Cypripedium parviflorum var. *pubescens* (Willd.) O.W. Knight: Conservation Assessment on the Tongass National Forest, Alaska Region

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Cover Photo: Photo by Kristin Lease (USFS, Tongass National Forest)

EXECUTIVE SUMMARY

Cypripedium parviflorum var. *pubescens* was proposed as a Species of Conservation Concern for USDA Forest Service and is listed by the Alaska Natural Heritage Program as S1 (critically imperiled to rare in the state). The global range of *Cypripedium parviflorum* var. *pubescens* spans from eastern Canada west to Washington and eastern British Columbia, and then widely disjunct to southeastern Alaska. It is not clear if populations in Alaska represent unique genotypes for this taxon, though genetic research is underway. A total of five populations have been identified, all of which occur in northern Prince of Wales Island. All extant populations occur on Tongass National Forest lands. All populations in Alaska are very small, with the largest populations consisting of fewer than 20 individuals and the smallest consisting of a single individual.

Cypripedium parviflorum var. *pubescens* is an orchid typically associated with open or partially shaded sites that are rich in calcareous substrates. Four out of five populations in the Tongass National Forest are found along the roadside or ecotone between karst-fen or forest and the roadside. However the habitat requirements of this species in Alaska are not well understood. One site that has not been revisited since its initial discovery is found along a marble cliff and forest. This species is regarded as a weak competitor. *Cypripedium parviflorum* var. *pubescens* requires mycorrhizal fungi for germination and seedling establishment. It requires insect pollinators for fruit and seed production and the nature of the small population sizes may result in hampered seed production due to rarity of compatible plants.

Road construction and maintenance are one of the primary threats to these populations, as the majority of populations occur within the right-of-way of the mainstem road on Prince of Wales Island. Additionally, plant collecting by orchid enthusiasts is widely acknowledged as one of the leading causes of population declines of *Cypripedium* species worldwide. The roadside location of these population makes them vulnerable to plant collection risk. Most of the populations also co-occur with non-native plant species, such as *Phalaris arundinacea* (reed canarygrass) that are overtopping the orchids. Competition with non-native species threatens long-term persistence of most populations in the Tongass National Forest. It is not clear what impacts timber harvest may have on the known populations. Invertebrate and vertebrate herbivory has been observed at a number of the populations; the magnitude of impacts from herbivory does not appear to be great, but could negatively affect seed production, recruitment, and survivorship rates of reproductive and vegetative individuals. Climate projections for southeastern Alaska predict modest change in temperature and precipitation patterns in the next 50 years, and are not expected to result in substantial impacts to *C. parviflorum* var. *pubescens*. Overall, the few populations of small numbers of individuals is a significant factor to the inherent vulnerability of this orchid. Single stochastic natural events, road construction or a bout of plant collecting could cause population extirpation.

The paucity of information on the orchid's basic ecology and demographics poses some limitations on our understanding of potential impacts from management-related activities,

climate change-related threats, and the natural vulnerability of *C. parviflorum* var. *pubescens*.

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INTRODUCTION

This assessment is one of many being produced to support current and future forest planning efforts on the Tongass National Forest. *Cypripedium parviflorum* var. *pubescens* is the focus of an assessment because it is both designated as a Sensitive Species' by the Alaska Regional Forester, and it is a Rare Species in Alaska. Within the National Forest System, Sensitive Species are plants and animals whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or significant current or predicted downward trends in habitat capability that would reduce a species distribution (FSM 2670.5 (19)). Sensitive Species require a detailed effects analysis to be conducted during project planning which identifies any special management that may be needed for a particular population. Knowledge of their biology and ecology is critical for a science-based, informed analysis that is consistent amongst resource managers. Rare Species serve as a barometer for species viability at the State level.

This assessment addresses the biology of *Cypripedium parviflorum* var. *pubescens* throughout its range in the Alaska Region, and more specifically within the Tongass National Forest, as the "planning area". The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. Furthermore, completing the assessments promptly requires establishment of some limits concerning the geographic scope of particular aspects of the assessment and further analysis of existing (but unanalyzed) field data. This introduction outlines the scope of the assessment and describes the process used in producing the assessments.

Goal

Species assessments produced as part of the Tongass National Forest Planning Project are designed to provide forest managers, research biologists, and the public a thorough discussion of the biology, ecology, and conservation status of certain species based on scientific knowledge accumulated prior to initiating the assessment. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations but provides the ecological background upon which management must be based. While the assessment does not provide management recommendations, it focuses on the consequences of changes in the environment that result from management (i.e. management implications). Furthermore, it cites management recommendations proposed elsewhere and, when management recommendations have been implemented, the assessment examines the success of the implementation.

Scope

The *Cypripedium parviflorum* var. *pubescens* assessment examines the biology, ecology, and management of this species with specific reference to the geographic and ecological characteristics of the Tongass National Forest and the Alaska Region. Although some (or a majority) of the literature on the species may originate from field investigations outside the region, this document places that literature in the ecological and social context of the southeastern and to a lesser extent,

south-central Alaska. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *Cypripedium parviflorum* var. *pubescens* in the context of the current environment rather than under historical conditions 200, 2000, or 2 million years ago. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on *Cypripedium parviflorum* var. *pubescens* are referenced in the assessment, nor were all published material considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with less certainty. We chose to use some non-refereed literature in the assessments, however, when information was unavailable elsewhere. Unpublished data (e.g. Natural Heritage Program and USFS records) were important in estimating the geographic distribution. These data required special attention because of the diversity of persons and methods used to collect the data.

Motivation to produce species assessments rapidly, in order to make information available for Forest Planning, lead to tight timelines. The goal to produce assessments rapidly limited the analysis of existing, unpublished data, or attempts to conduct meta-analysis to synthesize information from published literature. Review of literature found inherent data gaps in the natural history of the species. For example, there were limited data in basic habitat requirements, physiological limits, or response to any disturbance. We relied on the best available data such as observations of *C. parviflorum* populations in its range or data from other *Cypripedium* species. There are levels in uncertainty in observation data and response to disturbance. These data are not experimentally repeated measures and therefore caution should be used in the use of currently available data.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and observations limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hilborn and Mangel 1997), as may be observed in certain physical sciences. The geologist, T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (experiments, modeling, logical inference). Ecological science is, in some ways, more similar to geology than physical science because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide understanding of the world (Hilborn and Mangel 1997).

Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted and alternative explanations described when appropriate. While well-

executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding and used in synthesis for this assessment.

Major limitations were data gaps in the NRIS database where important population and ecological information were not recorded to USFS protocol, thus limiting the knowledge of the species distribution, abundance, and microhabitat parameters. It is noted when necessary data were missing to come to conclusions or biological opinions. Additionally, there is some uncertainty in the identification of material. The identifications on voucher specimens were not checked for this project and occurrences from the NRIS TESP database are not always associated with a voucher. The AKNHP therefore assumed that all determinations are correct.

The modeled climate data used in this analysis was obtained from Scenarios Network for Alaska and Arctic Planning (SNAP) at University of Alaska Fairbanks. Climate models are downscaled from the five best performing General Circulation Models for Alaska under the A2 emissions scenario. Data modeled into the future is predictive and therefore inherently uncertain. While this represents the best knowledge available at this time, the data should be interpreted at a broad scale representing regional patterns rather than pixel by pixel

Publication of Assessment on the World WideWeb

To facilitate use of species assessments in this Project, assessments are being published on the Tongass N.F. and Alaska Region World Wide Web site. Placing the documents on the web makes them available to agency biologists and the public more rapidly than publication as a book or report. More importantly, revision of the assessments will be facilitated. Revision will be accomplished based on guidelines established by the U.S.F.S. in the Alaska Region.

Peer Review

Assessments developed for the Species Conservation Process have been peer reviewed prior to release on the web. This report was reviewed through a process administered by an independent scientific organization which chose two recognized experts to provide critical input on the manuscript. Peer review was designed to improve the quality of communication and increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

This section describes the special management classifications assigned by government and non-government organizations in the U.S. and Canada. Existing regulatory mechanisms, management plans, and conservation strategies specific to *Cypripedium parviflorum* var. *pubescens* are discussed. Management actions and recommendations are reviewed. The information provided in this section is meant to be a historic and current overview of species management. More detailed information on potential future management options tailored to the Alaska Region and Tongass National Forest are provided in the "Conservation: Potential Management of the Species" section.

Management Status

Cypripedium parviflorum var. *pubescens* is not designated as an endangered species or candidate species by the U.S. Fish and Wildlife Service. In 2015, *Cypripedium parviflorum* var. *pubescens* was recommended to be designated as a Species of Conservation Concern in the Alaska Region of the U.S. Forest Service, due to its regional rarity, wide disjunction from other populations to the east, and possible threats associated with the majority of populations occurring along roadsides. It is currently known only from five sites in Alaska; all of which occur on the Tongass National Forest. The variety is considered to be secure globally (G5T5, NatureServe 2017). The species is ranked S1 (Critically Imperiled to Rare within the state) in Alaska (AKNHP 2017).

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

There is no federal listing of *Cypripedium parviflorum* var. *pubescens* as an Endangered or Candidate species by the US Fish and Wildlife Service, which would otherwise provide overarching protection of the species. Sensitive Species status provides some protection on National Forest lands. The USFS management objectives for Sensitive Species are designed to ensure continued viability throughout their range on National Forest System lands and to ensure that they do not become threatened or endangered because of actions of the USFS (FSM 2670.22). Existing policy calls for avoiding or minimizing impacts to species whose viability has been identified as a concern, or if impacts cannot be avoided, analyzing the significance of potentially adverse effects on populations or habitat within the area of concern and on the species as a whole (FSM 2670.32). The species is therefore targeted during Threatened, Endangered, and Sensitive Plant (TESP) surveys conducted by Forest Service personnel prior to implementing projects for special uses such as timber sales, mineral resource extraction, or infrastructure development. The occurrence of a sensitive species in a polygon could (but not automatically) halt the intended land application unless impacts to the species can be sufficiently mitigated.

The National Forest System Land Management Planning Rule was revised in 2012 and under the new regulations addresses species at risk in a slightly different way than the 1982 Planning Rule did through the sensitive species program. Both planning rules are currently being applied to NFS activities on the Tongass N.F. In both cases, each rule addresses the National Forest Management Act which requires that plans provide for diversity of plant and animal communities (16 USC 1604 (g)(3)(B)). The new regulations mandate plans to provide the ecological conditions necessary to contribute to the recovery of federally listed threatened, endangered, or candidate species. Those

species not under federal protection may be listed as a Species of Conservation Concern (SCC). Such species are determined and reviewed to be known to occur in the plan area and for which the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area. While the Tongass N.F. continues to assess species at risk under the provisions of the 1982 Planning Rule (Sensitive Species), transitioning to SCC is anticipated to occur within the next 3 to 5 years. Other than controls by the Convention on International Trade in Endangered Species that pertain only to international trade (CITES 2017), regulatory protections that apply to this species only affect occurrences on National Forest System land.

The new planning rule discontinues the concept of "sensitive species" and adopts a revised approach to at "At risk species" by evaluating potential "Species of Conservation Concern (SCC)". Similar to the sensitive species process of listing, formal SCC lists are designated by the Regional Forester in consultation with Forest managers who prepare recommendations based on a species ability to persist over the long term in the plan area (36 CFR 219.9). The Forest Service through direction from the National Forest Management Act requires that plans provide for diversity of plant and animal communities (16 USC 1604 (g)(3)(B)). The new planning rule requires that all plans identify and assess "At risk species" (36 CFR 219.6(b)). In addition, new direction requires plans to assess the status of the ecosystems for ecosystem integrity for the purpose of determining whether ecosystems are functioning normally and are uncompromised. The plan shall identify and assess available information relevant to the plan area for threatened, endangered, proposed and candidate species and potential species of conservation concern present in the plan area by assessing the ecological conditions for these species in the assessment.

Adopting the revised National Forest System regulations provided in the 2012 Planning Rule and new directive system (FSM 1909.12.52) which defines "At risk species" is currently in transition. The departure of the "Sensitive Species" designation and subsequent adoption of "Species of Conservation Concern" will likely take the Tongass N.F. several years. In the meanwhile, it is important to note that to date, this species (and others on the Tongass) remain under the "Sensitive Species" policy (FSM 2670.22 and 2670.32). Whether designated as "Sensitive" or as "SCC", the core concept of "At risk species" remains consistent in both definitions.

Other than controls by the Convention on International Trade in Endangered Species that pertain only to international trade (CITES 2017), regulatory protections that apply to this species only affect occurrences on National Forest System land.

Biology and Ecology

Classification and Description

Cypripedium parviflorum is a wide-ranging North American species, from the western Brooks Range in Alaska to Arizona and Georgia in the southern United States (the range maps of *C. parviflorum* are erroneous in FNA; Sheviak pers com. 2012). The species is quite morphologically variable and complex and a number of taxonomic concepts have been proposed to delineate plants at and below the species level. Some authors proposed the concept of North American plants as members of a circumboreal species, *Cypripedium calceolus* L. (Correll 1938).

Evidence now clearly shows that the North American *Cypripedium parviflorum* are more closely related to other North American species of *Cypripedium* than they are to the Eurasian *C. calceolus* (Sheviak 1994). The high morphological variation has been attributed to high phenotypic plasticity, hybridization with other *Cypripedium* species, and variable degrees of infraspecific differentiation (Sheviak 2002). Phenotypic plasticity is most clearly seen for plants growing on calcareous substrates and at the northern limits of its range, where plants tend to be smaller, with narrow leaves, and with smaller petals that are much less spiraled – transplantation to less environmentally stressful conditions results in plants with more typical vegetative and reproductive traits (Sheviak 2002). The treatment of the *C. parviflorum* in the Flora of North America (Sheviak 2002) is problematic and does not fully encompass current perspectives on the group (Sheviak pers. comm. 2012). Notably, Sheviak was uncertain with plants from northern Alaska (now *C. parviflorum* var. *exiliens* Sheviak) that appeared to be a form of var. *masakin*, a magnitude of phenotypic plasticity in var. *pubescens*, and gene flow from *C. montanum* in populations in western Canada during the time of publication.

There are four recognized varieties of *Cypripedium parviflorum*: var. *exiliens,* var. *makasin,* var. *parviflorum,* and var. *pubescens* (Sheviak 2002, 2010). Only the varieties '*pubescens'* and '*exiliens'* occur in Alaska and are separated geographically (Sheviak 2010, Sheviak pers. comm. 2012). The variety '*pubescens'* is distinct from other varieties in flower size, fragrance, color, and pubescence. It generally has large lips (though northern cordilleran and boreal plants can be as small as 20 mm in length), rose-like fragrance, and has less pigmentation in the sepals. The variety '*exiliens'* is a variety of the Brooks Range Alaska that has pale greenish-tan petals, a golden yellow lip and sparsely pubescent distal bract, a sweet-scent that fades to rose (Sheviak 2010, Nawrocki et al. 2014). See Table 2 for a morphological comparison of these Alaskan taxa.

The variety '*parviflorum'* has smaller flowers, uniformly dark sepals, also has a rose-like fragrance, but distributed in eastern and central North America. *Cypripedium parviflorum* var. *makasin* is a boreal species with a glabrous to inconspicuously pubescent distal sheathing bract, and distinctively sweet-scented. Variety *makasin* was originally described to occur in Alaska (Sheviak 2002) but since been revised to not occur in the Alaska region (Sheviak 2010, Sheviak pers. comm. 2012).

The plants from northern Prince of Wales Island are immediately identifiable as var. *pubescens* due to the large flower size and large lips – additionally the flowers retain a classic angular shape (Sheviak pers. comm. 2012). Further the low cespitose form with ascending leaves is typical of the variety found in open habitats, particularly among plants associated with the northern portion of the variety's range in prairies and limestone barrens around the Great Lakes and eastward (Sheviak pers. comm. 2012).

Table 1. Synonyms of *Cypripedium parviflorum* var. *pubescens.*

List of Synonym of *Cypripedium parviflorum var. pubescens* (Willd.) O.W. Knight
Cypripedium pubescens Willdenow
Cypripedium pubescens Willdenow var. *pubescens*
Cypripedium calceolus Linnaeus var. *planipetalum* (Fernald) Victorin & J. Rousseau
Cypripedium calceolus var. *pubescens* (Willdenow) Correll
Cypripedium flavescens de Candolle
Cypripedium furcatum Raf.
Cypripedium planipetalum (Fernald) Morris & Eames
Cypripedium parviflorum var. *planipetalum* Fernald
Cypripedium veganum Cockerell, P. Barker & M. Barker

Species Description

The following species description is adapted from (Sheviak 2002; **Error! Reference source not found.**):

> **Perennial**, rhizomatous, 7–70 cm tall, erect. **Leaves:** 3-5 alternate cauline, erect to spreading, orbiculate to broadly ovate, ellipitic-lanceolate or oblanceolate, 7.9-20.9 × 1.5-12 cm. **Bracts:** distal sheathing bract densely silvery- pubescent when young. **Inflorescence:** one to two flowers. **Flowers:** faint rose or musty scent; calyx greenish or yellowish, with some darker streaks or spots; dorsal sepal suborbiculate, ovate, to ovate-lance-acuminate; lateral sepals connate; petals greenish-yellowish, horizontal to descending, linear lanceolate, often twisted; lip pale to golden yellow, oblance-ovoid to calceolate or subglobose, 20–54 mm; orifice 10–23(–27) mm, orifice basal; staminode cordiform-ovoid, deltoid, or ovoid-oblong. 2n = 20.

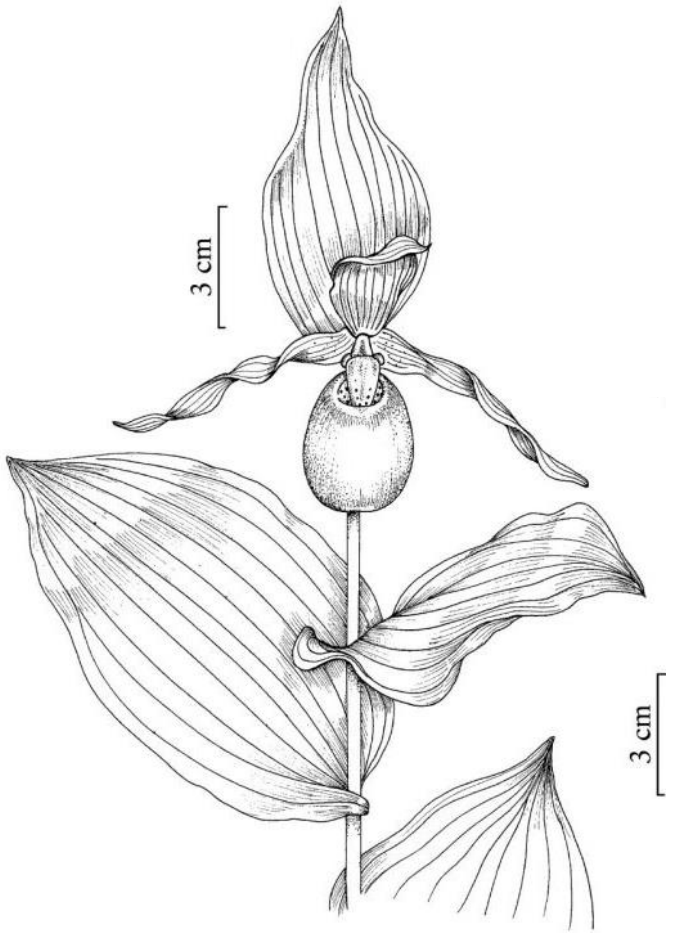

Figure 1. Illustration of *Cypripedium parviflorum* var. *pubescens*, courtesy of, Barbara Alongi illustrator.

Figure 2. *Cypripedium parviflorum* var. *pubescens* at a site near Neck Lake (EO #12) on northern Prince of Wales Island, Tongass National Forest. Photo by Kristin Lease, USFS.

Table 2. Diagnostic plant traits of *Cypripedium parviflorum* var. *pubescens* and similar varieties in Alaska.

Species	Bracts	Lip	Petals
Cypripedium parviflorum var. *pubescens*	Densely and conspicuously silvery-pubescent when young	Generally larger: up to 54 mm long	Generally larger, green-tan with red-brown spots
Cypripedium parviflorum var. *exiliens*	Glabrous to sparsely pubescent or pubescent in the lower half when young	Generally smaller: (16) 20 to 24 (26) mm long	Generally smaller: (23) 27 to 45 (53) mm long, green-tan with red-brown spots

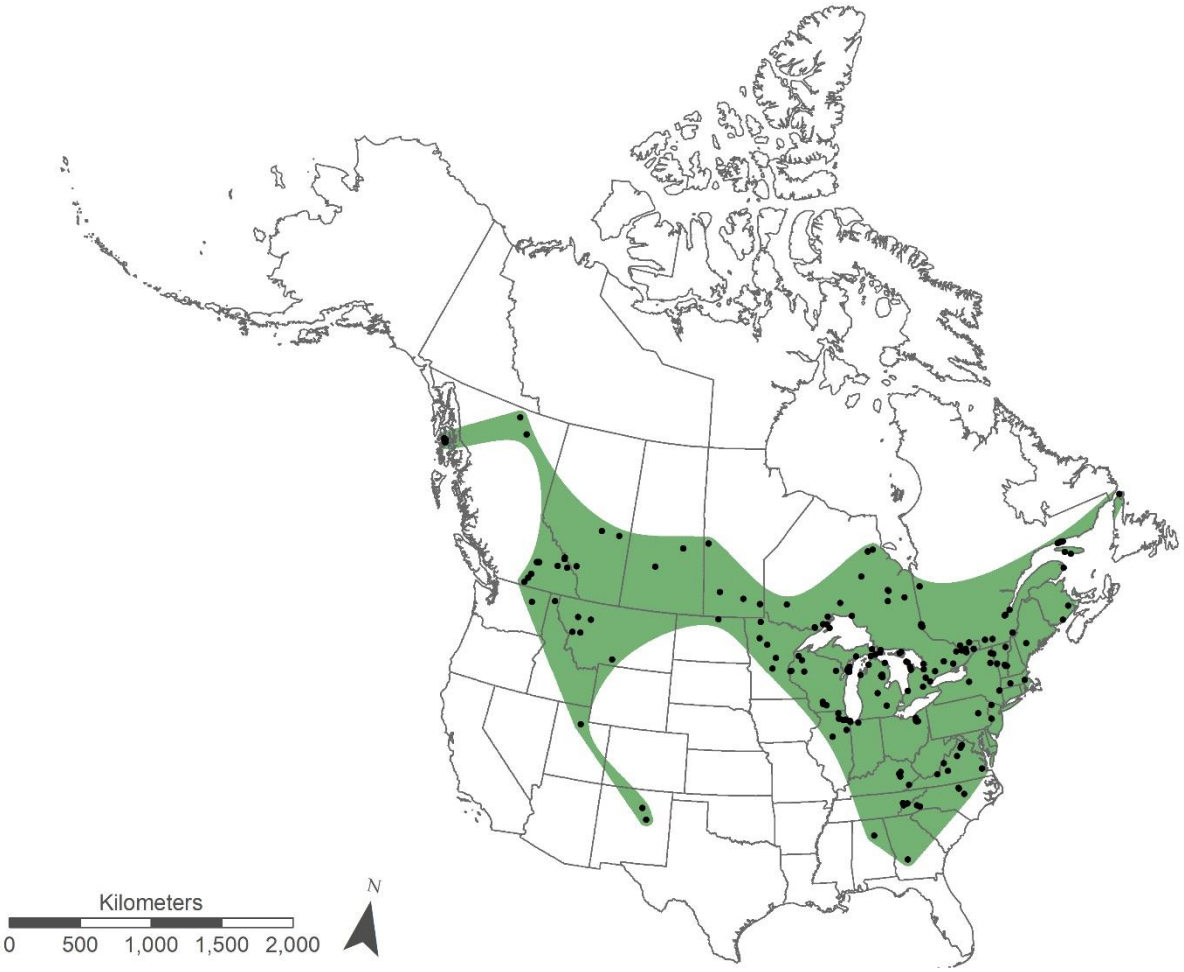

Figure 3. Distribution of *Cypripedium parviflorum* var. *pubescens* based on herbarium records, USFS NRIS database, Reddoch and Reddoch (1993), and Sheviak (2002, 2010).

Distribution

Globally, *Cypripedium parviflorum* var. *pubescens* occurs from Newfoundland Canada, south through Georgia and Mississippi and west through the Great Lakes states and southern Canadian provinces to British Columbia, Alaska, Washington, and Oregon (Sheviak 2002 in part).

Cypripedium parviflorum var. *pubescens* is known from fewer than ten records in Alaska. A number of erroneous records originate from a misidentification of *Cypripedium passerinum* from Tooth Lake, 1.5 km south of the McCarthy Road between the Wrangell and Chugach mountains. Additionally there is a questionable historic record from Krause 1895 (Kurtz in Engler, Bot. Jahrb. 19, 1895, p. 409) of "*Cypripedium pubescens*" along the Klehini River northwest of Haines. In addition to this historic record being unreliable, the accurate location would most certainly occur in British Columbia. We therefore omit discussion of the erroneous occurrences here. There are six unique records of *C. parviflorum* var. *pubescens* from northwestern Prince of Wales Island, two records represent the same population however; thus these five populations represent the entirety of the taxon in Alaska (NRIS database 2016, AKNHP 2017). However, these unique

records do not necessarily represent meaningful populations or occurrences since the data are often collected at a very fine spatial scale (< 100 m apart), are revisits to known sites, or there is uncertainty regarding the actual location for records collected without GPS. The Alaska Natural Heritage Program follows NatureServe guidelines for determining and identifying rare plant populations (Element Occurrences), where populations are defined as occurring ≥ 1 km apart (NatureServe 2002). Applying these standards results in five populations of *C. parviflorum* var. *pubescens* on Prince of Wales Island (Figure 5, APPENDIX). One site is from Flicker Creek (Element Occurrence #13), one from Perue Peak (EO #11), one from Red Bay (EO# 10 that includes two sub-populations), and two sites along the FR 20 near Neck Lake (EO #12; EO #14). All sites are found on Tongass National Forest Lands.

Populations on Prince of Wales Island are substantially disjunct (> 700 km) from the nearest populations in British Columbia (e.g., west of Fort Nelson) which are restricted to the western cordilleran mountains, particularly near the borders with Alberta and Washington. This pattern of broad disjunction from the Rockies to Prince of Wales Island is suggestive of former more continuous populations being divided during glacial periods in the Pleistocene; however more recent long-distance dispersal events are also possible as seed size is very small and can be transported by wind (Mergen 2006). Population genetic research that can address these questions is underway by Melissa McCormick at the Molecular Ecology Lab at the Smithsonian Museum.

Thus the *Cypripedium parviflorum* var. *pubescens* populations on Prince of Wales Island represent the primary location of this variety in the state of Alaska and due to the wide disjunction from the nearest known populations, British Columbia, Alberta, and Washington, are likely to represent a unique lineage that may have a divergent phylogenetic history than populations on the other side of the North American cordillera. These populations on Tongass National Forest contribute significantly to the regional floristic diversity.

Historic Range and Influence of Human Activity since European Settlement

With the exception of the questionable historical record of Krause (1895), no records prior to 2006 exist for *C. parviflorum* var. *pubescens* in Alaska and therefore evaluation of historic range, changes in distribution, and influence of land-use practices on populations is not possible. Timber harvest and associated road building on the Tongass National Forest has included the region where *C. parviflorum* var. *pubescens* is apparently restricted. Additionally, since this taxon was not recognized from the region until 2006, and not on Tongass Sensitive Species lists until then, it is possible (though unlikely) that this plant could have been overlooked in botanical surveys if this was not one of the plants targeted in the surveys. However more recent surveys by botanists contracted by the USFS in suitable habitat in northern Prince of Wales did not find additional populations (USFS 2014). Thus, it is possible that some *C. parviflorum* var. *pubescens* populations were impacted by past timber harvest, but the magnitude of potential impacts of human activity on populations of this plant is impossible to ascertain.

This plant is a calciphile (Mergen 2006), typically associated with sites that are rich in calcareous substrates. On Prince of Wales the sites are associated with limestone, marble, or turbidite deposits that encompass a range of sedimentary rocks including limestone, siltstone, and calcareous mudstones (see Wilson et al. 2015). These formations are common on the northwestern third of

Prince of Wales, Kosciusko, and Heceta islands. Additionally the Silurian turbidite formation extends to Kuiu Island and intermittently northwest to Chichagof Island, the Chilkat Mountains and Glacier Bay. It is not clear how tightly linked this plant is with these underlying lithologies in Alaska, but calcareous substrates are not uncommon in northern Prince of Wales, Kuiu, and regions to the north. It is possible that additional populations of *C. parviflorum* var. *pubescens* may be found on Prince of Wales and other areas of southeastern Alaska. The association of this plant to marble substrates could make it subject to adverse impacts due to future marble quarrying. The known populations are found in the general vicinity of the now abandoned town of Calder that was the site of the state's first significant marble quarry in 1902 (Burchard and Chapin 1920), as well as other well-known quarries on Marble Island, approximately 10 km south of *C. parviflorum* var. *pubescens* near Neck Lake.

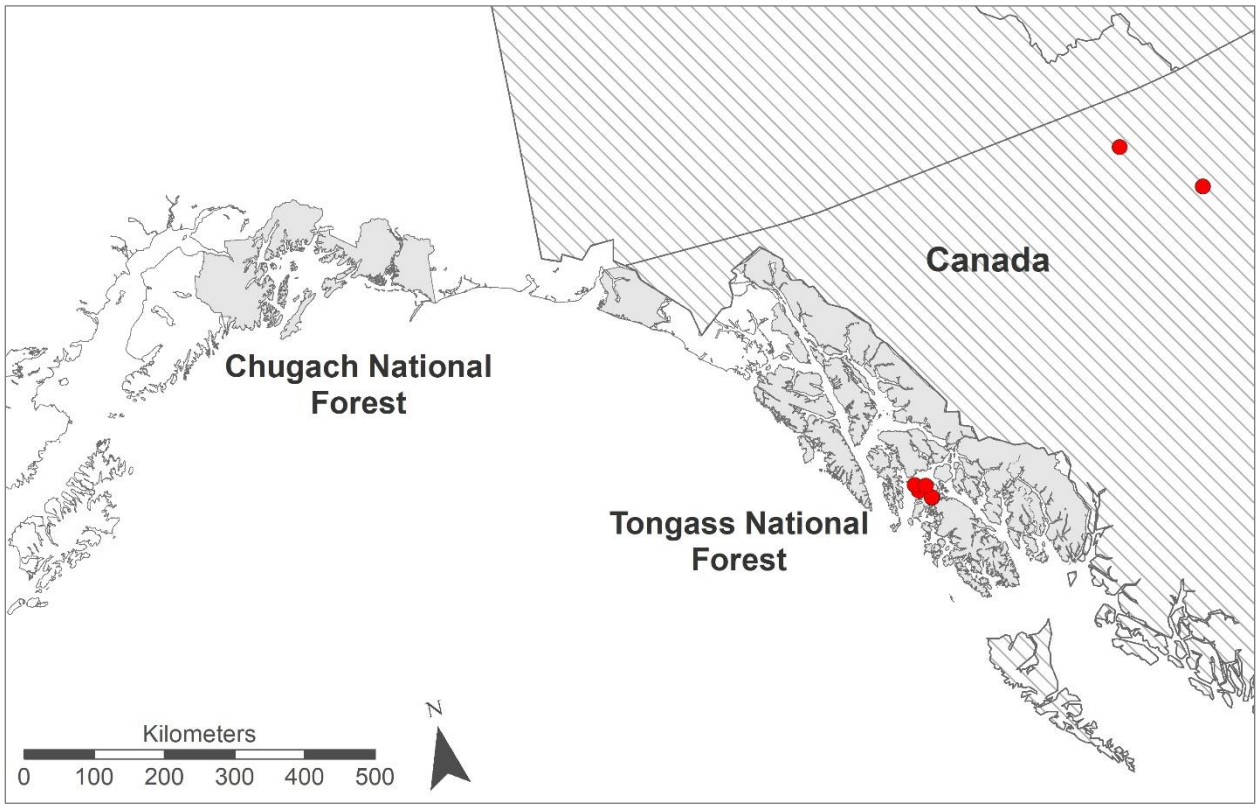

Figure 4. Distribution of *Cypripedium parviflorum* var. *pubescens* in Alaska Region and neighboring Canadian Territories.

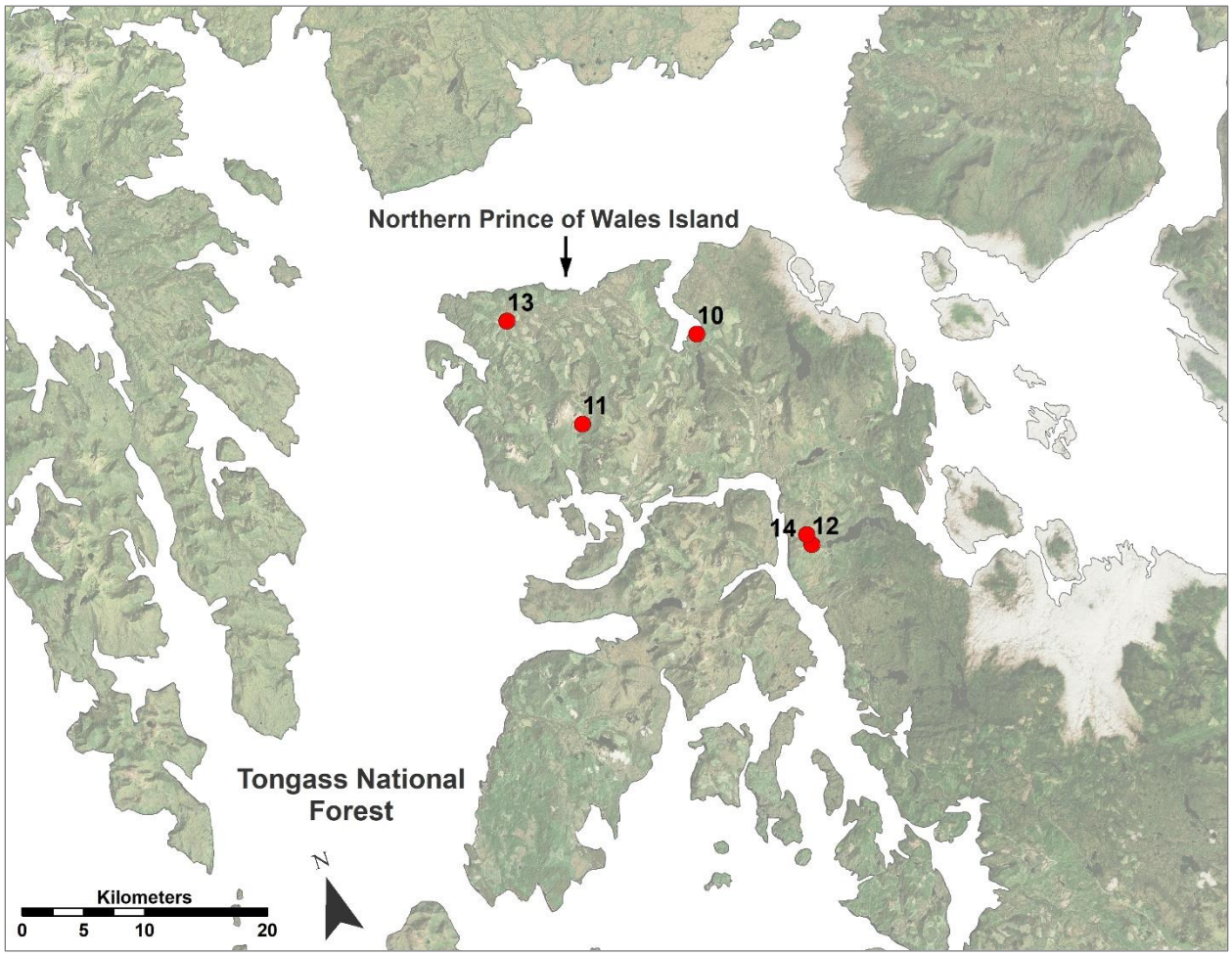

Figure 5. *Cypripedium parviflorum* var. *pubescens* Element Occurrences (EOs) on the Tongass National Forest. Element Occurrence number in bold and are defined by occurring ≤ 1 km apart as defined by the NatureServe national standard.

Population Trend and Abundance

Cypripedium parviflorum var. *pubescens* is clonal, with a single genetic individual often giving rise to numerous partially or wholly physiologically independent plants. Thus defining population size and trends is somewhat problematic. Most reports on the Tongass and elsewhere in its range report the number of flowering stems as a proxy for the number of individuals.

All of the populations on Prince of Wales Island are quite small and data were compiled from the NRIS database. The subpopulation EO (Element Occurrence) #10-1 is composed of approximately a single patch of 15 stems and nearby subpopulation EO #10-2 is composed of a single individual. An unknown number of plants are found at EO #11. The EO #12 is composed of seven individuals. The EO #13 was composed of 15 individuals, however when the area was revisited three months later in 2012 the site had been ditched and brushed. The EO # 14 is composed of a single individual that has not been observed in flower or fruit. This single individual has been present since 2014

and was revisited again in the summer of 2017 (I. Ginter pers. comm.). Two populations have been revisited and the number of individuals have fluctuated from 13 and 14 plants to 20 and 16 (Tongass FY14 Rare Plant Monitoring Information (K. Lease)). Overall, there is insufficient information to determine population trends of *Cypripedium parviflorum* var. *pubescens* in the Tongass.

Small population sizes such as those observed on the Tongass are consistent across the range of this species with most populations with less than 30 individuals (USFS 2014; Mergen 2006). Such populations with few individuals are more vulnerable to extirpation. Indeed, outside of Alaska this plant is noted to be vulnerable to population extirpation, such as has been documented for two populations in Arizona (NatureServe 2017). The information that is available is suggestive of a taxon in decline (Mergen 2006, NatureServe 2017).

Habitat

Populations in the Tongass are either associated with muskeg (peatlands) or gravelly roadsides and right-of-way habitats. One site (EO #14), the single plant was growing out of piled limestone rocks and gravel at the edge of a quarry (Figure 6). At EO #12 seven plants were found growing with *Phalaris arundinaceae* and *Trifolium repens* along the road edge. Specifically the peatlands where *Cypripedium parviflorum* var. *pubescens* grows in the Tongass have been described as Karst Fen Biophysical Setting (Boggs et al. 2016). This is a rare wetland type (S2); in fact, one of the rarest in North America (Almendinger and Leete 1998); that is defined by a high, slow-moving water table fed by calcium enriched groundwater. These karst fens are typically found in low to mid-elevation hydrologic discharge areas below limestone, dolomite, or marble outcrops and ridges. The uncommon hydrochemistry promotes high species diversity and unique plant associations. The plant associations diverge from the more common peatland fens in the Alexander Archipelago, with the karst fens typically lacking *Pinus contorta* var. *contorta*, *Sphagnum* spp., ericaceous shrubs and a hummocky microrelief (Boggs et al. 2016). Anthropogenic impacts to the Karst Fen Biophysical Setting are low; however they often occur in watersheds that are subject to timber harvest and may be impacted by alterations to runoff and ground water flow (Boggs et al. 2016).

Cypripedium parviflorum in general is most often associated with calcareous substrates (Rasmussen 1995, Kull 1999, Mergen 2006). In some cases it is found growing directly out of limestone scree, at the base of limestone cliffs, or in peaty soils. Substrate pH, moisture, and soil nutrient concentrations where the plants have been found is reported to be quite variable (Mergen 2006). However, low soil pH is suspected of limiting seedling establishment elsewhere in its range (Stuckey 1967). The plant is typically found in open or partially open woodlands, forests, fens, and bogs and light is commonly invoked as a limiting factor in *Cypripedium* species (see Mergen 2006 and references therein).

Figure 6. *Cypripedium parviflorum* var. *pubescens* habitats for EO #10 (upper left); EO # 13 (upper right); EO # 12 (bottom left); and EO # 14 (bottom right). Photos provided by Ian Grinter, USFS.

Overall we have a limited understanding of the habitat requirements of this taxon and it is likely that an interaction of environmental factors determine habitat suitability (Mergen 2006). However, it appears to be tightly associated with open habitats on calcareous substrates and calcium enriched fens on the Tongass National Forest. The Karst Fen Biophysical Setting is described as imperiled in the state (S2) and is certainly rare within Alaska; however it can be locally common on northern Prince of Wales and other restricted areas in Alexander Archipelago (Boggs et al. 2016). Thus the preferred habitat can be described as restricted on the Tongass National Forest lands.

Reproductive Biology and Autecology

This plant appears to flower from early to late June in the Tongass. Elsewhere it is reported that the floral longevity ranges from 11 to 17 days for this species (Eberle 1973, cited in Kull 1999). Insect visitation is necessary for seed and fruit production and other species of *Cypripedium* are self-incompatible (Weller 1994). While *Cypripedium parviflorum* is reported to produce some nectar (Mergen 2006), generally all *Cypripedium* species are regarded as a deceptive species, in which insect visitors are unable to extract a nutrient reward. *Cypripedium* species achieve pollination by deception through attraction and structural design (Dressler 1981, Cribb 1997). Releasing specific volatile compounds during flowering may be one of the primary means of luring a pollinator into the lip of the orchid. Specialized scent-producing hairs are strategically located in the inner surface of the lip and continue around to the rear of the lip near the exit (Lee 2004). The scent of *Cypripedium parviflorum* var. *pubescens* has been reported as pleasant, sweet, and rose-like when the flower ages (Sheviak 2010).

Pollination occurs when a visiting insect transfers pollen from the anthers to the stigma. In the majority of flowering species, pollination can occur between multiple flowers and individuals since pollen are individual grains and a flower can produce thousands of pollen grains. In the case for orchids however, all of the pollen is compacted into a single sticky package, the pollinia. In this reproductive strategy, all of an individual's pollen is transferred to the stigma in a one-time event. This strategy is successful because it promotes outcrossing and floral visitors are limited and specialized to a few species. In *Cypripedium parviflorum*, floral visitors enter the frontal orifice of the labellum and crawl to the back of the labellum (Case and Bradford 2009). The insects are probably led by olfactory or visual cues through this one-way path. When the insect enters, they depress the elastic lip near the column base, creating a passageway that leads toward one of two openings at the base of the column. This passageway is directly under the stigma and pollinia. To exit the flower, the insect must crawl through the small basal opening of the labellum where the sticky pollinia is attached on the upper side of their thorax or occasionally, the head of the insect.

Although the "one-way street" pathway in *Cypripedium* ensures pollinia removal, transfer of pollinia to a new flower or fertilization may not always be successful. The reproductive success rate in non-rewarding orchids is typically lower than in orchids that provide a benefit to the pollinator (Tremblay et al. 2005). The average fruit set of North American nectarless orchids is around 20% (Lipow et al. 2002). Reproductive success of *Cypripedium parviflorum* var. *pubescens* in the Alaska Region has not been measured at the individual level.

Various small solitary bees have been reported to be floral visitors of *Cypripedium parviflorum* var. *pubescens*, primarily bees of the *Andrena* species (Case and Bradford 2009). A diversity of *Andrena* species, including early emerging taxa, are present in the state. No information is available regarding the pollinator fauna of populations on Prince of Wales Island, the degree of pollen limitation on fruit and seed production.

Cypripedium parviflorum and *C. montanum* can hybridize to form *C.* × *columbianum* Sheviak when the two species are growing in mixed or adjacent stands (Sheviak 2002). Hybridization among other species in the genus is a possibility, but likely low in the Alaska Region. A population of *C. montanum* has been found within 50 km of a *C. parviflorum* var. *pubescens*, east of Prince of Wales Island, across Clarence Strait on Etolin Island (Fulkerson et al. 2017). While there are barriers for pollen transfer such as distance and water bodies that would make it difficult for small bees to overcome. The maximum foraging distance varies between bee species and is highly correlated to body size, where longer or larger bees are capable of greater flight distances (Gathman and Tscharntke 2002, Greenleaf et al. 2007, Guédot et al. 2009). On average, the maximum foraging distance from nesting sites to food resources can range from 500 to 1800 m for various *Osmia* species (Gathman and Tscharntke 2002, Guédot et al. 2009), but only 50% of solitary bees within a population are capable of such flight distances and the preferential foraging distance is within a few hundred meters of nesting sites (Zurbuchin et al. 2011). Unless a population of *C. parviflorum* var. *pubescens* occurs within the pollinator flight distance of *C. montanum*, hybridization is not likely to occur on the Tongass National Forest population.

Seeds of *Cypripedium parviflorum* are very small, with 7,000 seeds per fruit being recorded (Light and MacConaill 1998). The seed size and morphology is consistent with wind-dispersal. There are reports of other orchid species having seeds dispersed from between 100 and 1,500 km from the nearest seed source (Rasmussen 1995). Other potential vectors of dispersal include birds, mammals, and insects (Arditti and Ghani 2000). Seeds of this genus have been reported to remain viable for up to eight years (Curtis 1943).

Orchid seeds, unlike seeds of other flowering plants, lack a differentiated embryo, endosperm, and protective seed coat. A lacy, net-like outer seed coat covers an inner undifferentiated mass of cells (the proembryo). Because seeds do not have an endosperm, they may lack sufficient nutrients, energy reserves, metabolism, or metabolites to produce a seedling on their own and require a fungal symbiont (Arditti 1967, Rasmussen 1995). The largest group of fungi identified from mycelia isolated from *Cypripedium* roots is *Rhizoctonia*, an artificial genus that spans across multiple families in the Basidomycota (Shefferson 2005). For *C. parviflorum* var. *pubescens*, a narrow mycorrhizal association occurs with a symbiont in the Tulasnellaceae, a fungal family well known for many orchid symbionts (Shefferson 2005, Pecoraro et al. 2013).

Demography

Demographic assessment of a genetically and structurally complex population is problematic because aerial stems of a single individual do not always appear above ground each year and ramets are difficult to distinguish from genetically distinct individuals. Individuals of *C. parviflorum* may have extended periods of dormancy, where above ground growth may not occur for up to four years (Shefferson et al. 2001). The environmental causes of dormancy are not known and it is

unknown if or how extensive this behavior may be for populations in the Tongass. Studies need years of observation to characterize the demography of this species.

Information on plant longevity and vital rates of populations of *Cypripedium parviflorum* var. *pubescens* in the Tongass is lacking. Related species in Europe have been documented to live to nearly 200 years (Rasmussen 1995) and *Cypripedium parviflorum* is presumed to have a demography characterized by high adult survivorship, a lengthy period to achieve reproductive maturity, and low seedling establishment rates (Mergen 2006).

Population viability analysis of a European *Cypripedium* species indicated that probability of survival was greater when populations were larger (between 50 and 200 plants) than when populations were between 5 and 20 plants, and that removal of a few mature plants increased the risk of population extirpation regardless of population size (Terschuren 1999). Similarly, a monitoring program of *Cypripedium fasculatum*, which spanned several years, provided data for a population viability analysis. Data indicated that small populations are quick to go to extinction, where population with less than10 individuals had a 40% chance of extinction within 5 years and 90% chance after 30 years (Gray et al 2012). However, populations of greater than 100 had a near 0% chance of extinction, no matter the timeframe (Gray et al 2012).

A wide-ranging distribution across diverse habitats may contribute to increased natural selection and maintenance of genetic diversity (Hamrick and Godt 1989). Although the genetic diversity at the species or population level of Alaskan *C. parviflorum var. pubescens* is not known, it could be high. Case (1994) conducted a genetic analysis and reported that the wide-ranging *C. calceolus* had high levels of genetic diversity typical of a widespread, outcrossed, long-lived, herbaceous plant.

Cypripedium parviflorum var. *pubescens* demography may be influenced by disturbance, succession or changing edge effects. Patchy, small populations of *C. parviflorum* var. *pubescens* occur across its range. Fragmented habitats and isolated populations pose special challenges for gene flow in rare plants due to the distance between populations and a reduction in the number of mates (Wilcock and Neiland 2002). Because *C. parviflorum* var. *pubescens* populations in Alaska are spatially disjunct from populations in British Columbia; the distribution of genetic variation over time may be affected. However, without a genetic study, this can only be inferred.

Community Ecology

Cypripedium parviflorum var. *pubescens* appears to be associated with range of co-occurring plant species, often on disturbed substrates or in transition zones between disturbed roadsides and more established muskeg or forest. Elsewhere *Cypripedium parviflorum* is regarded as a species generally occupying mid-seral communities (Mergen 2006 and references therein) and some level of disturbance is likely necessary for it long-term survivorship. Elsewhere in its range *Cypripedium parviflorum* is characterized as a very weak competitor and competition for light may be one of the more important limiting ecological conditions for the plant (Mergen 2006). Ian Grinter, USFS Botanist, has indicated that roadside brushing is likely to maintain sufficient light conditions for two populations (EO# 12 and EO# 13) in more forested contexts. Competition for light and other resources is likely very important for this species, and at least one population

(EO# 13) is found growing with very abundant *Phalaris arundinacea*, which is one of the most competitive and ecologically destructive species in Alaska (Carlson et al. 2008).

Browsing of flowering stems by Sitka black-tailed deer has been observed at a number of the populations, including multiple years of the same single plant at EO# 14. In some cases browsing of flowering stems, results in flowers being produced on other stems, but herbivory has not been so extensive that plants were unable to grow back in subsequent years (Ian Grinter pers. comm.). In other parts of its range, leaf miners are known to preferentially feed on *C. parviflorum* var. *pubescens* (Light and MacConaill 2011).

Mycorrhizal relationships are necessary for seed development, seedling development, and potentially during periods for mature *Cypripedium parviflorum* plants (Mergen 2006 and references therein). Orchids do not have endosperm to nourish developing embryos and instead rely on the mycorrhizal partner to provide carbohydrates and other nutrients (Cribb 1997). *Cypripedium parviflorum* development is slow with leaves first appearing from between one to four years since germination (Rasmussen 1995); reliance on the mycorrhizal fungi is very high until sufficient photosynthesis is occurring in young plants. High specificity to mycorrhizal fungi in *Cypripedium* species has been reported (Shefferson et al. 2005). Thus the presence of the appropriate mycorrhizal fungi on the landscape is likely a limiting factor in the establishment of this plant.

CONSERVATION

This section describes the threats, conservation status, and potential management of *Cypripedium parviflorum* var. *pubescens* specifically within USDA Forest Service Alaska Region with focus on the Tongass National Forest. Threats include both risks to the habitat and direct threats to individuals and populations. Within the threats section, we have provided a climate sensitivity analysis including a comparison of climatic conditions in southeastern Alaska between the 2010s decade and the 2060s decade. The Conservation Status and Potential Management sections integrate habitat, current management, and potential management into the discussion of threats. The Conservation Status section details the distribution and population trends, inherent vulnerability of the species with regards to habitats available in Alaska and management risk in Alaska. The Potential Management section is a synthesis of management implications and potential tools and practices that may benefit species conservation in the Tongass National Forest.

The final section, Information Needs, details the current data gaps that may prevent the most effective and efficient conservation of *Cypripedium parviflorum* var. *pubescens* on the Tongass National Forest. These data gaps are discussed in terms of their direct relevance to management. Data gaps that are especially important for effective management are selected as research priorities.

Threats

The primary threats to *Cypripedium parviflorum* var. *pubescens* is the loss of sites and preferred habitat resulting from road construction and maintenance, impacts associated with timber harvest,

competition with non-native species, collection of plants by gardeners, herbivory by wildlife, and changes in community structure and composition due to ecological succession or changing climates. In general, population sizes are very small on the Tongass National Forest and stochastic events could cause population extirpation. The minimum number of individuals or populations of this plant that is necessary to be considered a viable population within a designated management area such as a National Forest is not known.

Human Activities

Potential threats due to human activities include development (e.g., trail maintenance, road building, and maintenance) that affect substrates and foster invasive species encroachment, timber harvest that alters the light regime, and mechanized equipment used for road construction. Additionally plants and habitat can be adversely affected by off-road motorized recreation, and non-motorized recreation that expose plants to trampling (Latham 2001).

Four of the five known sites occur within the maintained right-of-way of a primary gravel road and all individuals are within 20 feet of the road surface (Ian Grinter pers. comm.). Grading of the road surface is unlikely to impact populations. Brushing that occurs every four to five years may be beneficial to maintaining open light conditions for populations EO# 12 and EO# 13 (Ian Grinter pers. comm.). The EO# 14 is at the edge of an old quarry and is also unlikely to be targeted by the brusher although alder or other seedlings could show up in the future that might require brushing. Maintenance and clearing of roadside ditches with excavators is likely to pose a risk to all populations except EO# 12.

Long term state highway improvement plans include extending the paved portion of FS Road 20 from where it currently terminates (approximately Sarheen Cove) to Labouchere Cove, affecting four of the five sites on Prince of Wales Island (Ian Grinter pers. comm.). Currently EO #12 and #14 are closest to the proposed paving activities and of most immediate risk. Most of these roadside populations could also be impacted by motorists using the right-of-way for temporary parking. Additionally, these sites are all easily visible from the road and could be subject to collection by gardeners or flower pickers (USFS 2014).

Two of five populations are found within the boundaries of previous timber harvest. These two populations (EOs #12 and 14) occur along roadsides of areas where timber was harvested between 1975 and 1985 (USFS 2017). It is unclear if past timber harvest and associated activities had adverse or beneficial impacts to the populations in the short-term or long-term. Development of dense young-growth following clear-cutting would certainly not be beneficial, but more selective harvest that results in a mosaic of stand age, with significant canopy gaps may be beneficial. The majority of populations on Prince of Wales Island occur in open to partially open habitats and on road beds or adjacent to them, suggesting that road building to access timber sales may be beneficial. According to the US Forest Service (2014), there is sufficient amount of suitable *Cypripedium parviflorum* var. *pubescens* habitat associated with non-development Land Use Designations (LUDs). The EO #11 occurs within a Special Interest Area, EOs #12 and 14 occur in what is now Old Growth Habitat LUDs.

Competition

Cypripedium parviflorum var. *pubescens* is recognized to be a weak competitor and three of the five known sites occur within, or adjacent to, populations of one of the most ecologically threatening plants in the state, reed canarygrass (*Phalaris arundinacea*). One additional site (EO #14) occurs in very close proximity to recorded infestations (AKEPIC 2017). *Phalaris arundinacea* is very widely distributed throughout the road network of Prince of Wales Island and represents one of the more obvious threats to long-term survival of these populations. EO #13 occurs within a dense patch of *Phalaris arundinacea* (see Figure 6) and EO #12 grows with *Phalaris arundinacea* and *Trifolium repens*. Ian Grinter, US Forest Service Botanist, has hand-dug *P. arundinacea* adjacent to EO #10 in an effort to reduce the impact of the invasive grass on the *Cypripedium parviflorum* var. *pubescens* population.

There are over 2,600 non-native plant infestations occurrences on northern Prince of Wales Island from Point Baker south to Whale Passage (AKEPIC 2017). Table 3 shows the species of non-native plants, abundance, and perceived ecological risk. The only site that is unlikely to face current threats of competition with *P. arundinacea* is EO #12 that is found off the road system near Perue Peak.

Competition from native species, particularly taller-growing shrubs and trees, may pose a risk, since the species is very rarely found in dense or shaded conditions (see Mergen 2006). Growth of alder along roadsides and the quarry site (EO #14) could overtop the orchids; however roadside brushing and maintenance appears to maintain low shrub cover.

Table 3. Non-native plant species recorded from norther Prince of Wales Island, Point Baker to Whale Passage. Records obtained from AKEPIC (2017). Abundance (No. of Occurrences) and perceived ecological threat (Invasive Rank). Invasive ranks are scaled from 0 to 100, with '0' representing a plant that poses no threat to native ecosystems and '100' representing a plant that poses a major threat to native ecosystems (Carlson et al. 2008).

Species Name	Common Name	No. of Occurrences	Invasive Rank
Cirsium arvense	Canada thistle	4	76
Agrostis gigantea	redtop	110	-
Capsella bursa-pastoris	shepherd's purse	1	40
Cerastium fontanum ssp. vulgare	big chickweed	181	36
Centaurea stoebe	spotted knapweed	10	86
Cirsium arvensis	creeping thistle	4	76
Cirsium vulgare	bull thistle	4	61
Crepis tectorum	narrowleaved hawksbeard	2	56
Dactylis glomerata	orchardgrass	61	53
Deschampsia elongata	slender hairgrass	37	35
Dulichium arundinaceum	three-way sedge	1	-
Geranium robertianum	Robert geranium	4	67

Species Name	Common Name	No. of Occurrences	Invasive Rank
Hieracium aurantiacum	orange hawkweed	76	79
Hieracium piloselloides	tall hawkweed	1	-
Holcus lanatus	common velvetgrass	8	56
Hypericum perforatum	common St. Johnswort	9	52
Leucanthemum vulgare	oxeye daisy	102	61
Lolium perenne	perennial ryegrass	8	52
Matricaria discoidea	pineappleweed	1	32
Medicago lupulina	black medick	15	48
Mycelis muralis	wall lettuce	4	31
Myosotis scorpioides	true forget-me-not	1	54
Phalaris arundinacea	reed canarygrass	466	83
Phleum pratense	timothy	275	54
Plantago major	common plantain	379	44
Poa annua	annual bluegrass	36	46
Poa compressa	Canada bluegrass	3	39
Poa pratensis	Kentucky bluegrass	27	52
Ranunculus repens	creeping buttercup	51	54
Senecio jacobea	tansy ragwort	1	63
Sonchus arvensis	perennial sowthistle	1	73
Sonchus asper	spiny sowthistle	7	46
Taraxacum officinale	common dandelion	272	58
Trifolium dubium	suckling clover	1	50
Trifolium hybridum	alsike clover	43	57
Trifolium pratense	red clover	18	53
Trifolium repens	white clover	343	59
Veronica serpyllifolia ssp. *serpyllifolia*	thymeleaf speedwell	24	36
Vicia cracca ssp. *cracca*	bird vetch	1	73

Cypripedium parviflorum is a species associated with open to partially shaded habitats that is recognized to be negatively impacted by dense canopies. Elsewhere in its range, maintenance of open habitats and establishment of a mosaic of forest age due to forest fires is recognized to be important for this orchid (Mergen 2006). Forest fires in the Alexander Archipelago are exceedingly rare and not relevant to the populations on the Tongass National Forest; however maintenance of partially open sites due to road building and roadside maintenance may be beneficial. It is unclear if timber harvest would be detrimental or beneficial. Events that create smaller-scale openings, such as windthrows following storms and insect-damage may be beneficial for populations on the Tongass National Forest.

Plant Collection

Because of their beauty and long tradition of medicinal use in North America and eastern Asia, *Cypripedium* species historically have experienced extensive collection, causing critical declines in some populations (Cribb and Sandison 1998). Indeed, species of *Cypripedium* are the most collected group of orchids by orchid enthusiasts (Cribb and Sandison 1998). There has been an enduring tradition of using roots of *Cypripedium* species for medicinal purposes around the world (Koopowitz 2001). Popular in China, where a number of *Cypripedium* species are found, the roots of *Cypripedium* species were also used by North American indigenous peoples for a variety of medical problems from back pain to stomach cramps and "female trouble" (Moerman 1998). In the late 19th century, roots of *C. parviflorum* var. *pubescens* were collected in large quantities to produce the chemical extract, Cypripedin (Koopowitz 2001, Cech 2002). In North America, *C. pubescens* and Cypripedin were listed as a medicine to relieve general nervous ailments by promoting calmness (Felter and Lloyd 1898). Collecting the roots for making tinctures for medicinal use remains popular today (Willard 1992, Cech 2002). There has been no documented use of any orchid species by Alaska Natives (Garibaldi 1999).

The majority of material in horticulture is originally derived from natural populations. It is widely acknowledged that plant collectors are one of the primary threats to population persistence of *Cypripedium* orchids and that accessible populations along roadsides and near high recreation-use areas have suffered declines (Mergen 2006). Collection of flowers and fruits may impact seed production and recruitment, but the removal of whole rhizomes and plants for commercial, scientific, or recreational reasons, is of greater severity for *C. parviflorum* population persistence (Mergen 2006). All of the populations on Tongass National Forest lands, with the exception of EO #11 which is more remote, are readily road accessible and subject to the threat of plant collection. Additionally, because the populations are all quite small, a single collection effort could cause population extirpation.

Herbivory

Grazing of flowering stems and leaves by Sitka black-tailed deer has been observed at EO #14. Seed production is thus impacted and likely reduces the opportunities for recruitment within the population and establishment of new populations. Photographs of plants from EOs #12 and #13 show evidence of invertebrate herbivory on the leaves, particularly of the large reproductive plants. It is not clear what the magnitude of threat is imposed by invertebrate and vertebrate herbivores. Construction of exclosures may reduce vertebrate herbivory, but it may also draw attention of would be plant collectors, or curious public and is probably not advisable.

Climate change

As changing climates are already recognized to be affecting habitats and species worldwide (e.g., Parmesan 1996) and the rate of temperature increase in Alaska is approximately double the global average (Chapin et al. 2014), concern over the future status of rare species in the Alaska Region is warranted. Climate change vulnerability of a species is recognized to be a function of the exposure to (or degree of) climate change that populations will experience, the sensitivity of the species, and the capacity to adapt to the changes (Turner et al. 2003). A number of vulnerability assessment tools have been developed that incorporate all three elements (exposure, sensitivity, and adaptive

capacity) such as NatureServe Climate Change Vulnerability Index 2.1 (Young et al. 2011) and the U.S. Forest Service System for Assessing the Vulnerability of Species (Bagne et al. 2011). However, these systems require substantially more information than is available on the sensitivity and adaptive capacity of the species, are not appropriate for plants and lichens, or require environmental data not developed for Alaska. Further these methodologies often do not produce similar vulnerabilities for the same species (Lankford et al. 2014). Due to these limitations, we focus on estimations of the degree of climate change expected in the species' current range (i.e. "exposure") in the Tongass in a qualitative manner and discuss any known or suspected sensitivities and adaptive capacities of the species in a light of the degree of expected change.

"Climate" incorporates a vast array of factors, such as mean annual temperature, summer precipitation, and maximum wind speed for example, of differing importance for any one species. It is impractical to attempt to review all potential factors that compose the climate and we therefore focus on two factors: average summer temperature and average annual precipitation and compare current and predicted 2060 conditions. For most plants and lichens at higher latitudes, summer warmth (or mean July temperature) is well correlated with their distribution (Young 1971, and see Walker et al. 2005), indicating a strong association of the measure with biological limitations. Additionally plants and the habitats they are found in are well-known to be sensitive to soil/substrate and air moisture, and mean annual precipitation as a climate variable is expected to be most correlated with substrate and air moisture.

The current and predicted 2060 climates were developed for Alaska and western Canada by the Scenarios Network for Alaska & Arctic Planning (SNAP) at University of Alaska Fairbanks (UAF). Climate data generated by SNAP is downscaled using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) from the five best-performing General Circulation Models (GCMs) for Alaska. The data selected for this analysis is derived from the A2 emissions scenario, which represents a realistic future emissions projection based on current trends. Data are available at a 771 m grid. While this resolution is relatively fine-scale, interpretations are restricted to broad regions. Interpretations of micro-climate at population-sized sites for sensitive species are not appropriate. To avoid generalizing trends based on stochastic annual climate events, SNAP has provided decadal averages for all data (Fresco et al. 2014). Decade 2010-2019 is selected to represent the current time frame. The 2060s decade is selected to represent the future time-frame because 50 years in the future is far enough to observe meaningful trends without being so far in the future that it cannot be meaningfully compared to current management objectives.

Southeastern Alaska has a strong Pacific Maritime climate with low variation and relatively warm temperatures and high precipitation, much of which falls as rain at low to mid elevations. Both total annual precipitation and mean annual temperature generally decrease along a south to north gradient through the Tongass National Forest. Mean July temperatures is predicted to increase in the Tongass National Forest from the 2010s to the 2060s by between 1.0 to 2.0 °C (Figure 7). Areas around *Cypripedium parviflorum* var. *pubescens* populations are expected to increase by between 1.4 to 2.2 °C in 50 years. The percent change is expected to remain largely constant throughout the region. Mean July temperature is predicted to increase 10 to 20% within the majority of the Tongass National Forest by the 2060s relative to the current mean July temperature (Figure 7).

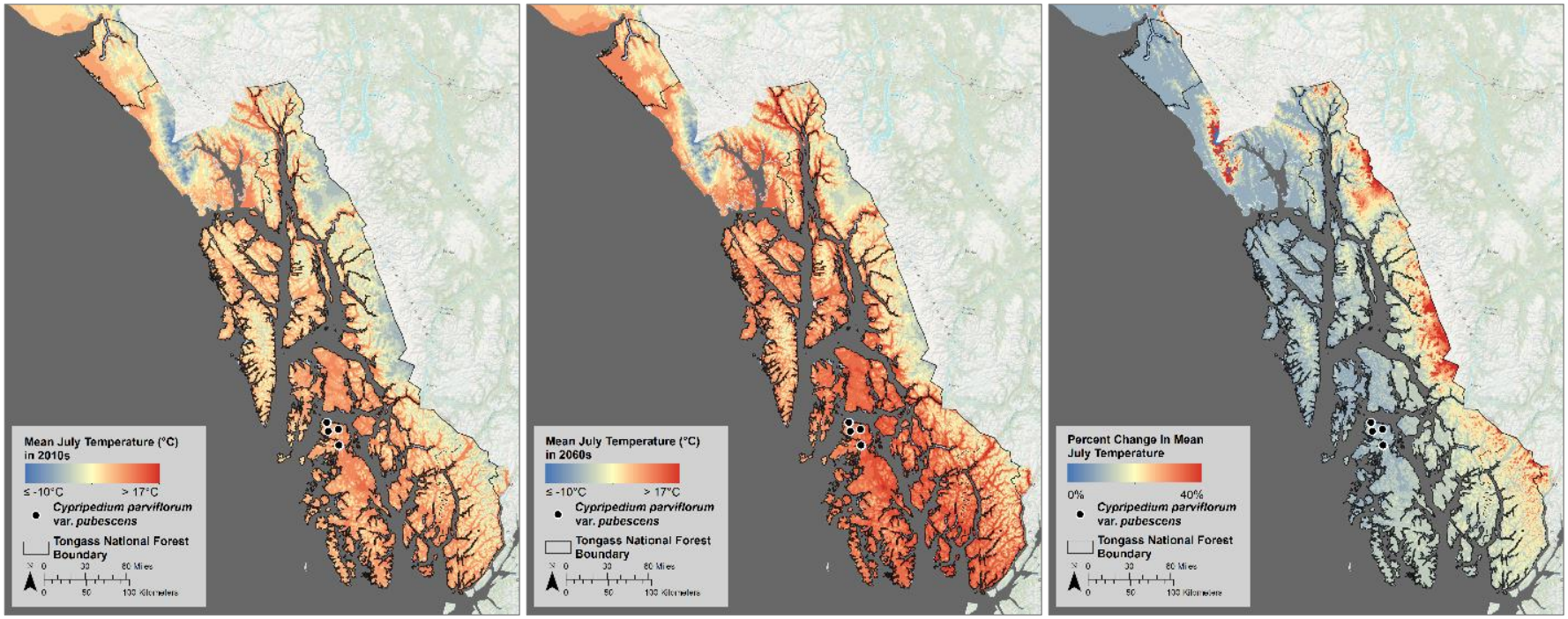

Figure 7. Current (left), predicted 2060 (center) and percent change (right) in mean July temperature (˚C) in the Tongass National Forest. Locations of *Cypripedium parviflorum* var. *pubescens* populations are shown as black dots.

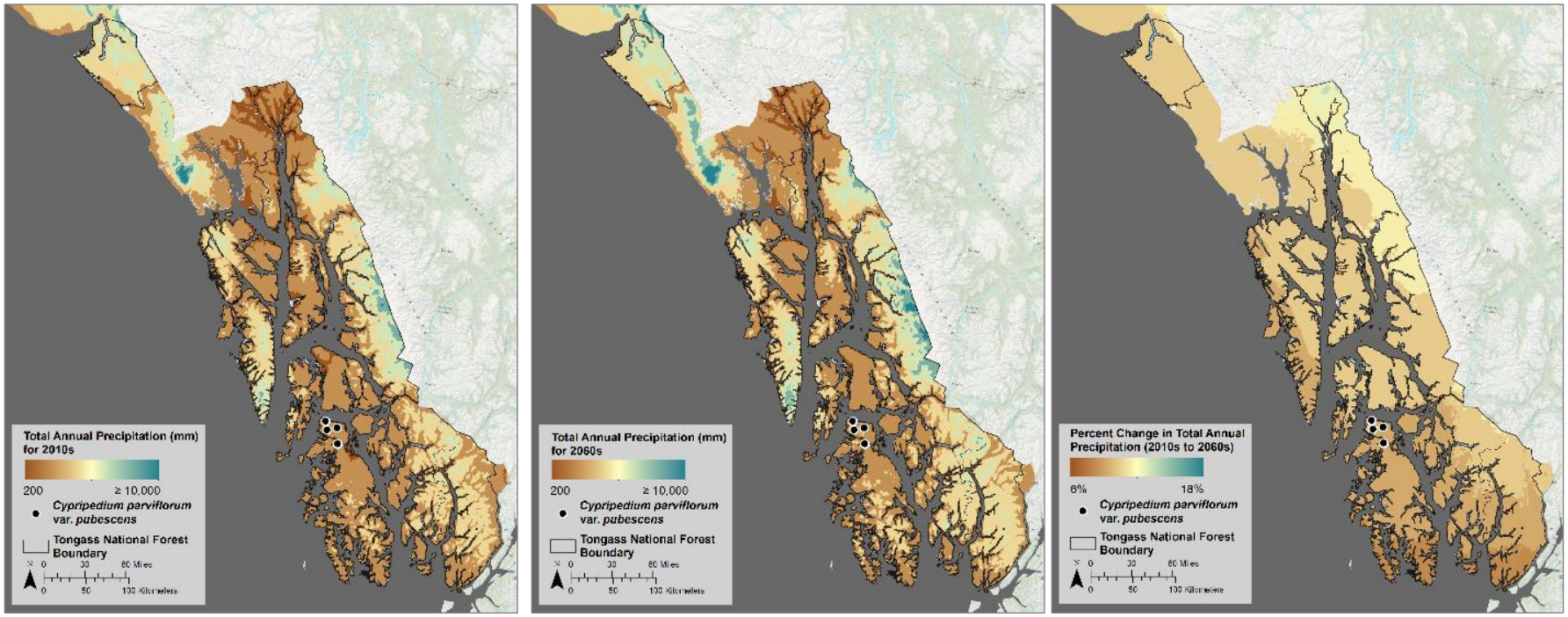

Figure 8. Current (left), predicted 2060 (center) and percent change (right) in mean annual precipitation (˚mm) in the Tongass National Forest. Locations of *Cypripedium parviflorum* var. *pubescens* populations are shown as black dots.

Annual precipitation is predicted to increase across the Tongass National Forest by the 2060s, but no regional gradients are apparent, largely because of competing patterns for summer and winter precipitation (Figure 8). Annual precipitation is predicted to increase by 9 to 12% for most of the Tongass National Forest. Precipitation is predicted to increase around known populations by approximately 200 mm; an increase in annual precipitation of between 9 and 11%.

Vulnerability of *Cypripedium parviflorum* var. *pubescens* to climate change is likely low in the near term. The predicted increases in summer temperature could increase evaporative stress, but when coupled with increased precipitation this danger seems low, especially considering that the range of this taxon includes areas that are considerably warmer and drier than predictions for Prince of Wales Island. Precipitation for all seasons is projected to increase and snow-day fractions (the fraction of days per month where precipitation falls as snow) are expected to decrease (McAfee et al. 2014).

Conservation Status in the Alaska Region and Tongass National Forest

With the protection of rare plants in the Tongass Land Management Plan (USFS 2008 and 2016), future occurrences of this plant and other rare plants in timber units and road right of ways may receive greater protection. Although Forest Plan standards and guidelines include recommendation for protection around known occurrences of sensitive and rare plant species, implementation of this protection is not a requirement (USFS 2008). The National Forest System Land Management Planning Rule was revised in 2012 and under both the old (1982) and new regulations, the Forest Service implements the intent of the National Forest Management Act which requires that plans provide for diversity of plant and animal communities (16 USC 1604 (g)(3)(B)). The new regulations mandate plans to provide the ecological conditions necessary to contribute to the recovery of federally listed threatened, endangered, or candidate species.

There is currently insufficient data on the distribution and abundance of *Cypripedium parviflorum* var. *pubescens* to infer whether the taxon is declining, stable, or increasing in the Alaska Region. Since initial discoveries in 2006, four of five sites have been revisited. Populations appear to be of similar size a decade later, based on the number of stems. Without careful demographic study with permanently marked and mapped plants it is difficult to ascertain changes in abundance. The vulnerability of this taxon in the Alaska Region primarily lies in its narrow geographic range, very small population sizes, and probability to roadside disturbance. On the Tongass National Forest, this orchid is restricted to the karst-fen-roadside, forest-roadside, or forest marble cliff ecotones in northwestern Prince of Wales Island. Four of the five populations are associated with roadsides and individual plants are not found more than 20 feet from the roadside. Similar habitats occur elsewhere in northern Prince of Wales Island, but additional populations have not been detected; and it is not clear what habitat and ecological factors may be limiting population establishment. In light of our poor understanding the habitat requirements of this species, we can speculate on whether the available habitat is increasing or decreasing. Most of the populations co-occur with invasive species, notably *Phalaris arundinacea*.

There are some aspects of this orchid's life history and ecology that suggests that it is vulnerable to population extirpation. Mycorrhizal associations with *Cypripedium* seeds are necessary for seed germination and establishment; however the abundance and distribution of the fungal symbiont in the Alaska Region is not known. Second, successful reproduction is believed to require pollinating insects to move pollen among compatible genotypes. Very small and isolated populations may have difficulty in attracting pollinators of the appropriate size and shape to transfer pollen and small populations of this clonal orchid may not have a sufficient number of compatible genotypes. Additionally, herbivory is a relatively common occurrence for populations on Prince of Wales Island that may impact survivorship rates of adults and reduce seed production as flowers and developing fruits are often grazed. This orchid is considered a weak competitor and thus competition from reed canarygrass and other invasive species represents a substantial risk. Once established, *C. parviflorum* are believed to be relatively long-lived (Mergen 2006), which should make populations more resilient to demographic stochasticy.

Potential Management of the Species on the Tongass National Forest and the Alaska Region

Persistence of viable *C. parviflorum* var. *pubescens* populations in the Alaska Region depend on protecting populations. Desirable environmental conditions for conserving *C. parviflorum* var. *pubescens* include sufficiently large areas where the natural ecosystem processes on which the species depends can occur.

There is evidence that populations on Tongass National Forest are vulnerable from potential management activities. Specifically, road-building, road-maintenance, and competition from non-native and native plants, and harvesting. Road maintenance and construction are the most immediate activities that could impact populations. Paving and widening the road on which four of five populations are found terminates two miles from the first *Cypripedium parviflorum* var. *pubescens* populations. Roadside brushing has occurred at one site; however this activity may be beneficial in reducing competition from shrubs and trees and creating more canopy gaps (Ian Grinter pers. comm.).

Non-native plant management is the second activity that could impact the plant. Four of five populations occur with or proximal to *Phalaris arundinacea* and other non-native species. Without reducing competition from non-native species, it is likely that there will be reduced survival and recruitment and eventual declines in *Cypripedium parviflorum* var. *pubescens* populations. Chemical control efforts of co-occurring non-native species could result in accidental damage to the orchid.

Worldwide, plant collecting by orchid enthusiasts for commercial or recreational purposes is recognized as a primary threat for species of *Cypripedium*. Current Alaska Region policies restrict collection of rare plant species (USFS 2016). While *Cypripedium* plant collection has not been observed or noted for the populations on Prince of Wales Island, the roadside location on the primary road on the island, coupled with the showy nature of the flowers and small size of populations all are factors that increase risk for this orchid.

A standardized monitoring program across populations would help confirm effective management practices, identify baseline trends that can be used to predict future changes, learn how different

management practices affect the land, and confirm current management practices. Trends and changes in population may be linked to management practices or changes in climate. Specific efficient inventorying and monitoring methods of rare plants and habitat are discussed elsewhere (*see* Noss 1990, Manley et al. 2006, Vesely et al. 2006).

A monitoring program would be very beneficial to land managers by providing data to determine demography and conduct a population viability analysis. Monitoring of *C. parviflorum* var. *pubescens* is challenging due to its dormancy phase. Monitoring would be best performed during the peak flowering time of the species in early-June. Flowering is not necessary for identification, but helpful in finding the species in the population. While there are multiple methods for rare plant monitoring, implementing a program to track individual plants would provide the most data that fills current data gaps of *C. parviflorum* var. *pubescens*. Small fixed labels or pins on a sample of individuals in the population would be one of the most beneficial aspects to a monitoring program and start a demography study for the species. This would allow the tracking of the dormancy of individuals that would provide better estimate population sizes than relying on fluctuating data. It would also allow the tracking of flowering and reproductive success for a few individuals in addition to the population as a whole.

Habitat modeling of *Cypripedium parviflorum* var. *pubescens* may be of limited value because the likely environmental variables of greatest predictive value are not available on a regional scale for Alaska and mapping scale may be too broad of habitat categories. GIS data from occurrences mapped in the Tongass National Forest database are available, but not all occurrences contain sufficient data for all the GIS parameters to confidently identify the orchids' affinity to a particular habitat. For example, there is limited spatial data on soil maps especially for calcareous substrates, which is highly associated with *Cypripedium parviflorum* var. *pubescens*. This makes habitat models and predictions with low confidence and reduces the understanding of the distribution on the Tongass National Forest.

Ex situ conservation may not be practical for *Cypripedium parviflorum* var. *pubescens*. Seeds of terrestrial orchids are often difficult to germinate in controlled settings (Arditti et al. 1981). Mycorrhizal fungi must be present to germinate and grow orchids, and the transfer of greenhouse grown orchids to occurrence sites may disrupt the mycorrhizal associations. Adding to the complexity of *in vitro* and *in situ* conservation, *Cypripedium parviflorum* var. *pubescens* has specialist mycorrhizal associates and has a low success rate (Shefferson 2005).

Research on the ecology and distribution of *Cypripedium parviflorum* var. *pubescens* will help managers to develop effective approaches to management and conservation. Until there is a more complete picture of the distribution and ecology of this species, priorities lie not only with conserving the known occurrence but maintaining favorable habitat.

Information Needs

Significant gaps in our understanding of *Cypripedium parviflorum* var. *pubescens* the development of truly effective management strategies. Virtually no aspects of the orchid's ecology or biology are understood in sufficient detail to develop proactive management recommendations. The

considerations outlined above may help to ensure the persistence of known populations, but based on information currently available, it is difficult to suggest management actions that might benefit the species or contribute to restoration. Time and resources might best spent developing and implementing monitoring protocols so as to provide better data on population trends and potential threats.

The distribution of *Cypripedium parviflorum* var. *pubescens* in Alaska appears to be restricted to the northwestern quarter of Prince of Wales Island in five small populations that are widely disjunct (> 750 km) from the main body of the taxon's distribution that originates in the North American cordillera and extends east to Labrador and Newfoundland. This is an interesting disjunction and could reflect a pre-Pleistocene vicariance or more recent, long-distance dispersal. It is likely that these populations on the Tongass National Forest represent a unique and isolated lineage. This species is quite showy and it is hard to imagine that it is in fact more widely distributed in the Tongass, but has gone undetected. Surveys in likely habitat more recently have not revealed more populations (NRIS Database). Additional targeted surveys on Kuiu, Chichagof, and islands adjacent to Prince of Wales in karst-fen habitats and karst-fen roadside ecotones would help establish its actual distribution in the state.

A better understanding of this taxon's habitat requirements in the Alexander Archipelago would be useful in developing a conservation strategy. Associated habitats of the five sites on Prince of Wales Island are variable, but generally include open or partially open habitats on karst-fen or forest to mineral (often roadside) ecotones in a region underlain with calcareous bedrock. It is not clear which environmental factors or what combination of environmental factors are important for establishment and persistence of populations of this orchid. Understanding the relationship of disturbance and competition (link to succession), impacts of competition with reed canarygrass, how changing climates may affect important habitat variables that in turn influence population vital rates.

Establishing a monitoring program for *Cypripedium parviflorum* var. *pubescens* would provide much-needed insight into the orchid's population trends. By establishing baseline population numbers and monitoring these populations over time, land managers could better evaluate the population-level effects of natural disturbance and management activities. However, population sizes are so low (generally less than ten individuals) that losses of just a few individuals due to stochastic events could result in population extirpation or significant proportional loss of individuals that is not related to the management actions. Revisiting EO #11 on the south side of Perue Peak would be very informative since this is the only site not located on the roadside and likely occurs in a different habitat; additionally there is not a good population estimates. Concentrating additional surveys to similar habitats near Perue Peak would be useful in delineating the extent of EO #11 and potentially finding additional populations.

The data collected during monitoring may also expand our understanding of the orchid's life history in Alaska. Much about the pollination and reproductive biology of *Cypripedium parviflorum* var. *pubescens* is not known; such as the primary pollinators and degree of pollen limitation in seed production. The specificity of pollinators and level of pollinator service will affect our understanding of *C. parviflorum* var. *pubescens*' inherent vulnerabilities. Small

populations (and particularly populations of a single reproductive individual) are presumably substantially limited in seed production due to the lack of compatible individuals nearby. Monitoring populations of *Cypripedium parviflorum* var. *pubescens* may also help to determine whether grazing by vertebrates and invertebrates occurs on the Tongass National Forest poses a threat to this plant. More focused research on the specificity and nature of mycorrhizal fungi in germination and establishment of seedlings is warranted. If many species of fungi that are widely distributed can fulfill the role of providing nutrition to the embryo and young plant, then this may not be a relevant factor in the taxon's intrinsic vulnerability; however, if there is a small number of the mycorrhizal fungi that have very restricted distributions, opportunities for population establishment would be much more limited.

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APPENDIX

Location information, general site descriptions, and observation dates for all known *Cypripedium parviflorum* var. *pubescens* occurrences on the Tongass National Forest. EO # is Element Occurrence numbers, in Red Bay two recorded sites occur within close proximity and are treated below as subpopulations of the same Element Occurrence.

General location	USFS Site #	EO No.	Habitat	Number of Flowering Stems	Collector	Collection Date	Last Observed
Red Bay, Prince of Wales Island	100554PT00001	10_1	Open muskeg along road	15, single clump of plants	Erin Uloth	6/10/2006	?
Red Bay, Prince of Wales Island	100554P000056	10_2	Open muskeg along road	3 (1 reproductive, 2 vegetative)	Mary Clemens	8/31/2006	Ian Grinter 8/9/2017
Perue Peak, Prince of Wales Island	100554PT00002	11	Edge of marble cliff	?	Erin Uloth	7/8/2006	
Neck Lake South, Prince of Wales Island	100554P000545 Y14	12	Road edge with reed canarygrass	3 (1 reproductive, 2 vegetative)	unknown	6/15/2014	Grinter 8/7/2017
Flicker Creek, Prince of Wales Island	100554P000443 Y12	13	Roadside shoulder in gravel-sand	10 (1 reproductive, 9 vegetative)	unknown	6/15/2014	Grinter 8/7/2017
Neck Lake North, Prince of Wales Island	100554P000546 Y14	14	Roadside – Quarry margin in limestone gravel	1 (reproductive)	unknown	8/18/2014	Grinter, 8/7/2017

DEFINITIONS

Calcareous substrates - soils completely or partially composed of calcium carbonate.

Calciphile - being associated with calcareous substrates.

Cordiform – heart shaped

Disjunct – separated from a main distribution by a great distance where gene flow between the populations would not be possible

Effectiveness monitoring – monitoring that determines if management activities are effective in producing desired conditions.

Implementation Monitoring – monitoring that determines if management activities are designed and carried out in compliance with forest plan direction and management requirements.

Labellum – the pouch or lip of the orchid flower derived from a modified petal.

Mycorrhizae – symbiotic relations of plant roots and fungi.

Orbiculate – nearly circular

Perennating bud – the bud of a perennial plant that overwinters in a dormant state and sprouts the following spring.

Perennial – a plant that normally lives for more than two seasons.

Phenotypic plasticity – the capacity for marked variation in the morphology of an organism as a result of environmental influences.

Pollinia – a mass of pollen grains packed as a single unit.

Pubescent – covered with hair.

Ramet – a member of a clone such as rooted cuttings or rhizomatous shoots that are identical genetically but can live independently.

Recruitment – the addition of new members to a population through reproduction.

Rhizomatous – possessing underground stems that often produce roots and shoots.

Sensitive species – those species for which population viability is a concern and identified by a regional forester as requiring special management as directed in FSM2670.

Seral – pertaining to an early stage of succession.

Staminode – a sterile stamen and in C. montanum a structure that partially covers the pouch opening.

Symbiont – an organism that interacts in a relation with another organism − maybe, but not always, to their mutual benefit.

Sympodial bud – a lateral bud that forms just behind the tip of a composite axis, elongating the axis.

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AUTHORS BIOGRAPHIES

The current version of the Cypripedium parviflorum var. pubsescens Conservation Assessment was revised by the Botany Program of Alaska Natural Heritage Program (AKNHP), University of Alaska Anchorage (UAA). AKNHP collects, synthesizes, and validates information on Alaska's animal and plant species of concern and their habitats, ecosystems of concern, and invasive species. This information is provided by AKNHP to government, business, land managers, scientists, conservation groups, and the public.

The botany program conducts research on the biology of rare and invasive plant species and participates in citizen science initiatives. The program is directed under Dr. Matthew Carlson, who also teaches in the Department of Biological Sciences at UAA. Areas of research expertise for the botany program include habitat modeling, biogeography of rare and invasive plants, reproductive ecology and evolution, and ecological impacts of non-native plants. The botany program also offers a wide range of related services including field surveys, monitoring studies, mapping, and conservation planning services. The AKNHP botany program also manages the University of Alaska Anchorage Herbarium (UAAH) which holds an extensive representation of Alaska's flora, including rare Alaskan plants, non-native plants, and cryptograms. Over 14,000 specimens are in the collection and can be viewed online at: http://www.pnwherbaria.org/

The botany program has extensive experience with rare plant conservation in Alaska and is an authority figure for assigning state level conservation ranks. Notably, the Alaska Rare Plant Field Guide has been published to aid in the identification, distribution, and ecology for plants of conservation concern in Alaska. The botany program is also the central repository of biological information on Alaska's rare and invasive plant species and tracks over 600 plant species. Lists of vascular plants and lichens of conservation concern of selected rare plants of Alaska are located on the Rare Plants page. AKNHP works closely with botanists across Alaska in an effort to ensure the most comprehensive and accurate data sets