Predicting invasive plant response to climate change: Prioritization and mapping of new potential threats to Alberta's biodiversity
(Chai et al. 2014)

Supplemental Information: Alberta non-native plant invasiveness ranking form
(Adapted from Carlson et al. 2008)

Full report available at http://www.biodiversityandclimate.abmi.ca

Scientific name:	*Cytisus scoparius*
Common name:	Scotch Broom
Assessor:	Shauna-Lee Chai
Reviewer:	Joseph Ditomaso
Date:	October 11, 2013

Outcome score:

A. Climatic Comparison

This species is present or may potentially establish in the following natural regions:

	Collected in Alberta regions	CLIMEX similarity in 1975	CLIMEX similarity in 2050
Boreal	No	0.738	0.790
Parkland	No	0.799	0.822
Foothills	No	0.834	0.859
Grassland	No	0.792	0.818
Rocky Mountains	No	0.773	0.801
Shield	No	0.650	0.720

B. Invasiveness Ranking

	Total (Total answered[1] points possible)	Total score
1. Ecological impact	40(40)	37
2. Biological characteristic and dispersal ability	25(25)	17
3. Ecological amplitude and distribution	25(25)	16
4. Feasibility of control	10(10)	8
Outcome score	100(100)[b]	[a]78
Relative maximum score[2]	78	*Highly Invasive*

[1]For questions answered "unknown" do not include point value for the question in parentheses for "Total answered points possible."

[2]Calculated as a/b x 100.

A. Climatic Comparison:

1.1 Has this species ever been collected or documented in Alberta?

__Yes – continue to 1.2

x No – continue to 2.1

Which natural region has it been collected or documented (see inset map)? Proceed to section B. Invasiveness Ranking.

__Boreal

__Rockies

__Grassland

__Foothills

__Parkland

__Shield

Documentation:

Sources of information: ANPC Rogues gallery, ACIMS, PLANTS database, GBIF

2.1 Is there a 70 percent or higher similarity (based on CLIMEX climate matching) between climates anywhere the species currently occurs and

a. Boreal - Yes

b. Rockies - Yes

c. Grassland - Yes

d. Foothills - Yes

e. Parkland - Yes

f. Shield – Not in 1975, but in 2050

-If "no" is answered for all regions, reject species from consideration

Documentation:

Sources of information:

B. Invasiveness Ranking

1. Ecological Impact

1.1 Impact on Natural Ecosystem Processes

a. No perceivable impact on ecosystem processes 0

b. Has the potential to influences ecosystem processes to a minor degree (e.g., has a perceivable but mild influence on soil nutrient availability) 3

c. Has the potential to cause significant alteration of ecosystem processes (e.g., increases sedimentation rates along streams or coastlines, reduces open water that are important to waterfowl) 7

d. May cause major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species alters geomorphology; hydrology; or affects fire frequency, altering community composition; species fixes substantial levels of nitrogen in the soil making soil unlikely to support certain native plants or more likely to favor non-native species) 10

u. Unknown

Score:10

Documentation: aggressive spread, creates high fire hazard, fixes nitrogen (Hoshovsky 1986)

Identify ecosystem processes impacted: fire

Rational:

Sources of information:

1.2 Impact on Natural Community Structure

a. No perceived impact; establishes in an existing layer without influencing its structure 0
b. Has the potential to influences structure in one layer (e.g., changes the density of one layer) 3
c. Has the potential to cause significant impact in at least one layer (e.g., creation of a new layer or elimination of an existing layer) 7
d. Likely to cause major alteration of structure (e.g., covers canopy, eradicating most or all layers below) 10
u. Unknown

Score:7

Documentation:Scotch broom can cover 90% of the canopy and intercept 65% of light (Prasad and Peterson 1997) in young Douglas fir plantations causing complete stand failures in some instances.

Identify type of impact or alteration:

Rational:

Sources of information:

1.3 Impact on Natural Community Composition

a. No perceived impact; causes no apparent change in native populations 0
b. Has the potential to influences community composition (e.g., reduces the number of individuals in one or more native species in the community) 3
c. Has the potential to significantly alter community composition (e.g., produces a significant reduction in the population size of one or more native species in the community) 7
d. Likely to cause major alteration in community composition (e.g., results in the extirpation of one or several native species, reducing biodiversity or change the community composition towards species exotic to the natural community) 10
u. Unknown

Score:10

Documentation: renders rangeland in the USA worthless (Hoshovsky 1986), threatens endangered Garry oak ecosystems in BC., retarding establishment and spread of many rare and endemic spp in these endangered ecosystems (Nuszdorfer et al 1991). Scotch broom is reported to form monocultures and become so dense that the areas where it occurs are impenetrable (Hoshovsky 2004). In addition, this species excludes the native vegetation to such an extent that common animals such as deer and quail are unable to forage (Hoshovsky 2004).

Identify type of impact or alteration:

Rational:

Sources of information:

1.4 Impact on higher trophic levels (cumulative impact of this species on the animals, fungi, microbes, and other organisms in the community it invades)

a. Negligible perceived impact 0
b. Has the potential to cause minor alteration 3
c. Has the potential to cause moderate alteration (minor reduction in nesting/foraging sites, reduction in habitat connectivity, interference with native pollinators, injurious components such as spines, toxins) 7
d. Likely to cause severe alteration of higher trophic populations (extirpation or endangerment of an existing native species/population, or significant reduction in nesting or foraging sites) 10
u. Unknown

Score: 10

Documentation: In California, reports of livestock loss due to ingestion of toxic quinolizidine alkaloids, sparteine and isoparteine produced by Scotch broom (Parker et al 1994). Wilson and Carey (2001) found a negative relationship between Scotch broom and deer mice, suggesting that Scotch broom areas have diminished value as wildlife habitat in the Oregon while oak communities in the Puget Trough, Washington. The small areas of remaining Oregon silverspot and Fender blue butterfly habitat have been invaded by Scotch broom and other nonnative species, changing plant community composition and structure and adversely affecting the quality of habitat for the threatened butterflies (Pickering 1997).

Identify type of impact or alteration:

Rational:

Sources of information:

Total Possible:37

Total:40

2. Biological Characteristics and Dispersal Ability

2.1 Mode of reproduction

a. Not aggressive reproduction (few [0-10] seeds per plant and no vegetative reproduction) 0
b. Somewhat aggressive (reproduces only by seeds (11-1,000/m2) 1
c. Moderately aggressive (reproduces vegetatively and/or by a moderate amount of seed, <1,000/m2) 2
d. Highly aggressive reproduction (extensive vegetative spread and/or many seeded, >1,000/m2) 3
u. Unknown

Score:3

Documentation:

Describe key reproductive characteristics (including seeds per plant):varies from a few hundred to over 7000 pods per plant with 0-22 seeds per pod (5-8 on average) (Hosking et al. 1996). 4142 seeds/m^2 (Smith and Harlen 1991)

Rational:

Sources of information:

2.2 Innate potential for long-distance dispersal (bird dispersal, sticks to animal hair, buoyant fruits, wind-dispersal)

a. Does not occur (no long-distance dispersal mechanisms) 0
b. Infrequent or inefficient long-distance dispersal (occurs occasionally despite lack of adaptations) 2
c. Numerous opportunities for long-distance dispersal (species has adaptations such as pappus, hooked fruit-coats, etc.) 3
u. Unknown

Score:2

Documentation:

Identify dispersal mechanisms: includes water, hard seed coat keep seeds viable (Williams 1981)

Rational:

Sources of information:

2.3 Potential to be spread by human activities (both directly and indirectly – possible mechanisms include: commercial sales, use as forage/revegetation, spread along highways, transport on boats, contamination, etc.)

a. Does not occur 0
b. Low (human dispersal is infrequent or inefficient) 1
c. Moderate (human dispersal occurs) 2
d. High (there are numerous opportunities for dispersal to new areas) 3
u. Unknown

Score:2

Documentation: vehicles, gravel, highway graders (Boateng 1994)

Identify dispersal mechanisms:

Rational:

Sources of information:

2.4 Allelopathic

a. no 0
b. yes 2
u. unknown

Score:0

Documentation:

Describe effect on adjacent plants:

Rational:

Sources of information:

2.5 Competitive ability

a. Poor competitor for limiting factors 0
b. Moderately competitive for limiting factors 1
c. Highly competitive for limiting factors and/or nitrogen fixing ability 3
u. Unknown

Score:3

Documentation: Efficient nitrogen fixer, drought tolerant (Wheeler et al. 1979)
Evidence of competitive ability:
Rational:
Sources of information:

2.6 Forms dense thickets, climbing or smothering growth habit, or otherwise taller than the surrounding vegetation

a. No 0
b. Forms dense thickets 1
c. Has climbing or smothering growth habit, or otherwise taller than the surrounding vegetation 2
u. Unknown

Score:1

Documentation: forms dense thickets, monospecific stands (Erskine 1960)
Describe growth form:
Rational:
Sources of information:

2.7 Germination requirements

a. Requires open soil and disturbance to germinate 0
b. Can germinate in vegetated areas but in a narrow range or in special conditions 2
c. Can germinate in existing vegetation in a wide range of conditions 3
u. Unknown

Score:2

Documentation: germination requirements vary by environment. Seeds imbibe water before germination and germination is best after a period of dormancy at temperatures 4-33 deg. Celsius (Bossard 1993)
Describe germination requirements:
Rational:
Sources of information:

2.8 Other species in the genus invasive in Alberta or elsewhere

a. No 0
b. Yes 3
u. Unknown

Score:3

Documentation:

Species: Portuguese broom (C. striatus)-not as widespread as Scotch broom, but thought to have similar characteristics (DiTomaso 1998). It is a noxious weed in Oregon.
Sources of information: USDA PLANTS database

2.9 Aquatic, wetland, or riparian species

a. Not invasive in wetland communities	0
b. Invasive in riparian communities	1
c. Invasive in wetland communities	3
u. Unknown	

Score: 1

Documentation:
Describe type of habitat:most rapid spread has occurred along water courses where the species is water dispersed (Hoshovsky, 1986)
Rational:
Sources of information:

Total Possible:25
Total:17

3. Distribution

3.1 Is the species highly domesticated or a weed of agriculture

a. No	0
b. Is occasionally an agricultural pest	2
c. Has been grown deliberately, bred, or is known as a significant agricultural pest	4
u. Unknown	

Score:4

Documentation:
Identify reason for selection, or evidence of weedy history: destroys rangeland. Introduced as an ornamental, used on highway banks (Peterson & Prasad, 1998). Causes economic loss in Douglas fir plantations (Prasad and Peterson 1997)
Rational:
Sources of information:

3.2 Known level of ecological impact in natural areas

a. Not known to cause impact in any other natural area	0
b. Known to cause impacts in natural areas, but in dissimilar habitats and climate zones than exist in regions of Alberta	1
c. Known to cause low impact in natural areas in similar habitats and climate zones to those present in Alaska	3
d. Known to cause moderate impact in natural areas in similar habitat and climate zones	4
e. Known to cause high impact in natural areas in similar habitat and climate zones	6
u. Unknown	

Score:1

Documentation:

Identify type of habitat and states or provinces where it occurs: threatens Garry oak woodland in BC (Haber 1996) (Cowichan Garry Oak Reserve) and rare and endangered species associated with these habitats.

Sources of information:

3.3 Role of anthropogenic and natural disturbance in establishment

a. Requires anthropogenic disturbances to establish 0
b. May occasionally establish in undisturbed areas but can readily establish in areas with natural disturbances 3
c. Can establish independent of any known natural or anthropogenic disturbances 5
u. Unknown

Score:3

Documentation: colonises disturbed sites. Does not normally grow in forests except on plantations. Can grow in river beds (Peterson and Prasad, 1998). Can establish in undisturbed areas (J. Ditomaso, pers. comm.)

Identify type of disturbance:

Rationale:

Sources of information:

3.4 Current global distribution

a. Occurs in one or two continents or regions (e.g., Mediterranean region) 0
b. Extends over three or more continents 3
c. Extends over three or more continents, including successful introductions in arctic or subarctic regions 5
u. Unknown

Score:3

Documentation:

Describe distribution: Africa, Europe, Canada, India, Australia, New Zealand (Peterson and Prasad, 1998)

Rational:

Sources of information:

3.5 Extent of the species Canada range and/or occurrence of formal state or provincial listing

a. 0-5 percent of the states/provinces 0
b. 6-20 percent of the states/provinces 2
c. 21-50 percent, and/or state/province listed as a problem weed (e.g., “Noxious,” or “Invasive”) in 1 state or Canadian province 4
d. Greater than 50 percent, and/or identified as “Noxious” in 2 or more states or Canadian provinces 5
u. Unknown

Score:5

Documentation:
Identify provinces invaded:noxious weed in Hawaii, Idaho, Oregon, California, Washington
Rational:
Sources of information: USDA PLANTS database

Total possible:25
Total:16

4. Feasibility of Control

4.1 Seed banks

a. Seeds remain viable in the soil for less than 3 years 0
b. Seeds remain viable in the soil for between 3 and 5 years 2
c. Seeds remain viable in the soil for 5 years and more 3
u. Unknown

Score:3

Documentation:
Identify longevity of seed bank: greater than 30 yrs (Smith and Harlen 1991)
Rational:
Sources of information:

4.2 Vegetative regeneration

a. No resprouting following removal of aboveground growth 0
b. Resprouting from ground-level meristems 1
c. Resprouting from extensive underground system 2
d. Any plant part is a viable propagule 3
u. Unknown

Score:1

Documentation: Physical and mechanical control methods applied to adult broom plants are often followed by sprouting from remaining root crowns or aboveground stems, and emergence of numerous broom seedlings (Prasad 2003)
Describe vegetative response:
Rational:
Sources of information:

4.3 Level of effort required

a. Management is not required (e.g., species does not persist without repeated anthropogenic disturbance) 0
b. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources 2
c. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment 3
d. Management requires a major, long-term investment of human and financial resources 4
u. Unknown

Score:4

Documentation:
Identify types of control methods and time-term required: several years are required due to seed bank and resprouting. Integrated management: Brooms are best controlled by an integrated vegetation management program including monitoring, prevention, biological control, uprooting, cutting, controlled burns, competitive planting, and spot treatments with herbicides as a last resort. The choice of specific methods, timing, and combinations depends on the site conditions and the nature of the infestation (Woo et al. 2004).
Rational:
Sources of information:

Total Possible: 10
Total: 8
Total for 4 sections Possible: 100
Total for 4 sections: 78

References:

Boateng, J. 1994. Broom: Putting it in its place. Queen's Printer, Victoria, BC. 4 pp.

Bossard, Carla C. 1993. Seed germination in the exotic shrub Cytisus scoparius (Scotch broom) in California. Madrono. 40(1): 47-61.

Carlson, M. 2008. Invasiveness Ranking System for Non-Native Plants of Alaska. USDA. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037575.pdf

DiTomaso, Joseph M. 1998. The biology and ecology of brooms and gorse. Proceedings, California Weed Science Society. 50: 142-148.

Erskine, D. S. 1960. The plants of Prince Edward Island. Plant Research Institute, Canada Department of Agriculture,Charlottetown, PE. Publ. no. 1088, 200 pp

Haber, E. 1996. Invasive plants of Canada: 1996 National survey results. National Botanical Services, Ottawa, ON. 25 pp

Hoshovsky, M. ed. 2004. Element Stewardship Abstract for Cystisus scoparius and Genista monspessulanus. The Nature Conservancy.

Hoshovsky, M. 1986. Element Stewardship Abstract for Cytisus scoparius and Genista monspessulanus. Scotch Broom, French Broom (http://tncweeds.ucdavis.edu). The Nature Conservancy. Arlington, VA 19 pp.

Hosking, J. R.; Smith, J. M. B.; Sheppard, A. W. 1996. The biology of Australian weeds. 28. Cytisus scoparius (L.) Link subsp. scoparius. Plant Protection Quarterly. 11(3): 102-108.

Nuszdorfer, F. C., Klinka, K. and Demarchi, D. A. 1991. Chapter 5, pages 81–93 in D. Meidinger and J. Pojar, eds. Coastal Douglas-fir zone, in ecosystems of British Columbia. BC Min. For., Victoria, BC, Special Rep. Ser. No. 6

Parker, B., Miller, G. and Burrill, L.C. 1994. Weeds — Scotch broom, Cytisus scoparius (L.) Link. Pacific Northwest Extension Publication No. 103, Corvallis OR

Peterson, D. J. and Prasad, R. 1998. The Biology of Canadian Weeds. 109. Cytisus scoparius (L.) Link. Can. J. Plant Sci. 78: 497–504.

Pickering, Debbie L. 1997. The influence of fire on west coast grasslands and concerns about its use as a management tool: a case study of the Oregon silverspot butterfly Speyeria zerene Hippolyta (Lepidoptera, Nymphalidae). In: Greenlee, Jason M., ed. Proceedings, 1st conference on fire effects on rare and endangered species and habitats; 1995 November 13-16; Coeur d'Alene, ID. Fairfield, WA: International Association of Wildland Fire: 37-46.

Prasad, R. and Peterson, D. J. 1997. Mechanisms of Invasiveness of the exotic weed, Scotch broom (Cytisus scoparius (L.) Link) in British Columbia. Proc. Expert Committee Weeds Ann. Meeting, 9–12 December 1996, Victoria BC. pp. 197–198. (Abstr.)

Prasad, Raj. 2003. Management and control of gorse and Scotch broom in British Columbia. Technology Transfer Note Number 30. Victoria, BC: Canadian Forest Service, Natural Resources Canada, Pacific Forestry Centre, Forestry Research Applications. 6 p.

Smith, J. and Harlen, R. 1991. Preliminary observations on the seed dynamics of broom at Barrington Tops, New South Wales. Plant Protect. Q. 6: 73–78.

Wheeler, C. T., Perry, D. Helgerson, O. and Gordon, J. 1979. Winter fixation of nitrogen in Scotch broom. New Phytol. 82: 697–701.

Williams, P. A. 1981. Aspects of the ecology of broom (Cytisus scoparius) in Canterbury, New Zealand. N.Z. J. Bot. 19: 31–43.

Wilson, Suzanne M.; Carey, Andrew B. 2001. Small mammals in oak woodlands in the Puget Trough, Washington. Northwest Science. 75(4): 432-349.

Woo, Isa; Drlik, Tanya; Swiadon, Laurie; Quarles, William. 2004. Sweeping away broom--integrated management for an exotic yellow legume. The IPM Practitioner. 26(3-4): 1-8.

Zouhar, Kris. 2005. Cytisus scoparius, C. striatus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2013, October 16].

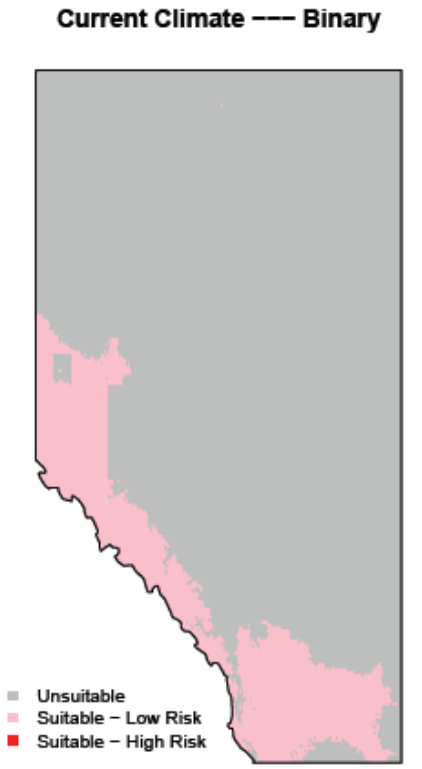
(Scotch broom invades similar habitats as gorse)

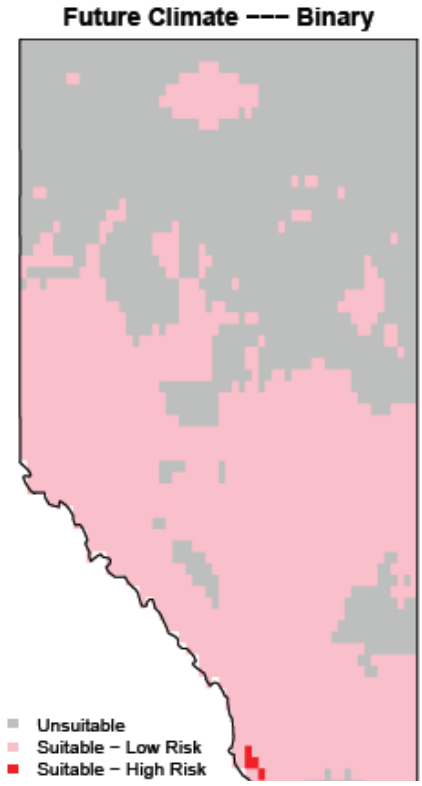
Natureserve I-rank:
http://www.natureserve.org/explorer/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=species_RptComprehensive.wmt&selectedReport=RptComprehensive.wmt&summaryView=tabular_report.wmt&elKey=138657&paging=home&save=true&startIndex=1&nextStartIndex=1&reset=false&offPageSelectedElKey=138657&offPageSelectedElType=species&offPageYesNo=true&post_processes=&radiobutton=radiobutton&selectedIndexes=138657&selectedIndexes=142957&selectedIndexes=149850
Scotch Broom is considered an aggressive invader and has invested more than 2 million acres in Washington, Oregon and California. It has also escaped from cultivation in the east, however, it is not as problematic there. This species, when it has established, alters abiotic characters of the ecosystem including adding nitrogen to the soil and altering the fire regime. It invades grasslands, shrublands, open forests and pastures. Finally, it produces copious seeds and requires active management.

Score interpretation

While different users will have different concepts of what constitutes various levels of invasiveness (e.g., what is "highly invasive" vs. "moderately invasive" may differ among management agencies), we divided the ranks into six blocks in Appendix A. We consider species with scores ≥80 as "Extremely Invasive" and species with scores 70–79 as "Highly Invasive;" both of these groups are composed of species estimated to be very threatening to Alaska. Species with scores of 60–69 as "Moderately Invasive" and scores of 50–59 represent "Modestly Invasive" species; both of these groups still pose significant risks to ecosystems. Species with scores of 40–49 are "Weakly Invasive", and <40 are considered "Very Weakly Invasive." These last two groups generally have not been shown to significantly alter ecosystem processes and communities elsewhere and probably do not require as much attention as the other species.

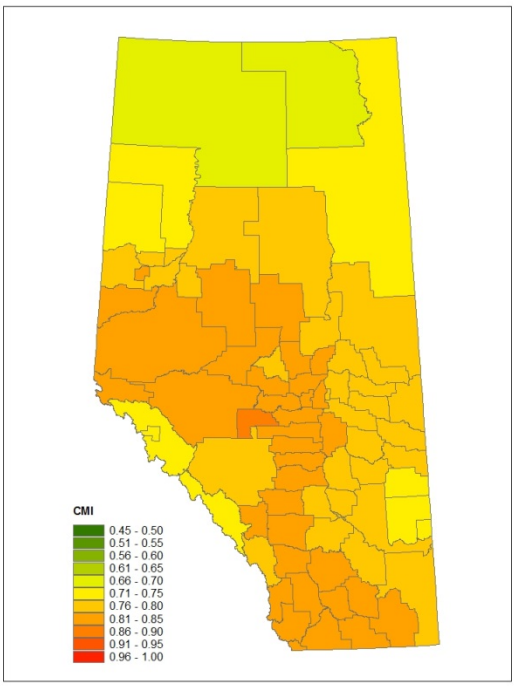
Species Distribution Models
Current=1975, future=2050





CLIMEX climate match

1975



2050