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:	*Ulex europaeus*
Common name:	gorse
Assessor:	Shauna-Lee Chai
Reviewers:	David Clements
Date:	October 4, 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	0.677	0.735
Parkland	No	0.748	0.794
Foothills	No	0.776	0.821
Grassland	No	0.742	0.763
Rocky Mountains	No	0.703	0.746
Shield	No	0.591	0.661

(0.7 is the climate suitability threshold)

B. Invasiveness Ranking

	Total (Total answered[1] points possible)	Total score
1. Ecological impact	40(40)	31
2. Biological characteristics and dispersal ability	25(25)	14
3. Ecological amplitude and distribution	25(25)	11
4. Feasibility of control	10(10)	9
Outcome score	100(100)[b]	[a]65
Relative maximum score[2]	65	*'Moderately 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 – not in 1975, but in 2050

b. Rockies - Yes

c. Grassland - Yes

d. Foothills - Yes

e. Parkland - Yes

f. Shield - no

-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 influence 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: Extremely competitive, displaces native plants, alters soils by fixing nitrogen and making soils acidic. Its optimal pH is 4.5-5 (Grubb et al. 1969). It extracts plant nutrients-Ca, Mg, Na which alters nutrient dynamics and can impoverish soil. Its oily seeds and foliage, which accumulate as litter, are highly flammable and it is an extreme fire hazard due to abundant dead material. Soil is often bare between plants increasing the likelihood of erosion. Grows spines and is in dense thickets and excludes grazing animals, reducing pasture quality. Can also interfere with economically important conifer seedling growth in forests (ISSG 2013). In New Zealand a fire spread rapidly through a gorse understorey destroying 1000 ha of forest plantation. Similar risks exist in BC's coastal areas (Zielke et al 1992).

Identify ecosystem processes impacted: fire, nutrient dynamics

Rational:

Sources of information: ISSG 2013

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: grows densely and excludes other species due to heavy leaf litter, acidifying soil and nutrient competition (ISSG). Grubb et al. (1969) observed in Great Britain that only a few woody species could grow under a canopy of U. europaeus. Evergreen habit and canopy architecture reduces light to other species.

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 alters 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:7

Documentation: as above. In BC's west coast, rare species occupy gorse range, particularly in Garry oak ecosystems (Erickson 1993). Potentially excludes rare species such as Howell's triteleia (Triteleia howellii Greene), golden paintbrush, (Castilleja levisecta Greenm) or deltoid balsamroot [Balsamorhiza del- toidea (Benth.) A. Gray] associated with the threatened Garry oak (Quercus garryana Douglas) ecosystem in British Columbia (Erickson 1993).

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: 7

Documentation: Not generally palatable due to spines (ISSG), although some ungulates such as sheep or goats may forage on it (Radcliffe 1985).

Identify type of impact or alteration:

Rational:

Sources of information:

Total Possible: 40

Total: 31

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: 2

Documentation: ISSG

Describe key reproductive characteristics (including seeds per plant):500-600 seeds/m^2, longevity of seed in soil, evergreen habit (Clements et al 2001). Vegetative reproduction is possible by creeping roots or fragments especially after disturbance/cutting or fire (Hoshovsky 1986); low stature plants may spread via lateral vegetative growth over many hectares after repeated mowing (Dennehy et al 2011).

Rational:

Sources of information: Johnson 2001

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: flattened winged pod present. Occasional long distance dispersal is water, wildlife. Long distance dispersal is infrequent (Zouhar 2005). Seeds are 6 mg and 2 mm long with hard water resistant coats and elaiosomes (Clements et al 2001)

Identify dispersal mechanisms:

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: spread of seeds by vehicles along roads, logging and agricultural equipment readily occurs (Clements et al 2001).

Identify dispersal mechanisms:

Rational:

Sources of information:

2.4 Allelopathic

a. no 0
b. yes 2
u. unknown

Score:0

Documentation:
There are no reports of allelopathic activity in U. europaeus.
Rational:
Sources of information: ISSG

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: Grows even in poor soils
Evidence of competitive ability:
Rational:
Sources of information: ISSG

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:2

Documentation: shrub usually up to 4.8 m tall. Dense, impenetrable thickets (Zouhar 2005). After 25-30 yr of dominating a site, other species may establish as gorse declines (Lee et al 1986)
Describe growth form: erect in British Columbia.
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: Increased germination is observed after disturbance in open conditions but does U. europaeus does not readily germinate under heavy vegetative cover (Richardson and Hill 1998).
Describe germination requirements: A large range of germination percentages are observed under different conditions, because of the hard seed coat which often renders seeds dormant.
Rational:
Sources of information: Zouhar 2005

2.8 Other species in the genus invasive in Alberta or elsewhere

a. No 0
b. Yes 3
u. Unknown

Score:0

Documentation: Associated species include in the Atlantic heathlands in France and Spain include dwarf gorse (U. minor), but no record of this species being invasive was found (Zouhar 2005).

Species:

Sources of information:

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: capable of invading riverbeds and riparian areas in New Zealand (Zouhar 2005)

Describe type of habitat:

Rational:

Sources of information:

Total Possible:25
Total:14

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:2

Documentation: Introduced as a hedge plant to contain livestock and for ornamental purposes and spread causing problems for livestock in some areas (Krause et al 1988, ISSG, Zouhar 2005)

Identify reason for selection, or evidence of weedy history:

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 Alberta 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: Invasive effects of the species is best recorded in New Zealand. Impacts recorded in Hinewai Reserve in New Zealand (Wilson 1990, 1994). In BC's west coast, rare species occupy gorse range within Garry oak ecosystems (Erickson 1993). Potentially excludes rare species such as Howell's triteleia (Triteleia howellii Greene), golden paintbrush, (Castilleja levisecta Greenm) or deltoid balsamroot [Balsamorhiza del- toidea (Benth.) A. Gray] associated with the threatened Garry oak (Quercus garryana Douglas) ecosystem in British Columbia (Erickson 1993).

Identify type of habitat and states or provinces where it occurs: forest

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: 0

Documentation: In Canada, it is only found in BC. Found in areas with degraded soil and disturbed sites such as roadsides, pasture lands, cleared forests, gravelly floodplains. Likewise establishment throughout its invaded range has been primarily through anthropogenic disturbance such as soil disturbance or deliberate planting (Richardson and Hill 1988).

Identify type of disturbance:

Rationale:

Sources of information: ISSG

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: Europe, Canada, South America, South Africa. The geographical distribution is controlled by temperature. It thrives in maritime climates similar to its native Mediterranean Europe, incl New Zealand)(Lee et al. 1986). It cannot tolerate arid climates or continental regions with extreme cold or heat and thus tends to occur in coastal areas. Short days inhibit maturation and prevents thorn formation and flowering. It will grow on most soil types (ISSG). Can occur in same habitats as *Cytisus*

scoparius (scotch broom) but on drier sites. It invades gradually and often goes unnoticed. Climate warming favours spread (Zielke et al 1992).

Describe distribution: From Virginia to Massachusetts and noxious in BC. Dry and degraded sites (Clements et al 2001).

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: Gorse is listed as a noxious weed in Washington, Oregon, California, Hawaii, and British Columbia. Identify provinces invaded: BC

Rational:

Sources of information:

Total possible:25

Total:11

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: Seed viability is variable by location. Up to 30 yrs has been reported.

Rational:

Sources of information: ISSG

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:2

Documentation:

Describe vegetative response: Vegetative reproduction is possible by creeping roots or fragments especially after disturbance/cutting or fire (Hoshovsky 1986, Dennehy et al 2011)

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: Annual costs for control in new Zealand are $17.8 million and $8 million in the agriculture and forestry sectors respectively (Sandrey 1985). Once established it is more difficult to eradicate than scotch broom (Zielke et al 1992, Clements et al 2001).

Identify types of control methods and time-term required:

Rational:

Sources of information:

Total Possible: 10
Total: 9
Total for 4 sections Possible: 100
Total for 4 sections: 65

Score Interpretation (Carlson et al. 2008):

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.

Thus gorse, Ulex europaeus, with a combined score for all 4 sections of 65 out of a possible 100 is characterized as "moderately invasive" (Carlson et al 2008).

Notes: On the world's 100 worst list

References:

ANPC Rogues gallery http://www.anpc.ab.ca/wiki/index.php/Main_Page, ACIMS http://albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-(acims).aspx , PLANTS database http://plants.usda.gov/java/, GBIF http://www.gbif.pt/, ISSG http://www.issg.org/

Carlson, M. L., Lapina, I. V., Shephard, M., Conn, J. S., Densmore, R., Spencer, P., Heys, J., Riley, J. and Nielsen, J. 2008. Invasiveness Ranking System for Non-Native Plants of Alaska. USDA. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037575.pdf

Clements, D. R., Peterson D.J., and Prasad, R. 2001. The biology of Canadian weeds. 112. Ulex europaeus L." Canadian Journal of Plant Science 81: 325-337.

Dennehy C., Alverson, E.R., Anderson, H.E., Clements, D.R., Gilbert, E.R., and Kaye, T.N. 2011. Management strategies for invasive plants in Pacific Northwest prairies, savannas, and oak woodlands. Northwest Sci. 85: 329-351.

Erickson, W. 1993. Garry Oak ecosystems. Ministry of Environment, Lands and Parks, Victoria, BC 4pp.

Grubb, P. J., Green, H. E. and Merrifield, R. C. J. 1969. The ecology of chalk heath: its relevance to the calcicole-calcifuge and soil acidification problems. J. Ecol. 57: 175–212

Hoshovsky, M. 1986. Element Stewardship Abstract for Ulex europaeus. Unpublished. The Nature Conservancy, California Field Office, 785 Market St., 3rd floor, San Francisco, CA. 25 pp. (http://tncweeds.ucdavis.edu/esadocs/ulexeuro.html)

Krause, M. A., Beck, A. C. and Dent, J. B. 1988. Control of gorse in hill country: an economic assessment of chemical and biological methods. Agric. Systems 26: 35–49.

Johnson, P. N. 2001. Vegetation recovery after fire on a southern New Zealand peatland. New Zealand Journal of Botany. 39(2): 251-267.

Lee, W. G., Allen, R. B. and Johnson, P. N. 1986. Succession and dynamics of gorse (Ulex europaeus L.) communities in the Dunedin Ecological District, South Island, New Zealand. N.Z. J. Bot. 24: 279–292.

Radcliffe, J. E. 1985. Grazing management of goats and sheep for gorse control. N.Z. J. Exp. Agric. 13: 181–190.

Richardson, R. G., Hill, R. L. 1998. The biology of Australian weeds. 34. Ulex europaeus L. Plant Prot. Q. 13(2): 46-58.

Sandrey, R. 1985. Biological control of gorse: an ex-ante evalua- tion. Agricultural Economics Research Unit Research Report No. 172. Lincoln College, Canterbury, New Zealand. 96 pp.

Wilson, HD. 1990. Gorse on Hinewai Reserve. Cantebury Botanical Society Journal 24: 45-47.

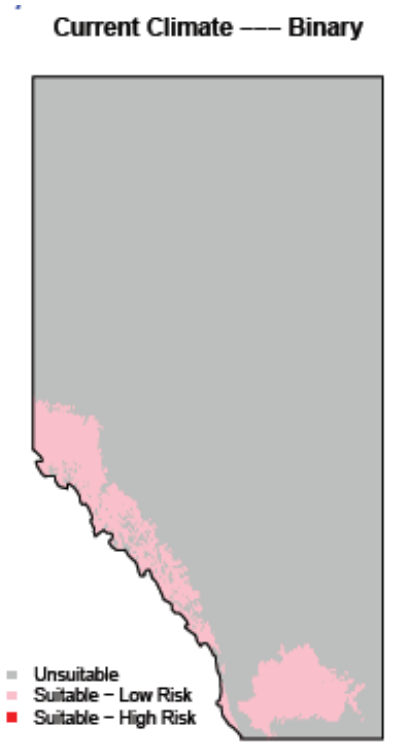
Wilson, HD 1994. Regeneration of native forest on Hinewai Reserve, Banks Peninsula. N.Z.J Bot. 32: 373-383.

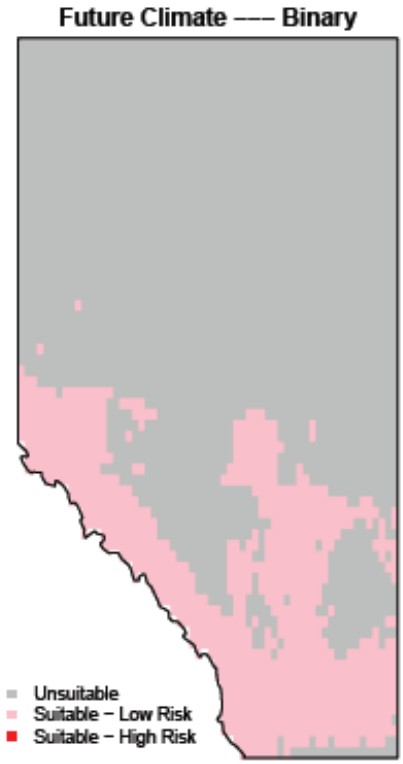
Zielke, K., Boateng, J., Caldicott, N. and Williams, H. 1992. Broom and Gorse: A Forestry Perspective Problem Analysis. British Columbia Ministry of Forests, Queen's Printer, Victoria, BC. 20 pp.

Zouhar, Kris. 2005. Ulex europaeus. 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 7].

http://www.fs.fed.us/database/feis/plants/shrub/uleeur/all.html

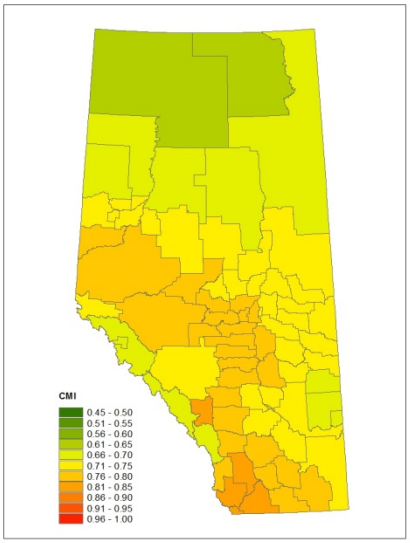
Species Distribution Model
(current climate =1975, future climate=2050)





CLIMEX Climate Match

1975



2050