39&p_type=all&p_sci=sci

Centre for Agricultural and Bioscience International, Invasive Species Compendium (Beta). *Hypericum calycinum*. www.cabi.org/isc/?compid=5&dsid=114902&loadmodule=datasheet&page=481&site=144

Coastal Invasive Plant Committee. St. John's Wort, *Hypericum perforatum* Control. www.coastalinvasiveplants.com/article/96-st-johns-wort

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www.esc.nsw.gov.au/weeds/Sheets/herbs/H%20St%20John%27s%20wort.htm

Jepson Online Interchange for California Floristics, University of California, Berkeley. *Hypericum calycinum* L. ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?HYCA10

Krueger, J., and R.Sheley. 2002. St. Johnswort (Hypericum perforatum). Montana State University Extension Service, Montguide MT199810 AG, 4 pp. www.ipm.montana.edu/cropweeds/Extension/weed%20species%20-not%20every%20file%20is%20here-/St%2520Johnswort.pdf

Missouri Botanical Garden, *Hypericum calycinum*. www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder/plant-details/kc/a520/hypericum-calycinum.aspx

United States Department of Agriculture, National Invasive Species Information Center, Plants, Species Profiles: St. Johnswort. www.invasivespeciesinfo.gov/plants/stjohnswort.shtml

United States Department of Agriculture, Natural Resources Conservation Service, PLANTS database profile: *Hypericum calycinum* L., Aaron's beard. www.plants.usda.gov/java/profile?symbol=HYCA10

Victoria Resources Online, New Zealand Department of Primary Industries, Land and Water Management, Impact Assessment – Large flowered St John's wort (*Hypericum calycinum)*in Victoria. vro.dpi.vic.gov.au/DPI/Vro/vrosite.nsf/pages/impact_large_flowered_stjohns_wort

Washington State Noxious Weed Control Board. Common St. Johnswort www.nwcb.wa.gov/detail.asp?weed=75

Washington State University, Clark County Extension, Pacific Northwest Plants database of searchable, categorized images. www.pnwplants.wsu.edu/PlantDisplay.aspx?PlantID=207

Weeds BC, A Guide to Weeds in British Columbia: St. John's-wort, *Hypericum perforatum* L. www.agf.gov.bc.ca/weedsbc/weed_desc/stjohns.html

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Personal communications

Sellentin, Ernie. Sellentin's Habitat Restoration & Invasive Species Consulting Ltd., Comox, BC. 27 January 2012.

Mr. Sellentin provides detailed information on biocontrol release methods, and will carry out releases. He commented that, "St. Johnswort is not considered a problem anymore as there is a very good biocontrol agent. New outbreaks are soon found and then hit hard by [the] defoliating beetle, *Chrysolina quadrigemina*. If you find [a St. Johnswort] site but no beetles, you can always bring some in to speed up the process. St.

Johnswort is [so widespread that] biocontrol is the only answer and increasing beetle numbers on a site early may stop further spread…If you are looking to purchase [I] could likely supply but I'll wager they are already at any significant sized infestations."