

**Annotated Bibliography on the
Ecology and Management of Invasive Species:**

Scotch broom (*Cytisus scoparius*)

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Abdallah-M-M-F {A}; Jones-R-A; El-Beltagy-A-S, 1989.

Title: An Efficient Method To Overcome Seed Dormancy In Scotch Broom
Cytisus-Scoparius.

Source: *Environmental-and-Experimental-Botany*. 1989; 29 (4): 499-505.

Language: ENGLISH

Abstract: Seeds of many wild members of the Leguminosae and Solanaceae have hard seed coats which restrict water absorption by the embryo. Failure to imbibe limits O₂ to the embryo and leaching of inhibitors, therein effectively enforcing dormancy of the embryo. For applied uses, dormancy-breaking treatments are required to provide more uniform and rapid seed germination responses. Permeability may be improved by scarifying the seed coat by mechanical means (e.g. clipping, abrasion or immersion in hot water) or chemically within strong oxidative agents (e.g. sulfuric acid, sodium hypochlorite). In either case, results obtained are often less than satisfactory and commonly a fraction of the seeds are damaged, significantly reducing the overall viability of the seed lot. A improved method of propagation from seed is desirable. We report there a simple, yet effective means to overcome dormancy in Scotch broom, a plant with potential value in dune erosion control. Sequential, rapid immersion in hot water followed by liquid nitrogen dramatically improved seed imbibition and germination responses by as much as 3.5 fold. The most effective immersion times and sequence of pretreatments were identified. The strategy outlined in this paper may be widely applicable to improving seed propagation of recalcitrant species.

Balneaves-John-M, 1992

Title: A comparison of surfactants to aid control of gorse and scotch broom with herbicides.

Source: *Plant-Protection-Quarterly*. 1992; 7 (3) 96-99.

Language: English

Abstract: Of the surfactants tested, only Silwet L-77 significantly enhanced the efficacy of glyphosate on gorse when used at 2.16 and 3.24 kg a.i. ha⁻¹ providing 100% mortality by 72 weeks. Frigate and Cidekick II appeared to antagonize glyphosate (3.24 kg a.i. ha⁻¹) control of gorse at the rates tested (2.0% and 0.75%, respectively). Metsulfuron-methyl at 120 g a.i. ha⁻¹ achieved 100% mortality of gorse without surfactant; while at 90 g a.i. ha⁻¹ the addition of Silwet L-77, Activator 90 or LI-700 gave faster brown-out and complete control. Bond appeared to antagonize metsulfuron-methyl. Triclopyr at 3.6 kg a.i. ha⁻¹ gave 100% gorse mortality without surfactant; the addition of Silwet L-77, Frigate, or Cidekick II increased the speed of kill. These surfactants added to 2,4,5-T/picloram (4.32/0.3 kg ha⁻¹) boosted gorse mortality to 100%. Complete mortality of Scotch broom was only achieved using glyphosate at 3.24 kg a.i. ha⁻¹ with the addition of either Silwet L-77 and LI-700. Metsulfuron-methyl at 90 g a.i. ha⁻¹ gave complete control but only with the addition of Silwet L-77. Activator 90 increased mortality of broom when added to both herbicides. Bond was ineffective with glyphosate and LI-700 was ineffective with metsulfuron-methyl (at the lower rate).

Balneaves-John-M, 1992.

Title: Silwet L-77 enhances rainfastness of glyphosate and metsulfuron-methyl when applied to gorse and Scotch broom.

Source: Plant-Protection-Quarterly. 1992; 7 (3) 109-111.

Language: English

Abstract: Glyphosate or metsulfuron-methyl with and without Silwet L-77 were applied to potted gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) plants, which were then subjected to simulated rainfall at intervals ranging from 2 min (0) to 24 hours after spraying. In the absence of Silwet L-77 rainfall reduced the effectiveness of both glyphosate and metsulfuron-methyl. Silwet L-77, especially at rates of 0.5%, aided rainfastness of glyphosate, and at 0.1% aided rainfastness of metsulfuronmethyl.

Balneaves-John-M, 1992.

Title: A comparison of surfactants to aid control of gorse and scotch broom with herbicides.

Source: Plant-Protection-Quarterly. 1992; 7 (4) 174-177.

Language: English

Abstract: Of the surfactants tested, only Silwet L-77 significantly enhanced the efficacy of glyphosate on gorse when used at 2.16 and 3.24 kg a.i. ha⁻¹ providing 100% mortality by 72 weeks. Frigate and Cidekick 11 appeared to antagonize glyphosate (3.24 kg a.i. ha⁻¹) control of gorse at the rates tested (2.0% and 0.75%, respectively). Metsulfuron-methyl at 120 g a.i. ha⁻¹ achieved 100% mortality of gorse without surfactant; while at 90 g a.i. ha⁻¹ the addition of Silwet L-77, Activator 90 or LI-700 gave faster brown-out and complete control. Bond

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Barrington Tops, Downey-P-O {a}; Smith-J-M-B, 2000.

Title: Demography of the invasive shrub Scotch broom (*Cytisus scoparius*) sat
Source: Austral-Ecology. [print] October, 2000; 25 (5): 477-485.

Language: English

Abstract: The exotic shrub Scotch Broom (*Cytisus scoparius*) has invaded large areas of eucalypt woodland at Barrington Tops, New South Wales, where it forms dense stands that have significant impacts on vegetation structure, flora and fauna. Data are presented from four 25 m² plots, which have been studied since 1985. Two plots were located in uniform broom thickets of different ages, and two were located across the margins of broom stands, which have since expanded to cover the entire plots. All broom plants in the plots (other than young seedlings, which were counted) were mapped, tagged and monitored annually. New seedlings appeared annually, but there was no relationship between their numbers (varying between years) and subsequent recruitment of older plants. The probability of seedlings reaching first flowering was less than 2%, and of surviving to mature size (> 10 cm² basal area) was negligible. Seedlings mainly died through suppression (shade). Individuals less than! 50 cm high were also browsed. Recruitment occurred only where light levels were high, either before closure of the broom canopy or after senescence had led to canopy opening. From approximately 12-30 years after initial invasion, broom stands underwent self-thinning of mature plants, accelerated by collapse of plants on to each other. Recruitment of new, maturing plants, after this period produced a stand that was less dense than that found after initial invasion. Broom is creating more disturbance-prone environments due to its impacts on other biota, likely alterations to the fire regime, and by harbouring feral pigs. Further disturbance favours broom, and elsewhere it has resulted in massive seedling regeneration. While fire or other disturbance can be used to stimulate germination, and thereby reduce a large part of the soil seed bank, denser broom infestations are likely to result unless follow-up treatments can be applied over long time periods. A wiser management option, at least in the short term, may be avoidance of all disturbance, especially for stands of mature broom.

Bellingham-P-J, 1998.

Title: Shrub succession and invasibility in a New Zealand montane grassland.

Source: Australian-Journal-of-Ecology. Dec., 1998; 23 (6) 562-573.

Language: English

Abstract: Two successive shrub invasions of a short tussock grassland induced by grazing and burning were examined in montane South Island, New Zealand. The first invasion was by a native shrub, matagouri (*Discaria toumatou* Raoul). The second invasion was by an exotic shrub, Scotch broom (*Cytisus scoparius* (L.) Link), which invaded the matagouri shrubland that had developed over the grassland. The invasions were investigated using analysis of spatial patterns of both shrubs and tussocks, and age, growth rates and size structure of the shrubs. Competition between the two shrub species was examined using spatial patterns and comparing allometric relationships. After initial invasion by matagouri of the grasslands, stand density increased by consolidation about its initial colonization points. Current matagouri distribution is often negatively associated with tussocks. Scotch broom occurs most frequently in a dense sward of introduced grasses and occasionally in tussocks in interstices among matagouri shrubs. Despite the palatability of Scotch broom to sheep that graze the site, there was no evidence that the spiny matagouri facilitates invasion by protecting Scotch broom seedlings; rather there was negative association between the shrub species. The two species probably compete for above-ground space. However, diameter and height growth rates of Scotch broom far exceed those of matagouri so Scotch broom is likely to increase in biomass rapidly at the site. The autogenic organization and disturbance history of the resident plant communities have rendered each vulnerable to successive invasions.

Bossard-C-C, 1991.

Title: The Role Of Habitat Disturbance Seed Predation And Ant Dispersal On Establishment Of The Exotic Shrub *Cytisus-Scoparius* In California Usa.

Source: American-Midland-Naturalist. 1991; 126 (1): 1-13.

Language: ENGLISH

Abstract: Effects of experimental habitat disturbance on seedling establishment of Scotch broom *Cytisus scoparius*, an alien shrub species now naturalized in California, were examined at two locations (the Sierra Nevada foothills and the northern coastal region). Variation in the species and foraging behaviors of ant dispersers of Scotch broom at the two sites resulted in differences in local seed dispersion at these sites. At the foothill location, soil disturbance significantly promoted seedling establishment. At the coastal site quail and grouse preferentially foraged in disturbed areas. The interaction of seed predators and dispersers modified the abiotic effects of habitat disturbance on seedling establishment, resulting in no significant differences being found among habitat disturbance treatments at the coastal site. Results of this study indicate effects of disturbance on seedling establishment of a given species are not generalizable

from one population or habitat to another.

Bossard-C-C {A}; Rejmanek-M, 1992.

Title: WHY HAVE GREEN STEMS?

Source: Functional-Ecology. 1992; 6 (2): 197-205.

Language: ENGLISH

Abstract: Photosynthetic activity of the cortical tissues of *Cytisus scoparius*. Link stems were examined in regard to individual biomass production and allocation, structural attributes of stem tissue, chlorophyll content, photosynthetic rates and ability to recover from herbivory. Biomass production and allocation were assessed through growth analysis of plants given one of four treatments: all stems loosely wrapped with aluminium foil; plants defoliated once; plants defoliated repeatedly; and controls. Stem photosynthesis made a significant contribution to growth and biomass production of this mesic species. Cortical stem tissue is structurally very similar to leaf tissue. Chlorophyll content and biomass accumulation of stems, leaves, roots, and nodules changed significantly with simulated herbivory. Apparently, in *Cytisus scoparius*, stem photosynthesis helps meet different needs, depending on which factor or combination of factors are most critical in any given habitat. For an invasive, weedy perennial like *Cytisus scoparius*, this flexibility may itself be the most important benefit of having photosynthetic stems. Photosynthetic stems may play an important role in the success of leguminous shrubs in general and in the success of invasive leguminous shrubs in particular.

Bossard-C-C {a}; Rejmanek-M, 1994.

Title: Herbivory, growth, seed production, and resprouting of an exotic invasive shrub *Cytisus scoparius*.

Source: Biological-Conservation. 1994; 67 (3) 193-200.

Language: English

Abstract: *Cytisus scoparius* (L.) Link (Scotch broom) is a nonnative shrub species now naturalized in California, currently occupying over 250,000 ha including several protected areas. In this paper, the impact of biocontrol agents and of general herbivory on two *C. scoparius* populations (one in the Sierra foothills and one along the California northern coast) were assessed and the productivity characteristics, seed production, and resprouting capabilities of this exotic species were determined in the field. The growth period occurs in May/June with dieback or no growth discernable from August to March. Estimated mean total number of viable seeds/shrub/year was 9650. The number of pods and seeds produced in the drought year 1988 was an order of magnitude lower than those produced in 1987 or 1989. In spite of the introduction of biological control agents, no significant vertebrate or invertebrate herbivory was found at any life stage of the foothills population; however, vertebrate herbivory significantly decreased biomass of the northern coast *C. scoparius*. Cutting at the end of the

dry season significantly decreased the rate of resprouting. Implications of this study for biocontrol are discussed.

Clements-David-R {a}; Peterson-David-J; Prasad-Raj, 2001.

Title: The biology of Canadian weeds. 112. *Ulex europaeus* L.

Source: Canadian-Journal-of-Plant-Science. [print] April, 2001; 81 (2): 325-337.

Language: English

Abstract: Gorse (*Ulex europaeus* L.) is a leguminous shrub native to western Europe and North Africa. During the past century it has greatly expanded its adventive range in Australia, New Zealand, Chile and Europe, and along the Pacific and Atlantic coasts of North America. In Canada, it is found in British Columbia (Vancouver, Vancouver Island, the Gulf Islands and Queen Charlotte Islands) where it is classed as a noxious weed. Gorse is also found from Virginia to Massachusetts on the east coast of North America. The shrub rapidly invades dry and disturbed areas, forming dense thickets that can suppress and inhibit native vegetation, including economically important conifer seedlings. It can occupy the same habitats as Scotch broom (*Cytisus scoparius* (L.) Link) but usually occurs on drier sites. Both of these legumes threaten native plant communities but *U. europaeus* persists longer and possesses conspicuous spines. Invasive characteristics of gorse include its evergreen habit, prolific seed production, longevity of seeds in the soil and nitrogen fixation. Human activities such as agriculture and construction of logging roads have accelerated the spread of gorse in British Columbia, but there is still an historic opportunity to restrict the population expansion that this species has exhibited in many other countries. Various methods of control (chemical, manual, biological and integrated) are evaluated.

Dungan-R-J {a}; Norton-D-A {a}; Duncan-R-P, 2001.

Title: Seed rain in successional vegetation, Port Hills Ecological District, New Zealand.

Source: New-Zealand-Journal-of-Botany. [print] March, 2001; 39 (1): 115-124.

Language: English

Abstract: Patterns in vegetation and seed rain were measured in an abandoned agricultural scrubland/forest system in lowland Canterbury to test relationships between patterns of seed rain and succession in seral scrub and established low forest. Indicator species analysis separated four distinct vegetation types which formed a successional chronosequence confirmed by air-photo interpretation and analysis of vegetation composition. Vegetation biomass (approximated by summed species importance scores) and species richness (mean species plot-1) both increased with successional stage. Although there was a significant difference in seed rain density among vegetation types, the relationship between seed rain and succession was clouded by individual species fecundity. There was a significant positive relationship between successional stage and seed rain

species richness. The proportion of seed species present in seed rain but absent from extant vegetation was greater in less advanced vegetation. This relationship was determined by low species richness in the vegetation and a suite of highly mobile seed species, typical of more mature forest, common to all vegetation types. We conclude that forest recovery is not dispersal limited in the forest and seral scrub vegetation we investigated, and that with the continued absence of grazing pressure forest recovery should be rapid.

Edwards-G-R {a}; Crawley-M-J, 1999.

Title: Herbivores, seed banks and seedling recruitment in mesic grassland.

Source: Journal-of-Ecology. June, 1999; 87 (3): 423-435.

Language: English

Abstract: 1 An experiment was carried out in a species-poor acid grassland to determine the effect of insect, mollusc and rabbit herbivory on the size and composition of the seed bank and on seedling recruitment from the seed bank and seed rain. From 1991 to 1997, insects and molluscs were excluded with pesticides, and rabbits with fences. Seedling recruitment was monitored over 22 months in gaps established in the vegetation in summer 1995. 2 The most common species recorded from the seed bank in early summer 1995 were dicots (17 species), but perennial grasses (five species) were numerically the most abundant (65% of total). There was no relationship between the species composition of the seed bank and the established vegetation. 3 The size of the seed bank of eight species was greater on fenced plots, a result that reflected increased seed rain where rabbits were excluded. Insects and molluscs had no effect on the size of the seed bank of any species. The number of species in the seed bank was not affected by any of the herbivore exclusions. 4 A comparison of seedling emergence in gaps formed over the original soil with gaps where the soil had been sterilized indicated that only *Galium saxatile* and *Cytisus scoparius* recruited from the seed bank. Seedling recruitment was almost entirely derived from the recent seed rain, was dominated by the most abundant perennial grasses in the vegetation (*Festuca rubra* and *Holcus lanatus*), and had a species composition that resembled the established vegetation. Results highlight that the potential for seedling establishment in gaps to bring about vegetation change in this grassland is low. 5 Six species had higher seedling densities on rabbit-fenced plots, but the significant effect of fencing disappeared by plant maturity for most species. Survival of seedlings was lower on fenced plots where non-grazed biomass accumulated, so that after 22 months *Agrostis capillaris* was the only species with more plants present where rabbits were excluded. *Rumex acetosa* and *Stellaria graminea* showed higher seedling emergence where molluscs were excluded. More seedlings of *Rumex acetosa* were also found where insects were excluded. These invertebrate effects were still evident at plant maturity.

Engel, H, 1964.

TITLE: The control of Broom (*Cytisus scoparius*) by helicopter.

SOURCE (BIBLIOGRAPHIC CITATION): 1964, *Gesunde Pflanzen*, Bad Godesberg 16 (1), 1964 (15-9). From abstr. in *Weed Abstr.* 13 (5), 1964 (1341).

ABSTRACT: Broom infesting 34.3 ha. of degenerate hill pasture in W. Germany was completely killed 6-9 months after thorough wetting with U46 Special (2,4-D + 2,4,5-T esters) applied by helicopter at 5 litres in 35 litres spray/ha., during flowering in June 1962. *Calluna vulgaris*, *Rubus fruticosus*, *R. idaeus* and *Rosa* spp. were also virtually eliminated, but there was no effect on *Crataegus monogyna* or *Juniperus communis*, and male fern [*Dryopteris filix-mas*] and teasel [*Dipsacus* sp.] received only a check to growth. Cost of treatment was ca. DM. 103.2/ha. and removal of dead Broom cost DM. 296.25/ha.

DESCRIPTORS: Aircraft,-use-in-forestry-weedkillers; *Calluna-vulgaris*; *Crataegus-monogyna*; *Cytisus-scoparius*; Grazing-and-pasture; Heather-chemical-control; Helicopters-application-of-weedkillers; *Juniperus-communis*; *Rosa*-spp.; *Rubus-fruticosus*; *Rubus-idaeus*; Silviculture-; Weedkillers,-application,-effects-&c.-aerial-sprays; Weedkillers-2,4-D-and-2,4,5-T

Esteban-Malo-Juan; Baonza-Jorge; Suarez-Francisco, 1995.

Title: Differences within and between populations, and between successive years in floral morphology of *Cytisus scoparius* (L.) Link.

Source: *Anales-del-Jardin-Botanico-de-Madrid*. 1995; 53 (1) 33-40.

Language: Spanish; Non-English

Abstract: The variability of three flower traits of *Cytisus scoparius* (length of standard, asymmetry and intra-plant variability in flower size) is analyzed at three levels: within a population, between populations and between successive years. The study was carried out on two populations, one central and one marginal in the altitudinal gradient occupied by the species in Madrid Province (Central Spain). The length of the standard shows significant differences among plants in each population, between populations, being also significant the interactions year times population and year times plant. Flowers are larger in the central population and in the mild-weather year. Flower size is less variable in the central population and in the second year, and asymmetry is reduced in the central population. Results suggest that size, variability and asymmetry of flowers may be under selective pressures from pollinators, and that plants from the peripheral population may be less able to cope with pollinator demands than plants from the central population.

Fogarty-Gael {a}; Facelli-Jose-M, 1999.

Title: Growth and competition of *Cytisus scoparius*, an invasive shrub, and Australian native shrubs.

Source: *Plant-Ecology*. [print] September, 1999; 144 (1): 27-35.

Language: English

Abstract: English broom (*Cytisus scoparius*) is an aggressive invasive shrub in native sclerophyll forests of South Australia. We studied its relative growth rate (RGR) and competitive ability in soils from invaded and uninvaded woodlands, in comparison to three native species it commonly displaces: *Hakea rostrata*, *Acacia verniciflua*, and *A. myrtifolia*. *Hakea* was the slowest growing species throughout the year. Both native species had their highest RGR during spring. The RGR of broom was higher than that of both *Hakea* and *Acacia* in the winter and spring. Despite losing its leaves in the summer, the RGR of broom through the year was higher than that of either of the native species. Soil from the invaded stands had higher organic C, N and soluble P than that from uninvaded sites. Broom and *Acacia* grew better in the higher nutrient soil than in the lower nutrient soil. Competition did not decrease the final biomass of any of the species in low nutrient soil. In the higher nutrient soil the biomass of broom was reduced by competition with *Acacia*, but not by competition with *Hakea*. Competition by broom reduced the biomass of *Hakea* but not that of *Acacia*. Broom's earlier and higher RGR, high competitiveness in nutrient rich soils, and probably its ability to change nutrient availability could be important contributors to the mechanisms by which it invades native woodlands.

Garcia-Gallo-A {A}; Wildpret-De-La-Torre-W; Del-Arco-Aguilar-M-J; Perez-De-Paz-P-L, 1989.

Title: On The Presence Of *Ulex-Europaeus* L. In Tenerife Canary Islands.

Source: *Boletim-da-Sociedade-Broteriana*. 1989; 62 (2): 221-226.

Language: SPANISH

Abstract: Several considerations about the bushes dominated by *Ulex europaeus* L. subsp. *europaeus* in Tenerife, are made, as well as, we mentioned the meddlings of *Cytisus scoparius* and *Spartium junceum* in the insular territory.

Harman-H-M , 1999.

Title: The effect of variability in the phenology of the reproductive stages of Scotch broom (*Cytisus scoparius*) on the synchronization of the life stages of broom seed beetle (*Bruchidius villosus*) in New Zealand.

Source: *Biological-Control*. July, 1999; 15 (3): 228-234.

Language: English

Abstract: Variability in timing of the reproductive stages of Scotch broom (*Cytisus scoparius*) may influence synchronization and establishment of the broom seed beetle (*Bruchidius villosus*), a biological control agent. A sampling scheme was devised to compare the phenologies of Scotch broom at different sites in the same season and in different seasons at the same site. The synchrony of the broom seed beetle's life stages with those of the host plant was also determined. The phenology of Scotch broom varied only slightly from season to season at Lincoln, but could vary considerably between sites in the same season.

At both sites where it is established, the broom seed beetle was synchronized with its host; adult beetles were present throughout the flowering period. Eggs were found on suitable green pods. The broom seed beetle appears capable of adapting to the phenology of its host and has the potential to be an effective agent for Scotch broom. Variability in phenology of the reproductive stages of Scotch broom, even at nearby sites, must be taken into account by practitioners of biological control when releasing broom seed beetles and later when sampling beetles to determine establishment.

Helgerson, O. T., Gordon, J. C., Perry, D. A., 1984.

Title: N₂ fixation by red alder (*Alnus rubra*) and scotch broom (*Cytisus scoparius*) planted under precommercially thinned Douglas-fir (*Pseudotsuga menziesii*).

Language: English

Subjects: Nitrogen/Fixation

Feature Article.

Source: Plant and Soil.

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Hoshovsky, Marc, 2000.

Element Stewardship Abstract for *Cytisus scoparius* and *Genista monspessulanus* Scotch broom and French broom. The Nature Conservancy.

Hosking-J-R {a}; Smith-J-M-B; Sheppard-A-W

Title: The biology Australian weeds: 28. *Cytisus scoparius* (L.) Link subsp. *scoparius*.

Source: Plant-Protection-Quarterly. 1996; 11 (3) 102-108.

Publication Year: 1996

Language: English

Johnston-Peter-R {a}; Parkes-Stephanie-L {a}; Broadhurst-Philip-G, 1995.

Title: Fungi associated with gorse and broom in New Zealand.

Source: Australasian-Plant-Pathology. 1995; 24 (3) 157-167.

Language: English

Abstract: Interest in the possibility of biological control of gorse and broom with fungal pathogens prompted a survey across New Zealand of fungi associated with diseased stem and leaf tissue of these weeds. New disease records made during the survey include: *Ascochyta ulicis*, *Botryosphaeria dothidea*, *Gibberella*

avenacea, *G. baccata*, *Glomerella cingulata* and *Septoria slaptonensis* on gorse; *Armillaria* sp., *Botryosphaeria dothidea*, *Colletotrichum acutatum*, *Gibberella avenacea* and *G. baccata* on broom. Of the species found during the survey *Pleiochaeta setosa* on broom and *Gibberella tumida* on broom and gorse may have potential for development as mycoherbicides. Notes are provided on the biology of all species known from gorse and broom in New Zealand, including those found during the survey, others previously reported in the literature, and species deposited in Herbarium PDD.

Lambert-M-G {A}; Jung-G-A; Harpster-H-W; Lee-J, 1989

Title: Forage Shrubs In North Island New Zealand Hill Country 4. Chemical Composition And Conclusions.

Source: New-Zealand-Journal-of-Agricultural-Research. 1989; 32 (4): 499-506.

Language: ENGLISH

Abstract: A range of shrubs was evaluated as potential sources of forage for grazing animals. Shrubs were established in rows in hill pastures near Woodville. Nine "true" shrubs, and two erect grasses, pampas grass (*Cortaderia selloana*) and toetoe (*C. fulvida*) were evaluated. The true shrubs were: *Chamaecytisus palmensis*, tagasaste; *Medicago arborea*, tree medic; *Ulex europaeus*, gorse (two variants: wild gorse and short-spined gorse); *Cytisus scoparius*, broom; *Robinia pseudoacacia*, black locust; *Leptospermum scoparium*, manuka; *Cassinia leptophylla*, tauhinu; and *Ceanothus griseus*, ceanothus. Nitrogen, and in most instances macro and micro-element, concentrations of leaf were higher than those of stem. Foliage of manuka, tauhinu, pampas, and toetoe was not an adequate nitrogen source for lactating ewes, and all species were deficient in phosphorus. Tauhinu, pampas, and toetoe were magnesium-deficient, and tagasaste, broom, black locust, and ceanothus were sodium-deficient. Leaf material consistently had lower neutral-detergent-fibre and acid-detergent-fibre concentrations than stem. On average, leaf also had lower lignin concentrations but this was not consistent across species. Toetoe pampas, hay, both gorses, and manuka had particularly high fibre levels in the foliage, and the gorses, manuka, and ceanothus had high lignin concentrations.

Lambert-M-G {A}; Jung-G-A; Harpster-H-W; Budding-P-J; Wewala-G-S, 1989.

Title: Forage Shrubs In North Island New Zealand Hill Country 3. Forage Digestibility.

Source: New-Zealand-Journal-of-Agricultural-Research. 1989; 32 (4): 491-498.

Language: ENGLISH

Abstract: A range of shrubs was evaluated as potential sources of forage for grazing animals. Shrubs were established in rows in hill pastures near Woodville. Nine "true" shrubs, and two erect grasses, pampas grass (*Cortaderia selloana*), and toetoe (*C. fulvida*) were evaluated. The true shrubs were: *Chamaecytisus palmensis*, tagasaste; *Medicago arborea*, tree medic; *Ulex*

europaeus, gorse (two variants: wild gorse and short-spined gorse); *Cytisus scoparius*, broom; *Robinia pseudoacacia*, black locust; *Leptospermum scoparium*, manuka; *Cassinia leptophylla*, tauhinu; and *Ceanothus griseus*, ceanothus. Digestibility of shrubs was assessed by in situ (nylon bag) digestion in cows' rumens, and by in vitro (cellulase) methods. The two methods ranked most forages similarly, but some inconsistencies did occur. Tree medic and tagasaste were highly digestible (71-73% estimated in vivo DM digestibility). Manuka, pampas, and toetoe had low digestibility (48-56%). Stem material was less digestible than leaf. Digestibility was strongly related to combinations of functions of cell wall content, degree of lignification, and degree of silicification. Oesophageal-fistulated sheep and goats were allowed to graze each of the shrub species in the field. They selected a diet 5-6% units more digestible than the average of the forage on offer.

Lambert-M-G {A}; Jung-G-A; Fletcher-R-H; Budding-P-J; Costall-D-A, 1989.

Title: Forage Shrubs In North Island New Zealand Hill Country 2. Sheep And Goat Preferences.

Source: New-Zealand-Journal-of-Agricultural-Research. 1989; 32 (4): 485-490.

Language: ENGLISH

Abstract: A range of shrubs was evaluated as potential sources of forage for grazing animals. Shrubs were established in row in hill pastures near Woodville. Nine "true" shrubs, and two erect grasses, pampas grass (*Cortaderia selloana*) and toetoe (*C. fulvida*) were evaluated. The true shrubs were: *Chamaecytisus palmensis*, tagasaste: *Medicago arborea*, tree medic; *Ulex europaeus*, gorse (two variants: wild gorse and short-spined gorse); *Cytisus scoparius*, broom; *Robinia pseudoacacia*, black locust; *Leptospermum scoparium*, manuka; *Cassinia leptophylla*, tauhinu; and *Ceanothus griseus*, ceanothus. Harvested forages were fed to individually housed sheep and goats. Pairs of forages were offered to animals for 6-10 min, and consumption over that period was used to calculate relative preferences. Preference of sheep for broom, pampas, and pasture was greater than preference of goats for these species. Conversely, goats preferred short-spined gorse, manuka, and ceanothus in comparison with sheep. In general, hay, gorse, and tagasaste were of high preference and toetoe, pampas, and tauhinu of low preference for both sheep and goats.

Lambert-M-G {A}; Jung-G-A; Costall-D-A, 1989.

Title: Forage Shrubs In North Island New Zealand Hill Country 1. Forage Production.

Source: New-Zealand-Journal-of-Agricultural-Research. 1989; 32 (4): 477-484.

Language: ENGLISH

Abstract: A range of shrubs was evaluated as potential sources of forage for grazing animals. Shrubs were established in rows in hill pastures near

Woodville. Nine "true" shrubs and two erect grasses, pampas grass (*Cortaderia selloana*) and toetoe (*C. fulvida*), were evaluated. The true shrubs were: *Chamaecytisus palmensis*, tagasaste; *Medicago arborea*, tree medic; *Ulex europaeus*, gorse (two variants: wild gorse and short-spined gorse); *Cytisus scoparius*, broom; *Robinia pseudoacacia*, black locust; *Leptospermum scoparium*, manuka; *Cassinia leptophylla*, tauhinu; and *Ceanothus griseus*, ceanothus. Based on four harvests per year (one each season), the most productive species were: wild gorse (817 g dry matter (DM)/m row); pampas (677); broom (581); toetoe (538); tagasaste (422); and black locust (315). These values were more than doubled where harvests were made only once as opposed to 4 times annually. Comparative pasture production was 422 g DM/m row. Percentage of leaf in the harvested material from the true shrubs (on an annual basis) was 21% (broom)-82% (short-spined gorse) for seasonal cuts and 8-75% respectively one annual cut.

Memmott-Jane {a}; Fowler-Simon-V; Paynter-Quentin; Sheppard-Andrew-W; Syrett-Pauline, 2000.

Title: The invertebrate fauna on broom, *Cytisus scoparius*, in two native and two exotic habitats.

Source: *Acta-Oecologica*. [print] May-June, 2000; 21 (3): 213-222.

Language: English

Abstract: This study quantifies the invertebrate fauna found on broom, *Cytisus scoparius*, L. (Link), in two countries where it grows as a native plant (France and England) and two countries where it grows as an alien plant (New Zealand and Australia). The data are used to test three hypotheses concerning the predicted differences in invertebrate community structure in native versus exotic habitats: (1) Are generalist phytophages dominant in exotic habitats and specialist phytophages dominant in native habitats? (2) Are there empty phytophage niches in exotic habitats? (3) As a plant species accumulates phytophages, do these in turn accumulate natural enemies? The broom fauna was sampled at five sites in each country by beating five broom bushes per site. The sampling efficiency of beating was quantified at one field site and it was shown to collect 87 % of invertebrate abundance, 95 % of invertebrate biomass and 100 % of phytophagous species found on the branches. Generalist phytophages were dominant on broom in exotic habitats and specialists dominant on broom in the native habitats. Thus, the two countries where broom grows as a native plant had higher numbers of total phytophage species and a higher abundance of specialist phytophages per bush. There was no significant difference in the average abundance of generalist phytophage species found per bush in native and alien habitats. Phytophages were assigned to seven feeding niches: suckers, root feeders, external chewers, flower feeders, seed feeders, miners and pollen feeders. Empty niches were found in the exotic habitats; species exploiting structurally specific parts of the host plant, such as flowers and

seeds, were absent in the countries where broom grows as an alien plant. The pattern of niche occupancy was similar between native and exotic habitats when just the generalist phytophages were considered. As phytophage abundance and biomass increased, there were concomitant increases in natural enemy abundance and biomass. Thus, it appears that as plants accumulate phytophages, the phytophages in turn accumulate natural enemies and a food web develops around the plant. Moreover, in the native countries, the history of association between the natural enemies and their prey has been sufficient for specialist predators and parasitoids, feeding on the specialist phytophages, to have evolved.

Morin-Louise {a}; Gianotti-Alison-F; Barker-Richard; Johnston-Peter-R, 1998.

Title: Favourable conditions for the bioherbicide candidate *Fusarium tumidum* to infect and cause severe disease on gorse (*Ulex europaeus*) in the controlled environment.

Source: *Biocontrol-Science-and-Technology*. June, 1998; 8 (2) 301-311.

Language: English

Abstract: The development of the pathogenic fungus *Fusarium tumidum* on gorse (*Ulex europaeus*), a major weed of pastures and plantation forests in New Zealand, was studied under controlled conditions. *F. tumidum*, like most other foliar fungal pathogens, requires moisture to infect plants. Long, continuous dew periods (gtoreq 24 h) after inoculation of plants provided favourable conditions for infection. The fungus, however, also caused severe disease on young plants (2 months old) exposed to two or three 12-h dew periods interrupted by 12-h dry periods. A delay of 24 h before inoculated plants were exposed to dew did not affect the severity of the disease. *F. tumidum* infected plants over a wide range of temperatures (5-27degree C), but more plants were killed as temperatures increased during the initial infection phase. All gorse plants tested (up to 4 months old) were susceptible to the fungus, but younger plants were more easily killed. Nevertheless, the biomass of older plants that were severely diseased but not killed by the fungus was significantly reduced. The effectiveness of *F. tumidum* in killing plants increased with the density of inoculum sprayed. The fungus applied at a density of 1×10^6 conidia/ml killed more than 95% of 1.5-month-old plants. This basic knowledge of the *F. tumidum*-gorse system will assist in the development of a pilot bioherbicide to control gorse and broom (*Cytisus scoparius*), another economically important weed in New Zealand which is also susceptible to the fungus.

Morin-Louise {a}; Gianotti-Alison-F; Lauren-Denis-R, 2000.

Title: Trichothecene production and pathogenicity of *Fusarium tumidum*, a candidate bioherbicide for gorse and broom in New Zealand.

Source: *Mycological-Research*. [print] August, 2000; 104 (8): 993-999.

Language: English

Abstract: The relationship between trichothecene production and pathogenicity was investigated for 29 isolates of *Fusarium tumidum*, a potential bioherbicide for gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) in New Zealand. All isolates originally derived from broom produced high levels of T-2 tetraol derivatives when grown on ground maize kernels and pearl barley grains, compared with isolates from gorse. Low amounts of scirpentriol derivatives were also produced by both groups of isolates. No nivalenol and deoxynivalenol derivatives were detected in any of the culture extracts. A subset of isolates cultured on gorse and broom tissue produced only small amounts of T-2 tetraol derivatives relative to the amounts produced in grain cultures. Overall, isolates from broom were more aggressive towards both hosts than isolates from gorse, but the pathogenicity of isolates was not correlated with their capacity to produce large amounts of T-2 tetraol derivatives in culture. Two isolates from gorse were highly aggressive towards both weeds. These isolates offer prospects for the development of a safe bioherbicide that could target two major weeds in New Zealand, as trichothecenes were not detected from them at the higher concentrations.

Paynter, Quentin, Simon V. Fowler, Jane Memmott, 1998.

Title: Factors affecting the establishment of *Cytisus scoparius* in southern France: implications for managing both native and exotic populations.

Title Variant: with appendix.

Language: English

Subjects: Brooms (Shrubs), Weeds/Control; Germination/Seedling emergence
Feature Article.

Source: The Journal of Applied Ecology. ISSN: 0021-8901.

Volume/Issue: 35 no4. Pages: 582-95. Date: Ag '98.

Record Type: article.

Physical Description: bibl il.

Parker-Ingrid-M, 1997.

Title: Pollinator limitation of *Cytisus scoparius* (Scotch broom), an invasive exotic shrub.

Source: Ecology-Washington-D-C. 1997; 78 (5) 1457-1470.

Publication Year: 1997

Language: English

Abstract: Introductions of exotic species provide unique opportunities to study the demographic significance of species interactions, but as yet there is little information on how mutualistic interactions affect the invasion process. A shortage of mutualists could potentially limit the rate of population growth for an invading species. The introduced shrub *Cytisus scoparius* (Scotch broom, Leguminosae) is a pest plant on the west coast of North America. It produces

flowers that are "tripped" open when pollinated and has a nearly obligatory relationship with resident humble bees and honey bees. Experiments in the state of Washington showed that 1% of untripped flowers produced fruits and that outcross-pollinated flowers yielded four-fold more fruit than self-pollinated flowers, revealing apparent inbreeding depression. Mean pollinator visitation rate, as determined by the proportion of flowers tripped, varied among three years and among four populations but was low (3-30%) in every case. Two urban populations (Magnuson Park and Discovery Park in Seattle) received higher numbers of visits than two native prairie populations (Johnson Prairie and 13th Division Prairie in southwestern Washington). Hand-pollination experiments revealed significant pollinator limitation in all populations in both 1993 and 1994, with the mean increase in fruit production ranging from 280 to 2620%. Prairie populations were more pollinator limited than urban populations. Resources available for per-flower fruit production appeared to be equally available in all populations in 1993 but more available in prairie populations than in urban populations in 1994. The relationship between natural visitation and proportion fruit set per branch was a saturating curve in 1993 but a linear function in 1994 and 1995. Significant correlations were found between pollinator visitation and variation in whole-plant fruit production in all 3 yr. No evidence was found for either (1) reallocation of resources between branches within a season, or (2) a cost of reproduction between seasons in plants receiving supplemental pollen. Demographic analysis showed that a very large cost of reproduction would be required to counterbalance the increase in fecundity achieved with full pollination. Simulations of new populations invading over a short time scale (10-30 yr) demonstrated little effect of pollen limitation in the slow-growing urban populations, but a potentially large effect of increasing pollinator visitation in the rapidly invading prairie populations.

Parker-Ingrid-M, 2000.

Title: Invasion dynamics of *Cytisus scoparius*: A matrix model approach.

Source: Ecological-Applications. [print] June, 2000; 10 (3): 726-743.

Language: English

Abstract: It is at the level of population dynamics that an invasion either fails or succeeds. By elucidating patterns of variation in population growth rates or demographic rates, it is possible to forge a connection between quantitative field data and theoretical ideas about invasiveness, invasibility, and rates of spread. Demographic models also provide a tool to guide control strategies for invasive pests. Here I report the results of a demographic study of *Cytisus scoparius*, an exotic shrub on the west coast of North America. I used matrix population models to describe demographic patterns in six populations (three in prairies and three in urban fields) and across advancing stages of invasion. At the edge of the invading front, all populations showed finite rates of increase (λ) > 1; however, prairie populations were increasing much more rapidly than urban

ones. While many individual vital rates differed between prairie and urban populations, Life Table Response Analysis revealed that seedling establishment made by far the largest contribution to the difference in growth rate between the habitats. Establishment is much higher in the prairies, which are also less anthropogenically disturbed and show higher plant species diversity. From the edge of the invading population to the center, λ generally decreased, and the elasticity pattern changed from one evenly distributed across life history stages to one dominated by the survivorship of large adults. Comparing the matrix model predictions to direct estimates of invasion (change over time of various measures of density and biomass), λ was most closely correlated with the increase of total biomass. From a control perspective, elasticities did not suggest one particularly sensitive life history stage ("Achilles heel") for this pest plant. A simulation was used to evaluate the potential efficacy of biological control agents that attack seeds. Based on model predictions, under current conditions a control agent would have to destroy over 99.9% of seeds in prairies, and 70% of seeds in urban populations, to suppress the invasion of *C. scoparius* populations.

Partridge-T-R, 1989.

Title: Soil Seed Banks Of Secondary Vegetation On The Port Hills And Banks Peninsula Canterbury New Zealand And Their Role In Succession.

Source: New-Zealand-Journal-of-Botany. 1989; 27 (3): 421-436.

Language: ENGLISH

Abstract: Soil seed banks at 21 sites covered with poor quality pasture, bracken fernland, scrubland of broom or gorse, and various forest types, were examined by germinating seed in soil samples. At most sites the composition of upper and lower soil layers was similar. Persistent, deeply buried seed banks of *Cytisus scoparius*, *Ulex europaeus*, and more rarely *Sophora microphylla*, were discovered at seven sites, four of which lacked that particular species in the above-ground vegetation, and are thus considered to be a former vegetation type. Forest sites tended to have more seeds and more species represented in the soil seed bank. Although an average of only 35% of the species in the seed bank were represented above ground at the sampling point, this rose to 60% within 5 m, and 72% within 10 m of that point. Those species further away were mostly widespread pasture weeds, even within forest sites, and are interpreted as being recently dispersed and transient. Large quantities of *Juncus* spp. in some sites are believed to be transported by water movement through the soil. Some species, including certain site dominants, were poorly or never represented in the soil seed bank. It is considered that the seed bank has an important role in establishing the initial floristic composition following disturbance.

However, differential seedling survival, resprouting, and competition probably help in maintaining the predisturbance vegetation at non-forest sites. Where forest is disturbed, especially by burning, there is the potential for a completely

different vegetation to develop from the seed bank.

Peterson, David J. and Raj Prasad, 1998.

Title: The biology of Canadian weeds. 109. *Cystisus scoparius* (L.) Link.

Source: Canadian-Journal-of-Plant-Science. July, 1998; 78 (3) 497-504.

Language: English

Abstract: Scotch broom (*Cytisus scoparius* (L.) Link.) is an exotic perennial, leguminous, deciduous shrub, which during the past century has greatly expanded its range along the Pacific and Atlantic coasts of North America, and in Australia, New Zealand, South Africa, Chile, Iran, and India. This shrub rapidly invades disturbed areas, forming dense thickets, which can suppress and inhibit native vegetation, including economically important conifer seedlings. The developmental characteristics whereby Scotch broom invades new sites include specialized stem photosynthesis, prolific seed production, longevity of seeds in the soil, and nitrogen fixation. Human activities such as planting along highways for beautification and prevention of soil erosion have accelerated the problem of rapid geographical dispersal. Various methods of control (chemical, manual, and biological) together with habitat, morphology, reproductive biology, growth and development are discussed.

Rees-Mark {a}; Paynter-Quentin, 1997.

Title: Biological control of Scotch broom: Modelling the determinants of abundance and the potential impact of introduced insect herbivores.

Source: Journal-of-Applied-Ecology. 1997; 34 (5) 1203-1221.

Language: English

Abstract: 1. Simulation and analytical models are developed for the European shrub Scotch broom *Cytisus scoparius* Link (Fabaceae). The simulation model is spatially explicit and allows us to explore not only changes in population size but also the proportion of ground covered by the weed. The simulation model incorporates spatially local density-dependent competition, asymmetric competition between seedlings and established plants, a seed bank, local seed dispersal and an age-structured established plant population. This model is designed to incorporate much of the known population biology of broom. The analytical models are simple approximations of the simulation. 2. The basic model contains nine parameters: the probability a site is disturbed, p -dist; the probability a seed becomes a seedling, g ; the probability a seedling survives the first year, s ; the probability a seed is lost from the seed bank, d , the minimum age for reproduction, A -min; maximum plant age, A -max; seed production per site, F ; the probability a seed is retained in the parental site, f -h; and the probability a site becomes suitable for colonization after broom senesces, p -so. 3. We review published data on the demography of broom from studies around the world, and also present some previously unpublished data. These data suggest that broom

in some exotic habitats can achieve higher fecundities and live longer than in its native range. 4. Analytical approximations provide a good description of the simulation results over a wide range of biologically reasonable parameter values. Specifically, the analytical models work well when plants are long-lived or highly fecund. 5. Analysis of the models indicates that when broom colonizes all suitable sites with probability one, that the fraction of sites occupied by broom is determined by only three parameters: the probability of disturbance, p -dist; the probability a site becomes suitable for colonization following plant senescence! , p -so; and maximum longevity, A -max. In exotic habitats, where individual broom plants can produce several thousand seeds, differences in these parameters are the most likely reason why broom populations are more weedy than in the native range. 6. The impact of insect herbivores, which reduce plant fecundity, on broom abundance is explored for several environmental scenarios. This analysis suggests that potential biological control agents are most likely to have a substantial impact if the disturbance rate is high, plant fecundity is low, and seedling survival is low. Even herbivores that reduce seed production by only 75% can have a dramatic impact on broom abundance, in contrast to several published predictions. 7. Extensions to the models to allow for arbitrary patterns of age-dependent senescence, and site-specific probabilities of disturbance are presented.

Rees-M {a}; Hill-R-L, 2001.

Title: Large-scale disturbances, biological control and the dynamics of gorse populations.

Source: Journal-of-Applied-Ecology. [print] April, 2001; 38 (2): 364-377.

Publication Year: 2001

Language: English

Abstract: 1. Simulation and analytical models were developed for gorse *Ulex europaeus*. The simulation model incorporated spatially local density-dependent competition, disturbance, asymmetric competition between seedlings and established plants, a seed bank, local seed dispersal, an age structured established plant population, and temporal variation in the probability of disturbance. The analytical models were simple approximation of the simulation. 2. The models extended our previously published model for Scotch broom *Cytisus scoparius* to include large-scale disturbances and possible management options, such as the use of fire, herbicides and oversowing with perennial grasses. Fire was assumed to influence established plant mortality, seed survival in the seed bank, and the probability of germination. 3. We reviewed published data on the demography of gorse in New Zealand, the current management techniques, and the ongoing biological control programme. 4. Over a wide range of biologically reasonable parameter values, the analytical models accurately predicted the outcome of the simulations. The analytical models worked well, providing gorse occupied a high proportion of the available sites and large-scale

disturbances did not occur too frequently. 5. The potential impact of seed-feeding biological control agents on gorse abundance was assessed, using the models, for several environmental and management scenarios. In particular, we explored how large-scale disturbance, such as fire and herbicide application, influences the outcome of biological control. 6. The success of a biological control programme was found to depend critically on the frequency and intensity of disturbance, whether disturbed sites became suitable for recruitment, and the effects of disturbance on germination and seed mortality. 7. The models highlight the need to manage recruitment opportunities carefully in order to maximize the effect of biological control agents. The models also indicate that details of plant population biology can have a profound effect on the success of any management strategy.

Robertson-D-C {a}; Morgan-J-W; White-M, 1999

Title: Use of prescribed fire to enhance control of English broom (*Cytisus scoparius*) invading a subalpine snowgum woodland in Victoria.

Source: *Plant-Protection-Quarterly*. 1999; 14 (2): 51-56.

Language: English

Abstract: English broom (*Cytisus scoparius*) is invading subalpine vegetation on the Bogong High Plains, Victoria. Current control measures involve spraying all visible plants in affected areas with herbicides but this will have limited effectiveness because *C. scoparius* forms a persistent soil seed bank from which reestablishment may later occur. Prescribed fire may enhance the control of *C. scoparius* in subalpine areas by promoting synchronized germination of seed from the soil seed bank. The resulting large seedling cohort can then be controlled by application of herbicides. We studied the effects of a single prescribed fire in an invaded snowgum (*Eucalyptus pauciflora*) woodland on previously sprayed *C. scoparius* plants and in situ germination, and also followed the post-fire recovery of the native vegetation. All sprayed *C. scoparius* plants were consumed by fire. Substantial germination occurred in burnt areas in the year after fire, whereas no germination was observed in unburnt areas. All native species in the study area, and all individuals of snowgum, were capable of vegetative regeneration following fire and most (94%) native species reflowered within three years of the fire. If burning is to enhance control efficacy of *C. scoparius*, follow-up strategies (i.e. herbicide spraying) are necessary within four years of the fire. After this time, *C. scoparius* seedlings begin to flower and will replenish the depleted soil seed bank.

Seo-Byung-Soo {a}; Richardson-Brian; Vanner-Arthur; Coker-Graham

Title: Effects of some common weed species on *Pinus radiata* seedling growth.

Source: *Journal-of-Korean-Forestry-Society*. 1997; 86 (1) 1-8.

Publication Year: 1997

Language: Korean; Non-English

Abstract: Second year results are presented from a trial designed to quantify the reduction in radiata pine (*Pinus radiata* D. Don) seedling growth caused by competition from a range of important weed species on a moist North Island site in New Zealand. Radiata pine seedlings (1/0) were grown on the weed free control and with either herbaceous broadleaves, grass, broom, pampas, buddleia, or gorse. Resource (nutrient and water) levels were varied by factorial +/- irrigation and fertilizer treatments. Radiata pine seedling volume growth 21 months after planting was greatest when it was grown on the weed free control or in association with gorse, and was least when grown with either buddleia or pampas. There was no evidence that the effects of the weeds on seedling growth were mediated by either competition for water or nutrients. Tall, fast-growing species that overtopped the seedlings (broom, buddleia, pampas) had the greatest effect on seedling growth and the magnitude of the effect was correlated with degree of overtopping. This implies that shading or competition for light is probably an important factor.

Smale-Mark-C {a}; Whaley-Patrick-T; Smale-Paul-N, 2001.

Title: Ecological restoration of native forest at Aratiatia, North Island, New Zealand.

Source: Restoration-Ecology. [print] March, 2001; 9 (1): 28-37.

Language: English

Abstract: Successional pathways in native forest, planted 15-33 years ago on reconstructed surfaces to restore aesthetic values destroyed by hydro-electric dam construction at Aratiatia, central North Island, New Zealand, were compared with those on similar surfaces left unplanted. Only native species were planted. Classification identified three canopy communities and several ground layer communities with significant inter-stratum relationships: *Pittosporum tenuifolium*-*Sophora tetraptera* short forest with ground layers dominated by litter; *P. tenuifolium*-*Kunzea ericoides* short forest over adventive grasses on planted sites; and adventive *Cytisus scoparius* shrubland over grasses on unplanted sites. Planted communities mirror young secondary forests on intact substrates in the district, but have lower density and similar or higher basal area than such forests elsewhere. Established seedlings of seven planted canopy trees, mostly early successional bird-dispersed species, are reasonably widespread in floristically rich *Pittosporum*-*Sophora* forest. Seedlings of only two species are widespread in floristically poor *Pittosporum*-*Kunzea* forest, and none on unplanted sites. This first large-scale attempt at ecological restoration in New Zealand, by mass planting of new surfaces with early successional native woody species, has created aesthetically-pleasing stands of indigenous forest on sites which would otherwise remain in relatively stable adventive shrubland communities for the foreseeable future. Only continued monitoring will show whether further management is necessary and whether natural processes are operating at a level sufficient to ensure that artificially initiated successions will

continue along more or less natural pathways.

Smith, J.M.B., 1994.

Title: The changing ecological impact of broom (*Cytisus scoparius*) at Barrington Tops, New South Wales.

Source: Plant-Protection-Quarterly. 1994; 9 (1) 6-11.

Language: English

Abstract: The invasive European shrub broom (*Cytisus scoparius*) was introduced to the Barrington Tops plateau during the 1840s and has spread particularly rapidly since 1969. In the Polblue area stands are now mainly over ten years old and consist of fewer, larger and more prostrate individuals than stands in the same area studied previously. Four broom growth stages are described. As stands age, partial recovery of ground cover occurs, though not by all pre-existing species, and without successful regeneration by broom and original overstorey trees. Implications for the future of broom-invaded vegetation are discussed.

Smith-J-M-B {A}; Harlen-R-L, 1991.

Title: Preliminary Observations On The Seed Dynamics Of Broom *Cytisus-Scoparius* At Barrington Tops New South Wales.

Source: Plant-Protection-Quarterly. 1991; 6 (2): 73-78.

Publication Year: 1991

Language: ENGLISH

Abstract: The leguminous shrub broom (*Cytisus scoparius*), native to Europe, has invaded large areas of woodland and grassland at Barrington Tops, NSW [Australia]. Seeds are produced at rates of approximately 70-380 m⁻² y⁻¹, are dispersed by several vectors, and contribute to a soil seed bank of up to 4,142 seeds m⁻². Seed dormancy may be terminated in the laboratory by scarification or heat. Seeds may remain dormant in soil for years, and pose major difficulties in broom control. Seed production and seed bank size are similar or larger at lower altitudes in NSW and in the British Isles [UK], but the species does not behave invasively there. Implications of these data for biological control are discussed.

Stewart, Ann, 2001.

Monitoring Garry oak meadows and broom removal plots at DND properties, Metchon BC. BSc. Thesis, University of Victoria.

Suzuki-Nobuhiko, 2000.

Title: Pollinator limitation and resource limitation of seed production in the Scotch broom, *Cytisus scoparius* (Leguminosae).

Source: Plant-Species-Biology. [print] August, 2000; 15 (2): 187-193.

Language: English

Abstract: Pollinator limitation and resource limitation of seed production were examined in flowers of a natural population of Scotch broom, *Cytisus scoparius*, by taking advantage of the floral characteristics that flowers tripped open by an effective pollinator were easily distinguishable from unvisited flowers. In total, 40.26% of flowers were visited by effective pollinators, 28.91% were pollinated and 13.75% matured fruits. Therefore, 71.80% of visited flowers were pollinated and 47.58% of pollinated flowers matured fruits. Thus, the most limiting factor for fruit production was pollinator visitation rate (pollinator limitation), and secondarily the process from pollination to fruiting further constrained fruit production (resource limitation). The pollinator visitation rate was significantly higher for plants growing in a sunny habitat than in a shady one, and pollinator limitation was more severe in the shady habitat than the sunny one. The proportion of fruit produced to pollinated flowers was not significantly different between the sunny and shady habitats, but was lower on larger plants, indicating that resource limitation was more severe on larger plants producing many more flowers.

Syrett, Pauline, 1993.

Title: The insect fauna of broom, *Cytisus scoparius*, in New Zealand.

Source: *New-Zealand-Entomologist*. 1993; 16 (0) 75-83.

Language: English

Abstract: The above-ground fauna of broom, *Cytisus scoparius* (L.) Link, was sampled for 1 complete season (1982-3) at a site on the Port Hills, Canterbury. Comparative samples in both November 1988 and January 1989 were taken from broom bushes at each of 17 sites throughout New Zealand. The most numerous species were the thrips *Thrips obscuratus* (Crawford) and the cryptophagid beetle *Paratomaria atomaroides* (Reitter). Only 2 specialised broom-feeding species were recorded: the twigmining moth *Leucoptera spartifoliella* Huebner and the tetranychid mite *Bryobia variabilis* Manson. The invertebrate fauna of broom in New Zealand was found to be meagre compared to that in its native Europe.

Syrett-P {a}; Emberson-R-M, 1997.

Title: The natural host range of beetle species feeding on broom, *Cytisus scoparius* (L.) Link (Fabaceae), in southwest Europe.

Source: *Biocontrol-Science-and-Technology*. Sept., 1997; 7 (3) 309-326.

Language: English

Abstract: The natural host range of beetles feeding on broom (*Cytisus scoparius*) and 14 other species (including six other *Cytisus* species) in the tribe Genisteae was investigated at 39 sites in Spain, Portugal and France in 1989 and 1992 as part of a biological control programme for broom. Data on host-plant associations were analyzed for 36 phytophagous beetle species from 18 sites, and host records were listed for an additional 58 species. Nine species were apparently restricted to the genus *Cytisus*: *Cryptocephalus octoguttatus*,

Gonioctena olivacea, Bruchidius lividimanus, B. villosus, Exapion elongatissimum, E. fuscirostre, Lepidapion sp. 1, Polydrusus confluens and Tychius parallelus. These field records suggest a narrower host-plant range for some beetle species than laboratory host-range tests, and may assist in interpreting host-plant associations reported in the literature. Beetle species with a restricted host-plant range were rarely found on related non-host plants.

Syrett-P; Harman-H-M, 1995.

Title: Leucoptera spartifoliella Hubner as a biological control agent for broom in New Zealand.

Source: Plant-Protection-Quarterly. 1995; 10 (2) 75-78.

Language: English

Abstract: The present distribution of the twig-mining moth *Leucoptera spartifoliella* in New Zealand is almost the same as that of its host plant, broom (*Cytisus scoparius*). The moth spreads readily under New Zealand conditions, with a rate of spread through Southland of 45 km in seven years. Numbers of eggs laid per female averaged 99 (se 9.3), comparable with maximum mean fecundity reported from England, as was the median longevity of 13 days for adults. The peak of adult emergence occurred during the first two weeks in December, with the peak for males 2-3 days earlier than for females. The ratio of males to females varied (1:0.8 and 1:1 in the two seasons measured). Mortality during the pupal stage was 26% lower than the rate observed in England and attributable to the absence of parasitism that contributes significantly to mortality in English populations. The large populations of *L. spartifoliella* achieved in New Zealand give this moth the potential to be an effective ! biological control agent of broom here, and its relatively rapid rate of colonization indicates that it should multiply and spread equally well in Australia.

Syrett-P {a}; Harman-H-M {a}; Fowler-S-V, 1995.

Title: Identification of risk to kowhai, a New Zealand native plant *Sophora microphylla* Ait., from a potential biological control agent for broom, *Cytisus scoparius* (L.) Link.

Source: New-Zealand-Journal-of-Zoology. 1995; 22 (3) 305-309.

Language: English

Abstract: Routine tests to determine the host specificity of the stem-mining weevil, *Pirapion immune*, a potential biological control agent for broom, *Cytisus scoparius*, indicate that kowhai, *Sophora microphylla*, is a possible alternative host plant. Many more weevils were reared successfully on *C. scoparius* (hivin x = 65.8) than on *S. microphylla* (hivin x = 0.8), and significantly more eggs were laid on *C. scoparius* than on *S. microphylla*. However, most females laid eggs on both species in choice tests. Field tests in Europe also showed that weevils given equal access to both plant species used both species. *P. immune* has been rejected

as a potential control agent for *C. scoparius* in New Zealand. Plants within the genus *Sophora* should be tested carefully for potential risk from any proposed introduction for control of weeds within the tribe Genisteae.

Tarrega-R {a}; Calvo-L {a}; Trabaud-L, 1992.

Title: Effect of high temperatures on seed germination of two woody Leguminosae.

Source: Vegetatio-. 1992; 102 (2) 139-147.

Language: English

Abstract: *Cytisus scoparius* and *Genista florida* regenerate after fire by stump-sprouting but also by seed. Seeds of these species were heated to a range of temperatures similar to those registered on the surface soil during natural fires (from 50 to 150 degree C) and a range of exposure times (from 1 to 15 min). No germination was observed a high temperature, gtoreq 130 degree C, when the exposure time was 5 min or more. However, moderate heat treatments (at 70 and 100 degree C) significantly increased the rate of germination relative to controls. *Cytisus scoparius* is more favored by fire action than *Genista florida*, with germination rates slightly greater following 100 degree C for 5 min and 130 degree C for 1 min than after mechanical scarification.

Thysell-David-R; Carey-Andrew-B , 2001.

Title: *Quercus garryana* communities in the Puget Trough, Washington.

Source: Northwest-Science. [print] Summer, 2001; 75 (3): 219-235.

Language: English

Abstract: Among the legacies of the Vashon Glaciation are Oregon white oak (*Quercus garryana*), prairie, wetland, and Douglas-fir (*Pseudotsuga menziesii*) communities arrayed in a mosaic in the Puget Sound Area (PSA). Much of this mosaic has been destroyed. The largest remaining portion is on Fort Lewis Military Reservation. We examined oak communities on Fort Lewis to assess encroachment by exotic plants and by Douglas-fir, to determine amounts of regeneration of oak and other tree species, and to compare oak community diversity with that of nearby Douglas-fir forests and glacial till prairies. For the 22 largest communities, we determined densities of trees, distributions of tree diameters and heights, amounts of regeneration for each tree species, evidence of exogenous disturbances, and covers of vascular understory species. For study sites, we calculated basal areas of tree species, richness and diversity of vascular plants, and percentages of species that were exotic. We constructed species accumulation curves for oak communities, Douglas-fir forests, and prairies. We performed Bray-Curtis and weighted averaging ordinations for 176 sampling plots from the 22 sites. Oak communities were typically more diverse than either Douglas-fir forests or prairies and were transitional in species composition between them. However, oak communities contained numerous exotics, particularly Scot's broom (*Cytisus scoparius*) and colonial bentgrass (*Agrostis*

capillaris). Most oak communities contained large-diameter Douglas-firs and other tree species and appeared to be transforming to conifer or conifer/mixed hardwood forests. With succession, exotic species become less prevalent, but the extent and abundance of oaks is diminished. Maintenance of oak communities, and the PSA natural mosaic, may require tree-density management in oak stands, removal of Douglas-fir, development of replacement oak sites, prescribed burning, and mechanical suppression of exotics before burning.

Ussery-Joel-G; Krannitz-Pam-G, 1998.

Title: Control of Scot's broom (*Cytisus scoparius* (L.) Link.): The relative conservation merits of pulling versus cutting.

Source: Northwest-Science. Nov., 1998; 72 (4) 268-273.

Language: English

Abstract: The control of invasive exotic plant species in sites of high conservation value should minimize both the impacts on the ecosystem of concern and the potential for regeneration of the exotic species. We examined how the method and timing of the removal of the invasive shrub Scot's broom (*Cytisus scoparius*) affected the level of site disturbance and subsequent broom regeneration from seed and resprouting in remnant Garry oak (*Quercus garryana*) meadow communities in Victoria, British Columbia. We compared manual uprooting versus cutting at two time periods: May, when the shrub was in flower, and in July, just prior to seed dispersal. Soil disturbance, trampling, and seedling regeneration were significantly higher in plots when broom plants were uprooted as compared to plots where broom plants were cut at the base. Amount of trampling was higher in July than in May, but in July the trampled plants were exotic grasses, while in May these included fruiting stalks of native common camas (*Camassia quamash*). Resprouting of cut stems was observed in only 7 of the 75 broom stems cut and these died-back within one year. These results suggest that the preferred Scot's broom removal strategy in Garry oak meadow communities of high conservation value is to cut broom after native herbaceous species have set and distributed seed. This approach will minimize damage to native vegetation and reduce the amount of broom seedling regeneration.

Wilson, Hugh D. 1994.

Title: Regeneration of native forest on Hinewai Reserve, Banks Peninsula.

Source: New-Zealand-Journal-of-Botany. 1994; 32 (3) 373-383.

Language: English

Abstract: One thousand hectares in the south-east sector of Banks Peninsula are being managed for the protection and restoration of native vegetation and wildlife under a policy of minimum interference. The probable pre-human vegetation cover (1000 yr B.P.), inferred from current evidence and some historical records, was continuous forest, c. 55% of it podocarp/hardwood forest

and 45% Nothofagus forest. About 4% of this old-growth forest survives. The remaining area is a diverse mosaic of successional vegetation. Approximately 30% of the total area is closed-canopy second-growth native forest. About 53% is under scrub of naturalised gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*). The remaining 13% is under pasture, fernland, and native tussockland. The predicted cover 50 years hence, assuming that fire can be excluded, is 95% secondgrowth native forest, 4% old-growth forest, and 1% tussock, shrubland, and scrub which will persist on bluffs. Successional pathways are diverse, involving both native and naturalised species. Monitoring of vegetational change to test predicted pathways and patterns began in October 1987. To date, observations show that in the absence of grazing animals and fire, regeneration of native forest is rapid, especially through gorse and broom scrub, and by the vigorous establishment of native seral hardwoods, especially kanuka (*Kunzea ericoides*).

Zhou-T-S {A}; Hara-N, 1990.

Title: Structure And Development Of Shoots In *Cytisus-Scoparius*.

Source: Canadian-Journal-of-Botany. 1990; 68 (12): 2576-2582.

Publication Year: 1990

Language: ENGLISH

Abstract: The vegetative winter bud of *Cytisus scoparius* Link contains about nine leaf primordia. It grows into a main axis during the current growing season. At the end of the growing season, a shoot system consisting of a main axis and many lateral branches is formed. The lateral branch originates as a primordium when winter buds expand in spring, from the axil between the sixth and eighth leaves (numbered from the base of the bud), following which the succeeding primordia of branches appear sequentially. These lateral primordia continue to extend synchronously with the extension of the main axis during the growing season: By the end of the growing season, the lateral branches have reached various lengths and are arranged in a somewhat characteristic manner on the main axis; the relatively long branches are often located on the portions with ternately compound leaves and are associated with the vigorous elongation of the main axis. The relationship between the growth of the lateral branches and the main axis is discussed.

Useful websites

[www.for.gov.bc.ca/hfp/amhome/summary/Scotch .htm](http://www.for.gov.bc.ca/hfp/amhome/summary/Scotch.htm)

Article by Pam Krannitz and Joel Ussery.

www.weedcenter.org/info/weedlist.html

Article by Coombs and Turner, 1995.

http://infoweb.magi.com/~ehaber/bc_broom.html

Overview of Scotch broom in BC by E. Carson, RNS Program UVic.

www.pfc.cfs.nrcan.gc.ca/biodiversity/broom_e.html

Article by Raj Prasad.

www.pfc.forestry.ca/pest/broom/index.html

Article by Raj Prasad.