United States Department of Agriculture

Animal and Plant Health Inspection Service

June 11, 2013

Version 1

Weed Risk Assessment for *Geranium lucidum* L. (Geraniaceae) – Shining cranesbill

Infestation of *Geranium lucidum* forming an almost continuous carpet in an Oregon White Oak riparian habitat (source: Bruce Newhouse, Bugwood.org; LaForest, 2013). Inset: Habit and flower of *G. lucidum* (source: Bruce Newhouse, Bugwood.org; LaForest, 2013).

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology

Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

Geranium lucidum L. – Shining cranesbill

Species Information

Family: Geraniaceae

Synonyms: *Geranium laevigatum* Royle (eFloras, 2013).

Initiation: The New Pest Advisory Group of APHIS-PPQ evaluated *Geranium lucidum* in 2007 and recommended a policy of non-reportable/non-actionable, partly because the states of California, Oregon, and Washington expressed no interest in establishing official control programs (NPAG, 2007). Recently, though, the King County Noxious Weed Program of Washington featured this species in its monthly newsletter (Shaw, 2013) and reported that it is regulated as a State Noxious Weed in Washington (NWCB, 2013) and Oregon (ODA, 2013). Because of this change in state policy, the PERAL Weed Team decided to evaluate this species. Because *G. lucidum* may also be a weed in Canada, we conducted this risk assessment in collaboration with the Canadian Food Inspection Agency (CFIA).

Foreign distribution: This species is native to Europe, northern Africa, the Middle East, Caucasus, central Asia, and temperate Himalaya (Aedo et al., 1998; eFloras, 2013). It has been introduced in Australia (Randall, 2007) and New Zealand (Howell and Sawyer, 2006; Tomson, 1922).

Canada distribution and status: This species was first collected in Canada in 1982 from a Vancouver Island roadside (Univ. of Alberta, 2013). In 2010, it was found southeast of Vancouver Island on a grassy roadside on Salt Spring Island (Klinkenberg, 2013). It is not clear if *G. lucidum* is casual or fully naturalized in British Columbia. It is not listed in online Canadian plant databases (Brouillet et al., 2013; Government of Canada, 2013), suggesting it is not fully naturalized. During a recent visit to the Salt Spring Island site, investigators did not find any *G. lucidum* plants (Clements, 2013). The status of the plants on Vancouver Island has not been verified.

U.S. distribution and status: *Geranium lucidum* is naturalized in 13 counties in Oregon, five in Washington and two in California (CISEH, 2013; Univ. of California, 2013). It is a Class A State Noxious Weed in Washington, so public and private landowners are required to control and eradicate the species (NWCB, 2013). It was first collected in 1971 in the United States from a cow pasture in Oregon (Dennehy et al., 2011; OSU Herbarium, 2006). *Geranium lucidum* is reported to be a cultivation escape (DiTomaso and Healy, 2007). We think it is cultivated to a very limited extent because we found it being sold by only one, specialized U.S. nursery (Anonymous, 2013a). Seeds are also available online from the United Kingdom (Plant World Seeds, 2013). This species may have been intentionally introduced into the United States because of its use as an herbal plant (ODA, 2013; PFAF, 2013).

WRA area[1]: Entire United States and Canada, including U.S. territories.

1. *Geranium lucidum* analysis

Establishment/Spread Potential

Geranium lucidum is a shade-tolerant winter annual that has become naturalized in the Western United States and has been spreading since it was first detected in 1971 (Dennehy et al., 2011; OSU Herbarium, 2006). This species is self-compatible (Yeo, 2004), reproduces by seed (Dennehy et al., 2011; Van Assche and Vandelook, 2006), and forms dense carpets of seedlings in invaded habitats (Dennehy et al., 2011; Taylor, 2006). Seeds are dispersed by the explosive recoiling of the awn (Aedo, 2000; Dennehy et al., 2011; Yeo, 2004), and even in still air the seeds can travel up to 20 feet (Salisbury, 1961). People also disperse seeds accidentally (Alverson, 2007; Anonymous, 2013b; Dennehy et al., 2011): *G. lucidum* spread from Oregon to Washington in contaminated nursery plants (Anonymous, 2013b; Dennehy et al., 2011). It may also spread as a contaminant of agricultural seed (Salisbury, 1961).Contributing to its success as an invasive species, *G. lucidum* forms a seed bank that persists for more than a year (Taylor, 2006; Van Assche and Vandelook, 2006). We had a less than average level of uncertainty with this risk element.

Risk score = 17 Uncertainty index = 0.11

Impact Potential

Geranium lucidum is primarily a concern to natural systems because it dominates habitat understories and excludes native herbaceous species (Alverson, 2007; Dennehy et al., 2011; FBP, 2006; ODA, 2013). Although it is currently not a direct threat to threatened and endangered species, it could make habitat restoration for rare species difficult (Alverson, 2007). In its native range in Europe, it is considered a garden weed (FNI, 2013; Salisbury, 1961). In the United States *G. lucidum* is considered a "major threat to the integrity of oak woodland habitats" (Dennehy et al., 2011). This species is being actively managed in Oregon (Dennehy et al., 2011; Taylor, 2006) and the Nature Conservancy in Oregon is trying to eradicate it from some preserves (Alverson, 2007). Washington state is also trying to eradicate it (NWCB, 2013). Because *G. lucidum* moves with nursery stock (Anonymous, 2013b; Dennehy et al., 2011), it may impact trade if the importing country or region regulates the weed. We had an average amount of uncertainty.

Risk score = 2.5 Uncertainty index = 0.17

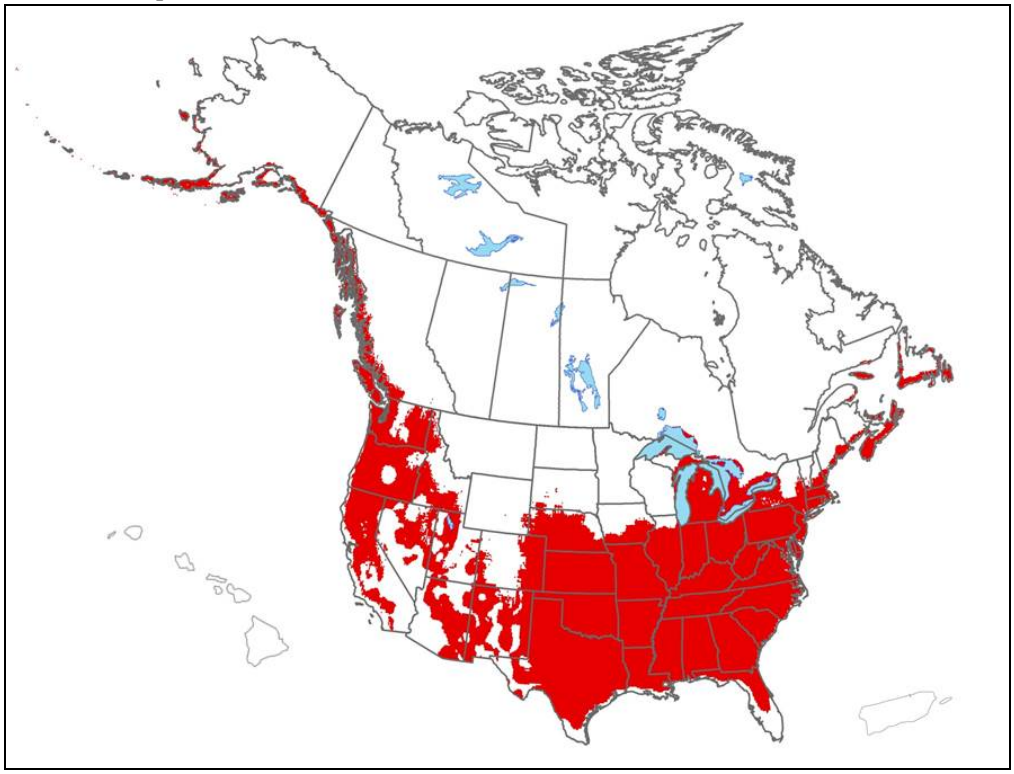
[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area" (IPPC, 2012).

Geographic Potential Based on three climatic variables, we estimate that about 54 percent of the United States and 4 percent of Canada is suitable for the establishment of *G. lucidum* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *G. lucidum* represents the joint distribution of Plant Hardiness Zones 6-9, areas with 10-100+ inches (25-254+ cm) of annual precipitation, and the following Köppen-Geiger climate classes: steppe, Mediterranean, humid subtropical, marine west coast, humid continental warm summers, humid continental cool summers, subarctic, and tundra.

The area estimated likely represents a conservative estimate as it uses only three climatic variables to estimate the area of the United States and Canada that is suitable for establishment of the species. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. In its native range, *G. lucidum* occurs in seashores, stony hillsides, rocks, hedges, and walls (Dunn, 1905; Presland, 2008; Stace, 2010). It can also grow in mountainous regions as high as 2000–3000 meters in elevation (eFloras, 2013). In the United States, it grows in oak woodlands, dry conifer forests, riparian forests, roadsides, and pastures (Dennehy et al., 2011; OSU Herbarium, 2006). It generally appears to be more invasive in moist habitats (Shaw, 2013).

Entry Potential We did not assess the entry potential of *Geranium lucidum* because it is already present in the United States (CISEH, 2013; Univ. of California, 2013) and Canada (Klinkenberg, 2013; Univ. of Alberta, 2013).

Figure 1. Predicted distribution of *Geranium lucidum* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 79.8%
P(Minor Invader) = 19.4%
P(Non-Invader) = 0.8%

Risk Result = High Risk

Secondary Screening = Not Applicable

Figure 2. *Geranium lucidum* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

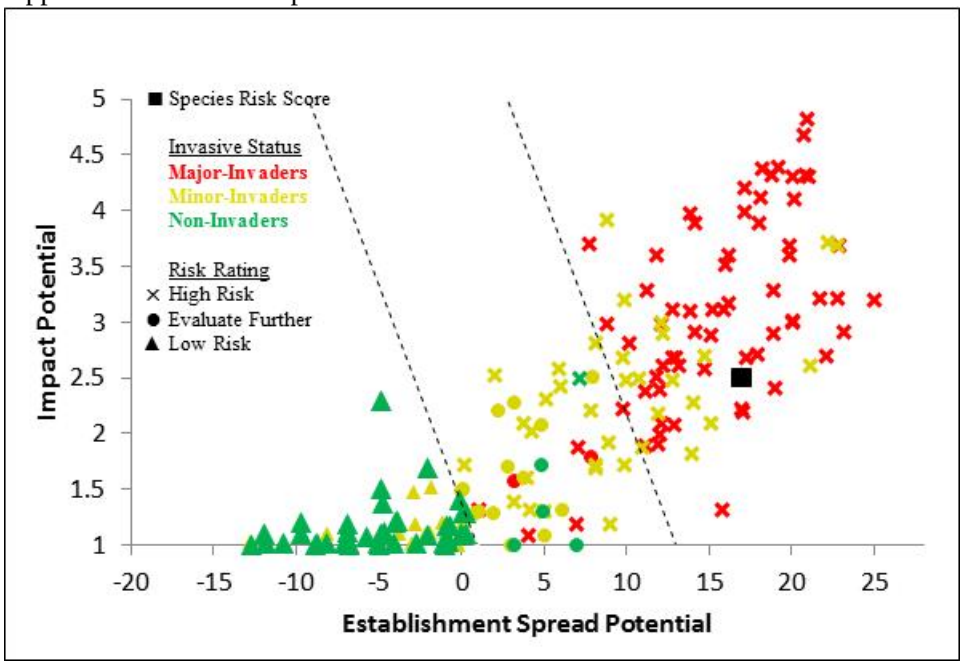
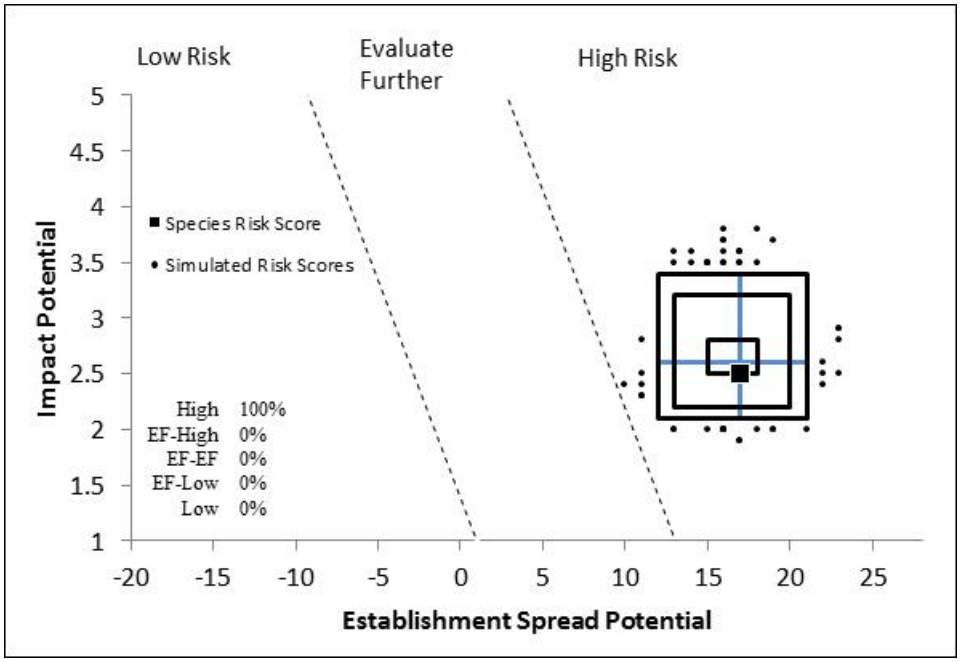


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Geranium lucidum*[a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Geranium lucidum* is High Risk (Fig. 2). Our uncertainty analysis supports this conclusion as all of the simulated risk scores also resulted in conclusions of High Risk (Fig. 3). Our model indicates *G. lucidum* has an 80 percent likelihood of becoming a major invader, and its invasive behavior in the Pacific Northwest coast supports this idea. Since it was first detected in Oregon in 1971, it has rapidly spread throughout the region. Natural dispersal, unintentional dispersal by people, and dispersal in the nursery trade have contributed to its spread.

"Once fully established, *Geranium lucidum* is virtually impossible to eliminate from a site due to its rapid rate of increase, high plant density, persistent seed bank, and difficulty of implementing management treatments without causing collateral damage to associated native herbaceous species" (Dennehy et al., 2011). A natural-areas manager believes it cannot be eradicated from heavily infested areas in Oregon, but keeping it from spreading to new areas may be possible using Early Detection and Rapid Response activities (Alverson, 2007).

4. Literature Cited

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

Aedo, C. 2000. The genus *Geranium* L. (Geraniaceae) in North America. I. Annual species. Anales del Jardin Botánico de Madrid 58:39-82.

Aedo, C., F. M. Garmendia, and F. Pando. 1998. World checklist of *Geranium* L. (Geraniaceae). Anales del Jardin Botánico de Madrid 56(2):211-252.

Alverson, E. 2007. Biology and status of *Geranium lucidum*. Personal communication to A. L. Koop on January 18, 2007, from Edward Alverson, Willamette Valley stewardship ecologist with The Nature Conservancy.

Anonymous. 2013a. Geraniaceae.com. Geraniaceae. Last accessed June 3, 2013, http://geraniaceae.com/cgi-bin/welcome.py.

Anonymous. 2013b. Shiny geranium (a.k.a. Shining geranium, Shining crane's bill) *Geranium lucidum*. Noxious Weed Control Program, King County, Washington. Last accessed May 6, 2013, http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification/shiny-geranium.aspx.

Ather, A., R. Abid, and M. Qaiser. 2012. The seed atlas of Pakistan-VII. Geraniaceae. Pakistan Journal of Botany 44(3):1059-1064.

Backyard Gardener. 2013. Plant Finder [online database]. BackyardGardener.com. http://www.backyardgardener.com. (Archived at PERAL).

Boersma, P. D., S. H. Reichard, and A. N. v. Buren (eds.). 2006. Invasive Species in the Pacific Northwest. University of Washington Press, Seattle, WA, U.S.A. 285 pp.

Brouillet, L., F. Coursol, S. J. Meades, M. Favreau, M. Anions, P. Bélisle, and P. Desmet. 2013. VASCAN, the Database of Vascular Plants of Canada. http://data.canadensys.net/vascan/search. (Archived at PERAL).

Burrows, G. E., and R. J. Tyrl. 2001. Toxic Plants of North America. Iowa State University Press, Ames, IA. 1342 pp.

CISEH. 2013. Early Detection and Distribution Mapping System, Online Database. The University of Georgia - Center for Invasive Species and Ecosystem Health (CISEH). http://www.eddmaps.org/. (Archived at PERAL).

Clements, D. 2013. Status of *Geranium lucidum* in British Columbia. Personal communication to K. Castro on May 30, 2013, from David Clements (Coordinator of Environmental Studies, Trinity Western University) who relayed observations made by Rebecca Prins, botany student.

Dennehy, C., E. R. Alverson, H. E. Anderson, D. R. Clements, R. Gilbert, and T. N. Kaye. 2011. Management Strategies for Invasive Plants in Pacific Northwest Prairies, Savannas, and Oak Woodlands. Northwest Science 85(2):329-351.

DiTomaso, J. M., and E. A. Healy. 2007. Weeds of California and Other Western States (vols. 1 & 2). University of California, Oakland, CA, U.S.A. 1808 pp.

Dunn, S. T. 1905. Alien Flora of Britain. West, Newman, and Co., London, U.K. 208 pp.

eFloras. 2013. Electronic Floras, online database. Missouri Botanical Garden, St. Louis, MO and Harvard University Herbaria, Cambridge, MA. http://www.efloras.org. (Archived at PERAL).

FBP. 2006. Invasive weeds at Mt. Pisagh. Friends of Buford Park and Mt. Pisagh, Eugene, OR, U.S.A. Last accessed July 21, 2006, http://www.bufordpark.org/WorstWeedsatHBRA_Flyer11-2.pdf.

FNI. 2013. Flora of Northern Ireland (FNI) [Online Database]. Botanical Society of the British Isles. http://www.habitas.org.uk/flora/index.html. (Archived at PERAL).

GBIF. 2013. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://data.gbif.org/welcome.htm. (Archived at PERAL).

Government of Canada. 2013. Plants of Canada. Canadian Forest Service of Natural Resources Canada and Canadian Food Inspection Agency. http://www.plantsofcanada.info.gc.ca/. (Archived at PERAL).

Heap, I. 2013. The international survey of herbicide resistant weeds. Weed Science Society of America. www.weedscience.com. (Archived at PERAL).

Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.

Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1991. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, Florida, U.S.A. 391 pp.

Howell, C. J., and J. W. D. Sawyer. 2006. New Zealand naturalised vascular plant checklist. New Zealand Plant Conservation Network, Wellington, New Zealand. 60 pp.

IPPC. 2012. International Standards for Phytosanitary Measures No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy.

Klinkenberg, B. 2013. E-Flora BC: Electronic Atlas of the Plants of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. http://www.geog.ubc.ca/biodiversity/eflora/. (Archived at PERAL).

Koop, A., L. Fowler, L. Newton, and B. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294.

LaForest, J. 2013. Image usage request 100020. Personal communication to A.

Koop on May 1, 2013, from Joe LaForest, Bugwood Image Database Manager.

Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and nitrogen fixation. Australian Systematic Botany 3:91-100.

NGRP. 2013. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl?language=en. (Archived at PERAL).

Nickrent, D. 2009. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL. Last accessed June 12, 2009, http://www.parasiticplants.siu.edu/ListParasites.html.

NPAG. 2007. *Geranium lucidum* L.: Shining geranium. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology, Plant Epidemiology and Risk Analysis Laboratory, New Pest Advisory Group (NPAG), Raleigh, NC, U.S.A. 4 pp.

NWCB. 2013. Noxious Weeds. Washington State, Noxious Weed Control Board (NWCB), Olympia, WA. Last accessed May 6, 2013, http://www.nwcb.wa.gov/nwcb_nox.htm.

ODA. 2013. Shiny geranium (*Geranium lucidum*) Oregon Department of Agriculture (ODA), Salem, Oregon. Last accessed May 6, 2013, http://www.oregon.gov/ODA/plant/weeds/Pages/profile_shinygeranium.aspx.

OSU Herbarium. 2006. Oregon Herbarium Records for *Geranium lucidum*. Oregon State Universtiy Herbarium, Corvallis, OR, U.S.A. Last accessed November 28, 2006, http://ocid.nacse.org/cgi-bin/qml/herbarium/plants/vherb.qml.

PFAF. 2013. Plants for a Future (Online Database). Plants for a Future (PFAF). http://www.pfaf.org/index.php. (Archived at PERAL).

Plant World Seeds. 2013. *Geranium lucidum*. Plant World Seeds, Devon, United Kingdom. Last accessed May 6, 2013, http://www.plant-world-seeds.com/store/view_seed_item/627.

Presland, J. 2008. The flora of walls: Dry stone versus mortared. Botanical Society of The British Isles 108:7-11.

Randall, J. M. 2007. The Introduced Flora of Australia and its Weed Status. CRC for Australian Weed Management, Department of Agriculture and Food, Western Australia, Australia. 528 pp.

Randall, R. P. 2012. A Global Compendium of Weeds, 2nd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 1107 pp.

Salisbury, E. 1961. Weeds and Aliens. Collins, London. 384 pp.

Shaw, S. 2013. Weed of the Month: Shiny Geranium (*Geranium lucidum*). King County Weed News, March:1-2. http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-news.aspx.

Stace, C. 2010. New Flora of the British Isles (3rd ed.). Cambridge University Press, Cambridge, United Kingdom. 1130 pp.

Sykes, W. R. 1982. Checklist of dicotyledons naturalised in New Zealand 15. Annonales, Berberidales, Cactales, Fagales, some Geraniales, Juglandales, Laurales, Rutales, Salicales, Sapindales, Tiliales, Nyctaginaceae, and Zygophyllaceae. New Zealand Journal of Botany 20(4):333-341.

Taylor, T. 2006. *Geranium lucidum* in Eugene, Oregon. Personal communication to

A. L. Koop on July 24, 2006, from Trevor Taylor, a natural areas supervisor with the city of Eugene.

Tomson, G. M. 1922. The Naturalisation of Animals & Plants in New Zealand. Cambridge University Press, Cambridge, U.S.A. 588 pp.

Univ. of Alberta. 2013. Vascular plant herbarium, Online database. University of Alberta. http://www.biology.museums.ualberta.ca/en/VascularPlantHerbarium.aspx. (Archived at PERAL).

Univ. of California. 2006. California Herbarium Records for *Geranium lucidum*. University of California, Consortium of California Herbaria, CA, U.S.A. Last accessed November 28, 2006, http://ucjeps.berkeley.edu/consortium/.

Univ. of California. 2013. Consortium of California Herbaria. Regents of the University of California. http://ucjeps.berkeley.edu/consortium/. (Archived at PERAL).

Van Assche, J. A., and F. E. A. Vandelook. 2006. Germination ecology of eleven species of Geraniaceae and Malvaceae, with special reference to the effects of drying seeds. Soil Seed Science 16:283-290.

WTU. 2006. Herbarium records of *Geranium lucidum* from the University of Washington. Burke Museum of natural Hisotry and Culture, Seatle, WA, U.S.A. Last accessed November 28, 2006, http://www.washington.edu/burkemuseum/collections/herbarium/index.php.

Yeo, P. F. 2004. The morphology and affinities of *Geranium* sections *Lucida* and *Unguiculata*. Botanical Journal of the Linnean Society 144(4):409-429.

Appendix A. Weed risk assessment for *Geranium lucidum* L. (Geraniaceae). The following information was obtained from the original risk assessment for this species (full responses and all guidance), which is available upon request. We modified the information here to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	f - negl	5	This species is broadly native from Europe and northern Africa through the Middle East to Nepal, Pakistan, and northwestern India (NGRP, 2013). Introduced to Australia (Randall, 2007). Introduced to New Zealand as early as 1903 (Tomson, 1922) and currently casual (Howell and Sawyer, 2006; Sykes, 1982). Has been collected twice from roadside habitats in Canada (Vancouver Island and Salt Spring Island) (Klinkenberg, 2013; Univ. of Alberta, 2013). Naturalized in the United States (Aedo, 2000) and spreading (Univ. of California, 2006). "It was first collected in Oregon in Yamhill County in 1971. It has now spread throughout the Willamette Valley, and is beginning to spread south into the Umpqua and Rogue Valleys, and north into Washington. As of 2010, populations have been documented in Washington in Clark, Thurston, King, and Skagit Counties" (Dennehy et al., 2011). Alternate answers for the Monte Carlo simulation are both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	This species is cultivated to a limited extent (Anonymous, 2013a; Backyard Gardener, 2013); however, we found no evidence of domestication or breeding to reduce weed-associated traits. Seeds are available online from the United Kingdom (Plant World Seeds, 2013).
ES-3 (Weedy congeners)	y - negl	1	*Geranium molle*, *G. simense*, and *G. tuberosum* are principal weeds in one country each (Holm et al., 1991). The similar species *G. robertianum* is causing a decline in native species in the understory of Pacific Northwest habitats (Boersma et al., 2006).
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	Occurs in seashores and stony hillsides (Dunn, 1905). In the United States, "*Geranium lucidum* is most abundant in open shade, especially in oak woodlands, but also in riparian and bottomland forests that are dominated by hardwoods" (Alverson, 2007). Grows well in shady areas of Oregon (FBP, 2006; OSU Herbarium, 2006), California (Univ. of California, 2006), and Washington (WTU, 2006). Generally grows in shade (Dennehy et al., 2011). It is interesting that it is reported to be mostly shade intolerant in Europe, but in the United States it is shade tolerant (ODA, 2013). Perhaps there are other ecological factors affecting its distribution. Regardless, there is negligible uncertainty as it grows in the shade in the United States.
ES-5 (Climbing or smothering growth form)	n - negl	0	Plants are terrestrial herbs 5-45 cm tall (Aedo, 2000).
ES-6 (Forms dense thickets)	y - negl	2	Forms dense populations (Dennehy et al., 2011; Taylor, 2006). Seeds germinate in mass in the fall, producing carpets of seedlings (Dennehy et al., 2011).
ES-7 (Aquatic)	n - negl	0	Plant is not an aquatic species; rather, it is a terrestrial herb (Aedo, 2000; Yeo, 2004).
ES-8 (Grass)	n - negl	0	Species is in the Geraniaceae (NGRP, 2013).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	The Geraniaceae (NGRP, 2013), is not a plant family known to contain nitrogen-fixing species (Martin and Dowd, 1990).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Reproduces by seed (Anonymous, 2013b; Dennehy et al., 2011; Van Assche and Vandelook, 2006).
ES-11 (Self-compatible or apomictic)	y - low	1	"[T]he flowers automatically self, with the stigmas diverging slightly before the flower opens and the dehisced anthers pushing their pollen up between them" (Yeo, 2004). The very similar congener *G. robertianum* is also self-compatible (Boersma et al., 2006).
ES-12 (Requires special pollinators)	? - max		Unknown. Two sources indicated it is pollinated by insects (Anonymous, 2013b; PFAF, 2013), but they don't report what kind of insects. Another source indicates that small bees with long tongues are attracted to the nectar (Yeo, 2004), but this does not confirm pollination.
ES-13 (Minimum generation time)	b - negl	1	Plant is an annual (Aedo, 2000; eFloras, 2013; Yeo, 2004) or biennial (DiTomaso and Healy, 2007). A winter annual (Van Assche and Vandelook, 2006). Plants normally germinate in autumn, but they can also germinate in spring, at which point they will have an abbreviated lifecycle where flowers appear before the cotyledons wither and die (Yeo, 2004); this reference does not consider plant lifecycle or minimum generation time. Alternate answers for the Monte Carlo simulation are "c" and "a."
ES-14 (Prolific reproduction)	? - max	0	Unknown. There was not enough information in the literature to either directly or indirectly answer this question. Although online pictures of high population densities in the Pacific Northwest coast of the United States would suggest that prolific reproduction is possible, we did not see any pictures of high densities of flowering and fruiting plants. There are multiple species of cranesbill geraniums. For most species in cornfields, seed production ranges between 300 and 400 per plant (Salisbury, 1961).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Dispersed in yard trash that is dumped alongside roads (Alverson, 2007). It may also be dispersed in mud attached to vehicles and people (Alverson, 2007). Seeds disperse on feet of people (Dennehy et al., 2011), but no specific evidence provided. Seeds disperse on shoes and vehicles (Anonymous, 2013b). This species was detected on Salt Spring Island near a clump of cut stems (Klinkenberg, 2013), but it unclear if it arrived in that location via plant trash.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	It spread from Oregon to Washington in contaminated nursery plants (Anonymous, 2013b; Dennehy et al., 2011). It may also be spread as an impurity in agricultural seed (Salisbury, 1961).
ES-17 (Number of natural dispersal vectors)	1	-2	For ES17a through ES17e: Fruit in the cranesbill geraniums consist of five single-seed carpels (Salisbury, 1961). In *G. lucidum*, "Seed 2 mm long, oblong, reddish, glabrous, lower end with a black protuberance" (eFloras, 2013). In Pakistan, seeds are oblong, approximately 1-1.2 mm by 0.9-1.0 mm (Ather et al., 2012). As a member of the subgenus *Robertium*, the mericarps with their single seed each are actively discharged by the explosive recoiling of the awn (Aedo, 2000; Dennehy et al., 2011; Yeo, 2004). Even in still air, the seeds can be dispersed up to 20 feet away (Salisbury, 1961).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17a (Wind dispersal)	n - low		No evidence and does not seem likely.
ES-17b (Water dispersal)	n - low		No evidence and does not seem likely.
ES-17c (Bird dispersal)	n - low		No evidence and does not seem likely.
ES-17d (Animal external dispersal)	y - mod		It may be dispersed on mud attached to wild and domesticated animals (Alverson, 2007). The pattern of population dispersion suggests it is dispersed by animals and humans (Taylor, 2006), but this doesn't distinguish between internal and external dispersal. Primary long-distance dispersal mechanism is on the feet of deer or livestock (Dennehy et al., 2011), but no specific evidence provided. Dispersed by wildlife (presumably externally), but supporting information not given (ODA, 2013). Answering yes with moderate uncertainty based on the number of anecdotal comments. Seeds of the invasive congener *G. robertianum* have a sticky fiber at one end that allows them to stick to animals, leaves, or other surfaces (Boersma et al., 2006). *Geranium lucidum* may have a similar dispersal trait.
ES-17e (Animal internal dispersal)	n - mod		No evidence. Using moderate uncertainty because it is unknown if seeds may be consumed by browsing animals.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	Freshly matured seeds of *G. lucidum* have water impermeable seed coats (Van Assche and Vandelook, 2006). Seed burial experiments showed that seeds remain viable for more than one year and need a period of desiccation to break dormancy (Van Assche and Vandelook, 2006). Experience from managers controlling populations suggests it has a long-term seed bank (Taylor, 2006).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	No evidence (Heap, 2013). "*G*[*eranium*] *lucidum* can be treated with either glyphosate or triclopyr" (Dennehy et al., 2011). "All the cranesbills are relatively resistant to selective herbicides," but some control can be achieved if applied at the early seedling stage (Salisbury, 1961).
ES-21 (Number of cold hardiness zones suitable for its survival)	4	0	
ES-22 (Number of climate types suitable for its survival)	8	2	
ES-23 (Number of precipitation bands suitable for its survival)	10	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Unknown. It may have an allelopathic effect based on how it smothers other herbaceous vegetation (Alverson, 2007). "The extreme abundance of *G. lucidum* at some sites, to the exclusion of other vegetation, suggests an allelopathic effect" (Dennehy et al., 2011). Answering unknown because neither of these two sources provide any evidence.
Imp-G2 (Parasitic)	n - negl	0	No evidence. This species is not a member of a plant family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - mod	0	No evidence.
Imp-N2 (Change community structure)	y - high	0.2	We did not find any evidence this species changes the physical structure of habitats by creating or eliminating a layer. However, based on the guidance, because it dominates habitat understories (Alverson, 2007; ODA, 2013) and thereby eliminates their structural diversity, we are answering yes, but with high uncertainty. Also see images on bugwood.org.
Imp-N3 (Change community composition)	y - negl	0.2	Forms extensive pure stands (FBP, 2006). Displaces natives and probably inhibits recruitment of native forbs (Dennehy et al., 2011). "Pushes out" early spring wildflowers (ODA, 2013). Appear to suppress the growth of native herbaceous species (Alverson, 2007).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - mod	0.1	Because this species forms extensive stands that outcompete early spring wildflowers (ODA, 2013), it is likely to impact understory threatened and endangered species. In Oregon, it generally wouldn't impact threatened and endangered species because those species, tend to occur in prairie habitats; however, *G. lucidum* could make it extremely difficult to restore habitat for these rare species (Alverson, 2007).
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	y - high		This species is considered a "major threat to the integrity of oak woodland habitats" in the United States (Dennehy et al., 2011). Because of its ability to form extensive pure stands (FBP, 2006), it is likely to affected globally outstanding ecoregions along the west coast of North America.
Imp-N6 (Weed status in natural systems)	c - negl	0.6	It is a major weed of natural systems (Dennehy et al., 2011). It can invade and overwhelm high quality native habitat, including woodlands and prairies (Anonymous, 2013b). The Nature Conservancy in Oregon has been trying to eradicate it from some of their preserves (Alverson, 2007). It is a specific management target in Washington and Oregon in oak woodland, prairie, and savanna habitats within the Willamette Valley-Puget Trough-Georgia Basin ecoregion (Dennehy et al., 2011). Hand pulling is effective for small populations, but for larger infestations, herbicide application at the seedling stage is best (Dennehy et al., 2011). Similar tips for management can be found on the King County government website (Anonymous, 2013b). Alternate answers for the Monte Carlo simulation are both “b.”
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	No evidence.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	No evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - high	0	No evidence.
Imp-A4 (Weed status in anthropogenic systems)	b - low	0.1	It easily becomes established in gardens, paved areas, and on walls (Yeo, 2004). Occasionally common and weedy in gardens (Salisbury, 1961). Prolific garden weed in Belfast

Question ID	Answer - Uncertainty	Score	Notes (and references)
			(FNI, 2013). Grows in wet swales of a roadside in Oregon (OSU Herbarium, 2006). But no evidence of control in these types of systems. Alternate answers for the Monte Carlo simulation are "c" and "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - mod	0	No evidence.
Imp-P2 (Lowers commodity value)	n - high	0	No evidence. It may reduce the forage value of unimproved pastures that occur on hillsides where cultivation is not possible (Alverson, 2007).
Imp-P3 (Is it likely to impact trade)	y - mod	0.2	This species is a quarantine pest in the state of Washington, where it cannot be sold or moved within the state (Anonymous, 2013b). Furthermore, landowners are required to remove it from their properties (Anonymous, 2013b). Because this species can contaminate nursery stock (Anonymous, 2013b; Dennehy et al., 2011), it is likely to affect some trade in plants for planting.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	No evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	No evidence that this species or genus (Burrows and Tyrl, 2001) is toxic.
Imp-P6 (Weed status in production systems)	a - low	0	In pasture in Oregon (OSU Herbarium, 2006). However, there is no evidence it is considered a weed of production systems. Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise noted, all evidence below represents point-occurrences obtained from GBIF (2013).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	No evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	No evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	No evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	No evidence.
Geo-Z5 (Zone 5)	n - high	N/A	Right along interface between zone 5 and 6 in Norway. Assuming no since it is not present within zone 5.
Geo-Z6 (Zone 6)	y - negl	N/A	Sweden and Norway.
Geo-Z7 (Zone 7)	y - negl	N/A	Germany, Norway, Spain, OR (USA). Hardy to zone 7 (PFAF, 2013).
Geo-Z8 (Zone 8)	y - negl	N/A	France, Spain, OR (USA).
Geo-Z9 (Zone 9)	y - negl	N/A	Spain, Greece, WA (USA).
Geo-Z10 (Zone 10)	n - high	N/A	A few points near edge in San Francisco (USA) and India.
Geo-Z11 (Zone 11)	n - negl	N/A	No evidence.
Geo-Z12 (Zone 12)	n - negl	N/A	No evidence.
Geo-Z13 (Zone 13)	n - negl	N/A	No evidence.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	No evidence.
Geo-C2 (Tropical savanna)	n - negl	N/A	No evidence.
Geo-C3 (Steppe)	y - negl	N/A	Spain and Morocco.
Geo-C4 (Desert)	n - high	N/A	Two points in Algeria, one in Egypt. Because this species

Question ID	Answer - Uncertainty	Score	Notes (and references)
			appears to favor moist sites (Shaw, 2013), we are assuming these points are either erroneous or represent occurrences in protected microhabitats.
Geo-C5 (Mediterranean)	y - negl	N/A	Portugal, Spain, United States.
Geo-C6 (Humid subtropical)	y - low	N/A	Greece, Pakistan, one point in Turkey, and one point in Azerbaijan.
Geo-C7 (Marine west coast)	y - negl	N/A	United Kingdom and France.
Geo-C8 (Humid cont. warm sum.)	y - mod	N/A	One point in Pakistan and two in Armenia.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Sweden.
Geo-C10 (Subarctic)	y - low	N/A	Norway and Germany.
Geo-C11 (Tundra)	y - low	N/A	Norway.
Geo-C12 (Icecap)	n - negl	N/A	No evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - high	N/A	Two points in Algeria, one in Egypt. Because this species appears to favor moist sites (Shaw, 2013), we are assuming these points are either erroneous or represent occurrences in protected microhabitats.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Spain, Israel, and one point in Azerbaijan.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Germany, Sweden, and France.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	France, Belgium, Portugal, Pakistan, and India.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	OR (USA), Spain, and Ireland.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	WA and OR (USA) and the United Kingdom.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	WA (USA) and the United Kingdom.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	United Kingdom.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	United Kingdom.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	United Kingdom.
Geo-R11 (100+ inches; 254+ cm))	y - low	N/A	United Kingdom.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Naturalized and spreading in the United States (CISEH, 2013; Univ. of California, 2013). Also, this species has been collected twice in Canada from roadside habitats (Klinkenberg, 2013; Univ. of Alberta, 2013). Cultivated in California (Anonymous, 2013a).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	Seeds are available on the internet for resale (Plant World Seeds, 2013). Available a nursery in California that will also mail plants (Anonymous, 2013a). Has been used for centuries as a diuretic and astringent in Europe, but is less well known in North America (ODA, 2013; PFAF, 2013). Cultivated (Randall, 2012).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	An impurity in agricultural seed (Salisbury, 1961).
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	