THE UNIVERSITY OF ALBERTA

A biosystematic study of *Arnica* subgenus *Arctica*

by

Stephen Roy Downie

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A biosystematic study of *Arnica* subgenus *Arctica* submitted by Stephen Roy Downie in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Plant Taxonomy.

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Dedication

To my parents

Abstract

Evaluation of systematic relationships of *Arnica* subgenus *Arctica* show that the complex, as circumscribed in the present study, consists of seven species. No new taxa have been proposed; however, names of seven taxa previously recognized are treated as synonyms. *Arnica angustifolia*; *A. frigida* and *A. lonchophylla*, each consisting of two subspecies, are polymorphic and varied in ploidy level and foliar flavonoid chemistry. Cluster (TAXMAP and UPGMA) and principal component analyses of *A. angustifolia* (*s.l.*) revealed this circumpolar aggregate to be best represented as two subspecies: *A. angustifolia* subsp. *angustifolia* (a combination of the previously recognized subspecies *angustifolia, attenuata, sornborgeri, intermedia; iljinii, alpina* and *A. plantaginea*); and *A. angustifolia* subsp. *tomentosa*. Subspecies *louiseana* and *frigida* of *A. louiseana* are now ranked as species, and a new combination, *A. frigida* subsp. *griscomii*, is presented. The subspecies name *chionopappa* of *A. lonchophylla* is synonymized with the latter; *A. lonchophylla* subsp. *arnoglossa* is maintained. Studies on the reproductive behaviour of *A. fulgens* and *A. sororia* revealed them to be amphimictic and self-incompatible, with artificial hybridization experiments being unsuccessful. Both are maintained as separate species.

The basic chromosome number for the subgenus is x=19, with *A. angustifolia* and *A. frigida* 2n=38, 57, 76 and 95, *A. lonchophylla* 2n=38, 57 and 76, *A. louiseana* 2n=76 and 95, *A. rydbergii* 2n=38 and 76, and both *A. fulgens* and *A. sororia* 2n=38. Twelve flavonoids were isolated, and eleven identified, from *Arnica* subgenus *Arctica*. Simple mono-glycosides of quercetin and kaempferol were ubiquitous, thus indicative of a somewhat primitive biochemical profile. Flavonoid profiles are relatively simple, with two to six compounds identified per population. Flavonoid diversity appears to have accompanied high morphological variability. Amphimictic species of subgenus *Arctica* are closely correlated with non-glaciated regions. Disjunct distributions are probably the result of survival in refugia during the late Wisconsinan, with apomictic phases being

responsible for the recolonization of previously glaciated areas. Phylogenetic relations amongst all taxa, using structural and flavonoid synapomorphies, revealed *A. angustifolia* to be the progenitor of all taxa within the subgenus. *Arnica* subgenus *Arctica* probably represents the most ancestral group, giving rise to all other *Arnica* subgenera.

A taxonomic revision of the subgenus includes descriptions, keys, synonymies, distribution maps, and listings of representative specimens.

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My appreciation and thanks first extends to Dr. Keith E. Denford, my thesis advisor, who for the last four years had contributed significantly to this thesis. From suggesting the project and providing the facilities and generous financial assistance to carry it out, to being a never ending source of stimulating ideas and moral support, his input is greatly acknowledged.

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I. Introduction

Family Asteraceae

The family Asteraceae is one of the largest and most successful families of vascular plants, and includes more than 1100 genera and 20,000 species (Cronquist 1981). Asteraceae is cosmopolitan in distribution and exhibits great diversity in habitat, pollination method and type of seed dispersal (Cronquist 1981). The majority are herbaceous, with about 1.5 percent shrubs or trees (Willis 1966). Economically the family is of considerable importance, but the actual number of species used by man is small compared to its size. In addition to being a source of food for man (lettuce, artichoke, endive, chicory and sunflower), many species are used as ornamentals (aster, chrysanthemum, coreopsis, dahlia, marigold and zinnia). Some are weeds (*Centaurea, Cirsium, Senecio* and *Taraxacum*) and others are used to a limited extent in medicinal preparations (*Arnica, Arctium, Achillea* and *Artemisia*).

The Asteraceae appear to be a clearly defined family based upon uniformity of floral structure. All members possess a 5-lobed gamopetalous corolla, an inferior bicarpellate uniloculate ovary with a single basal ovule, 5 syngenesious stamens and an aggregation of flowers into a capitulum.

The uniformity in floral structure of the Asteraceae tends to make the recognition of tribes and genera difficult (Cronquist 1977). Bentham's (1873a, 1873b) classification of the family, adopted and modified from the earlier work of Cassini (1826, 1829, 1834), de Candolle (1836, 1838) and Lessing (1831), into 13 tribes, is still used today. Some tribal groupings have been questioned or challenged (Cronquist 1955), and several new tribes have been proposed (Robinson and Brettell 1973; Nordenstam 1977). Cronquist (1977, 1981) has stated that the Asteraceae is so morphologically and ecologically diverse that many genera are not well defined, and the traditional arrangement of the genera into tribes may not be correct. This diversity may be generated by the prevalence of hybridization, polyploidy and apomixis within the family. In addition, the pronounced taxonomic problems at the tribal and generic levels are also inherent at the species level.

Genus Arnica

Although *Arnica*[1] is clearly defined, taxonomic boundaries amongst the species are rather obscure and concise delimitation can be difficult. In fact, many species appear to exhibit greater intraspecific divergence than the amount of divergence between some closely related species (Maguire 1943). A genus of about 28 species, *Arnica* is confined to the boreal and montane regions of the northern hemisphere, with the majority of species in the western cordillera of North America. These rhizomatous perennial herbs, have simple or branched stems bearing opposite leaves and large, single or cymose, heads of yellow flowers.

Arnica, commonly placed in the Senecioneae, is now generally excluded from this tribe. The opposite leaves, the large ray florets, the immersed style base and the *Helianthus* - type pollen suggest that, morphologically, *Arnica* has closer affinities with the Heliantheae (Nordenstam 1977). Chemical evidence supports morphological evidence favouring the removal of *Arnica* from the Senecioneae. Robins (1977) stated that the chemical constitution of *Arnica* is more characteristic of the Heliantheae; for its chemistry is markedly different from any other member in the Senecioneae. Similarly, serological tests indicate no relationship to the Senecioneae (Schumacher 1966). *Arnica* lacks the characteristic furanoeremophilane sesquiterpene lactones and pyrrolizidine alkaloids typical of most members of the Senecioneae, but possesses pseudoguaianolide sesquiterpenes, novel in the Senecioneae but common in other tribes. In addition, melanins and polyacetylenes found in *Arnica* are rare in the Senecioneae. Nordenstam (1977) stated that *Arnica* may form a natural group together with a number of genera from the Helenieae, a tribe now combined with the Heliantheae (Cronquist 1955) or more recently, dismembered completely and redistributed among six other tribes (Turner and Powell 1977). Nordenstam (1977) further suggests that if *Arnica* and related genera cannot be accepted into the Heliantheae (the capillary pappus of *Arnica* would be

[1]The derivation of the name *Arnica* is unknown. It may be a corruption of *Ptarmica* (Abrams and Ferris 1960).

somewhat anomalous in the Heliantheae) the only possible solution would be to create a new tribe Arniceae. The genus *Arnica* must be thoroughly studied before it can be assigned to any tribe.

Medicinal and Economic Importance

The medicinal value of *Arnica* has been recognized in the Pharmacopoeia of the United States (1907), and the drug obtained from the plant was widely used throughout Europe during the nineteenth and early twentieth centuries. The active principle in *Arnica* rhizomes, roots, leaves and flowers is arnicin (a pseudoguaianolide sesquiterpene lactone), a yellowish-brown amorphous substance having an acrid taste (Bentley and Trimen 1880; Williams 1960; Robins 1977). It has been employed chiefly in the form of an eczema-inducing tincture, externally as a counterirritant for sprains and bruises; or internally as a stimulant and irritant in ailments and diseases such as bronchitis, diabetes, diarrhea, epilepsy and back pain (Duke 1985).

More recently, medicinal preparations involving *Arnica* have been used to enhance phagocytosis, to prevent smoking, to promote hair growth, and as a component in beauty cream (Robins 1977; Duke 1985). The dried flowers of *Arnica* are bactericidal (Duke 1985) and the extracted oils have been used recently in the product *Lavilin*, an antiperspirant and foot deodorant. *Arnica* is used in perfumery and Germany alone markets more than 100 drug preparations containing *Arnica* extract (Duke 1985). The flowers of the European *A. montana* were used as the primary source of the drug. In North America, *A. cordifolia*, *A. fulgens* and *A. sororia* have also been used and are considered superior to the European plants (Hocking 1945). However, the Food and Drug Administration (U.S.A.) has classified this plant as unsafe, for when ingested violent toxic gastroenteritis, a change in pulse rate, increased blood pressure, muscular weakness and death may result.

Arnica Subgenus Arctica

The most recent monograph of *Arnica* was by Maguire (1943) in which he recognized 32 species in five subgenera: *Andropurpurea, Arctica, Austromontana, Chamissonis* and *Montana*. Subgenus *Austromontana* has recently been systematically investigated by Wolf (1981), who recognized nine species within the subgenus, reducing the number of taxa recognized by Maguire by four.

Subgenus *Arctica*, as circumscribed by Maguire (1943), is distinguished by its large hemispheric to campanulate-turbinate capitula; white, barbellate pappus and narrow, lanceolate to oblanceolate leaves. Maguire recognized seven species and thirteen subspecies, including a polymorphic circumpolar species (*A. angustifolia* Vahl) found in seven fairly distinct geographical areas. The subgenus is confined primarily between 45° and 80° N Latitude in North America and between 60° and 80° in the U.S.S.R. with disjunct members in northern Scandinavia. In North America three species extend as far south as Colorado in the Rocky Mountains. The distribution of the *Arctica* complex is shown in Figure 1. Taxonomic treatments of this complex have been greatly influenced by the morphological variability encountered, particularly within *A. angustifolia, A. frigida* Meyer *ex* Iljin and *A. lonchophylla* Greene.

Historical Taxonomic Summary

A historical account of the genus *Arnica* has been provided by Maguire (1943), consequently the following discussion pertains only to subgenus *Arctica*. A comprehensive account of all taxa within the subgenus is provided in the taxonomy chapter of this thesis. In his *Flora Lapponica* of 1737, Linnaeus recognized the Scandinavian race of *A. angustifolia* as *Doronicum foliis lanceolatis*. This taxon was again recognized in Linnaeus' *Flora Suecica* of 1745. The first report of *Arnica* in the U.S.S.R. appeared during 1747-1769 in Gmelin's *Flora Sibirica*. Here *Doronicum foliis caulinis oppositis varietas foliis lanceolatis* was recognized. In synonymy was placed *D. foliis lanceolatis*.

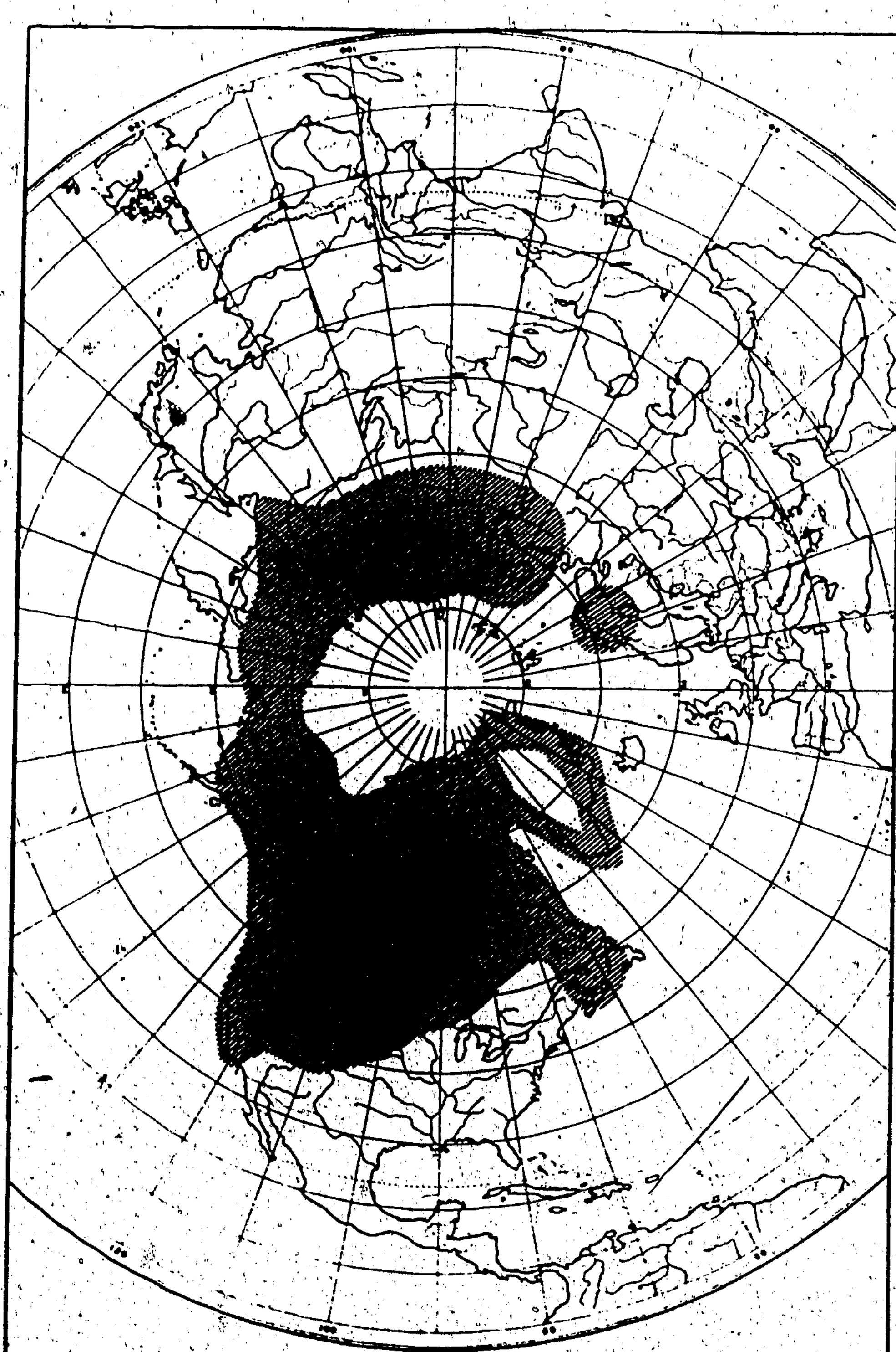

Figure 1 - The circumpolar distribution of *Arnica* subgenus *Arctica*.

In Linnaeus' *Species Plantarum* (1753) six species of *Arnica* were described, including *A. montana* var. *alpina*. In his dissertation *De Arnica* of 1799, Olin recognized this taxon as a distinct species, *A. alpina* (L.) Olin. Ferguson (1973), however, has rejected the commonly used name of *A. alpina* for it is a later homonym of *A. alpina* Salisb. (1796), a *Doronicum* species. The next available name, *A. angustifolia*, was proposed by J.M. Vahl in 1816 for plants collected in Greenland. Since then, the name *A. angustifolia* Vahl has been variously attributed to different plants of North America, Europe and the U.S.S.R. In *Flora Americae Septentrionalis*, Pursh (1814) recognized *A. plantaginea* Pursh and *A. fulgens* Pursh. Torrey and Gray (1843) provided the first revision of North American *Arnica*. However, because of inadequate material, their interpretation of *A. angustifolia* was confused, for it included *A. plantaginea*, *A. fulgens*, the purple-anthered *A. lessingii* Greene, and all the then known members of the *A. angustifolia* aggregate.

In Herder's *Plantae Raddeanae Monopetalae* (1867), *A. angustifolia* was retained for plants of Labrador, Greenland, Scandinavia and northern Siberia. Herder also retained *A. frigida*, a taxon originally described in 1831 by Lessing (as *A. alpina* L.) in his report on plant material gathered during the Romanzoffiana expedition (1815-1818). Herder's work was significant for it demonstrated a better understanding of *Arnica* than that of earlier American botanists, primarily because of the large quantities of material he had at his disposal.

The second revision of North American *Arnica* was in Gray's (1884) *Synoptical Flora of North America*. Gray recognized 15 species of *Arnica*, still interpreting *A. plantaginea* and *A. fulgens* as *A. angustifolia*. During the period from 1897 to 1904, twelve species of *Arnica* were described by Greene, Rydberg, Nelson and Macoun, of which only four are currently recognized: *A. arnoglossa* Greene, *A. tomentosa* Macoun, *A. rydbergii* Greene and *A. lonchophylla* Greene. In 1906, Miss Edith Farr described *A. louiseana* from the vicinity of Lake Louise, Alberta, and four years later Greene (1910) published *A. sororia*. Over the next two decades, Fernald proposed six names for members of subgenus *Arctica* in northeastern North America, with only three still consistently used (*A. griscomii*, *A. chionopappa* and *A. sornborgeri*), the rank dependent upon the taxonomic authority.

In 1927 a revision of *Arnica* appeared by Rydberg in which he recognized 107 species. Despite the large number of species, his arrangement of taxa shows a much better understanding of relationships than before. In arranging these subgeneric groups, Rydberg primarily used pappus characteristics, as did Maguire (1943) in his delimitation of specific and subgeneric groups. In subgenus *Arctica*, Rydberg recognized eight names, which today are all regarded as synonyms.

Maguire's (1943) recognition of seven species and thirteen subspecies within the subgenus was based primarily on herbarium material available within North America. At this time, information on chromosome numbers and reproductive behaviour within the genus was virtually unknown. One consequence of this was ignorance as to the amount of morphological variation in these plants created by apomixis, polyploidy and phenotypic plasticity. Maguire's (1943) treatment of subgenus *Arctica*, and other classifications which have been proposed, are presented in Table 1.

In their revision of *Arnica* for the *North America Flora*, Ediger and Barkley (1978) essentially adopted Maguire's (1943) treatment of subgenus *Arctica*, recognizing six species and seven varieties. However, *A. plantaginea* was combined with Maguire's *A. alpina* subsp. *sornborgeri* and the assemblage treated as *A. alpina* var. *plantaginea*. In addition, the infraspecific taxa of *A. lonchophylla* were not recognized. Douglas and Ruyle-Douglas (1978) have treated *A. lonchophylla* as a subspecies of *A. angustifolia*, with no justification for this change given.

One taxon in subgenus *Arctica* which has generated taxonomic debate is *A. louiseana*. Consisting of three disjunct subspecies, these plants are prevalent throughout arctic western North America and eastern Siberia; and also occupy smaller areas in Alberta and Atlantic Canada. Influenced by the large amount of polymorphism exhibited by the widespread arctic taxon, Rydberg (1927) proposed five names for these plants, whereas Maguire (1943) subsequently placed these plants under synonymy with *A. louiseana* subsp. *frigida*. Hultén (1968) has maintained the name *A. frigida* for these arctic plants, distinguishing them from the southern *A. louiseana*. Maguire (1943) and

Table 1. A comparison of classifications for *Arnica* subgenus *Arctica*.

Rydberg (1927)	Maguire (1943)	Ediger & Barkley (1978)	Ferguson (1973) Douglas (1982)	Iljin (1961)
	A. alpina (L.) Olin subsp. *alpina*		*A. angustifolia* subsp. *alpina* (L.) I.K. Ferguson	*A. alpina* (L.) Olin
	A. alpina subsp. *intermedia* (Turez.) Maguire			*A. intermedia* Turez.
	A. alpina subsp. *iljinii* Maguire		*A. angustifolia* subsp. *iljinii* (Maguire) I.K. Ferguson	*A. iljinii* (Mag.) Iljin
A. alpina (L.) Olin	*A. alpina* subsp. *angustifolia* (Vahl) Mag.	*A. alpina* var. *angustifolia* (Vahl) Fern.	*A. angustifolia* Vahl subsp. *angustifolia*	
A. tomentosa Macoun *A. pulchella* Fern.	*A. alpina* subsp. *tomentosa* (Macoun) Maguire	*A. alpina* var. *tomentosa* (Macoun) Cronquist	*A. angustifolia* subsp. *tomentosa* (Macoun) Dougl. & Ruyle-Dougl.	
A. attenuata Greene	*A. alpina* subsp. *attenuata* (Greene) *Maguire*	*A. alpina* var. *attenuata* (Greene) Ediger & Barkl.	*A. angustifolia* subsp. *attenuata* (Greene) Dougl. & Ruyle-Dougl.	
A. sornborgeri Fern.	*A. alpina* subsp. *sornborgeri* (Fern.) Maguire	*A. alpina* var. *plantaginea* (Pursh) Ediger & Barkl.		
A. brevifolia Rydb. *A. illiamnae* Rydb. *A. mendenhallii* Rydb. *A. nutans* Rydb. *A. sancti-laurentii* Rydb.	*A. louiseana* subsp. *frigida* (Meyer ex Iljin) Maguire	*A. louiseana* var. *mendenhallii* (Rydb.) Maguire	*A. louiseana* subsp. *frigida* (Meyer ex Iljin) Maguire	

Rydberg (1927)	**Maguire (1943)**	**Ediger & Barkley (1978)**	**Ferguson (1973) Douglas (1982)**	**Iljin (1961)**
A. griscomii Fern.	*A. louiseana* subsp. *griscomii* (Fern.) Maguire	*A. louiseana* var. *griscomii* (Fern.) Boivin		
A. louiseana Farr	*A. louiseana* subsp. *genuina* Maguire	*A. louiseana* Farr var. *louiseana*	*A. louiseana* Farr subsp. *louiseana*	
A. plantaginea Pursh	*A. plantaginea* Pursh			
A. rydbergii Greene *A. sulcata* Rydb.	*A. rydbergii* Greene	*A. rydbergii* Greene	*A. rydbergii* Greene	
A. fulgens Pursh	*A. fulgens* Pursh	*A. fulgens* Pursh	*A. fulgens* Pursh var. *fulgens*	
A. sororia Greene *A. trinervata* Rydb.	*A. sororia* Greene	*A. sororia* Greene	*A. fulgens* var. *sororia* (Greene) Dougl. & Ruyle-Dougl.	
A. wilsonii Rydb. *A. lonchophylla* Greene	*A. lonchophylla* subsp. *genuina* Maguire			
A. fernaldii Rydb. *A. gaspensis* Fern.	*A. lonchophylla* subsp. *chionopappa* (Fern.) Maguire	*A. lonchophylla* Greene	*A. angustifolia* subsp. *lonchophylla* (Greene) Dougl. & Ruyle-Dougl.	
A. arnoglossa Greene	*A. lonchophylla* subsp. *arnoglossa* (Greene) Maguire			

Raup (1947) have stated that in several respects the eastern Canadian populations are more similar to *A. louiseana* subsp. *frigida* than to those plants from Alberta. However, the consensus has been to maintain all three taxa in *A. louiseana* (Maguire 1943; Ediger and Barkley 1978; Scoggan 1979; Douglas 1982).

Arnica fulgens and *A. sororia* are very similar in vegetative and reproductive features with only the presence of septate hairs scattered amongst the stipitate-glandular hairs of the disc corolla and dense axillary tufts of brown woolly hairs in the persistent leaf bases traditionally used to separate them (Maguire 1943; Ediger and Barkley 1978). Douglas and Ruyle-Douglas (1978) observed that the diagnostic features used to separate the two species, with the exception of disc corolla pubescence, are unsatisfactory and that all other characters overlap to such an extent that separation at the specific level does not appear warranted. They therefore treated *A. sororia* as a variant of *A. fulgens*.

Arnica wilsonii is a taxon of considerable phytogeographical interest. First described by Rydberg in 1927, it is the only member of subgenus *Arctica* to be found in southcentral Ontario. With only a single collection available, Maguire (1943) refused to treat this taxon as a distinct species, and suggested that it may represent a hybrid between *A. angustifolia* and *A. lonchophylla*. Subsequent collections led Ediger and Barkley (1978) to place this taxon in synonymy with *A. lonchophylla*.

Arnica angustifolia sensu lato is another complex aggregate in subgenus *Arctica*. The apparent intergradation in morphology between the members of this aggregate has promoted considerable taxonomic confusion. In his major treatment of the aggregate, Maguire (1943) recognized seven taxa: subspecies *angustifolia, attenuata, tomentosa, sornborgeri, intermedia, iljinii* and *alpina* (subspecies *genuina* being illegitimate) of *Arnica alpina* (L.) Olin. Each of these taxa is confined to a particular geographic area. Previous studies have recognized the polymorphic nature of *A. angustifolia* (Maguire 1943; Benum 1958; Polunin 1959; Engell 1970; Ediger and Barkley 1978; Douglas 1982). Plants have been described from the Northwest Territories (Raup 1947) and Greenland (Jorgensen *et al.* 1958) which fit into the circumscription of subspecies *alpina* from Scandinavia. Ediger and Barkley (1978) have stated that "the species consists of some seven thoroughly intergradient varieties, each of which is variable and might sometimes be mistaken for another variety in the absence of geographic data." In North America, taxonomic treatments range from recognition of one species, comprised of four confluent varieties (Ediger and Barkley 1978), to four separate species (Rydberg 1927). In Europe and the U.S.S.R., Iljin (1961) has recognized subspecies *alpina*, *intermedia* and *iljinii* at the species level.

Biosystematic Investigations

The basic chromosome number for *Arnica* was shown by Böcher and Larsen (1950) and Ornduff *et al.* (1967) to be x=19, with chromosome races of 2n=38 to 2n=152 being reported (Ornduff *et al.* 1967; Keil and Pinkava 1976; Straley 1979, 1982). Ornduff *et al.* (1967) have observed a high frequency of meiotic irregularities in triploids and tetraploids, which Barker (1966) suggests may be due to aneuploidy. Previously reported chromosome counts are summarized in Table 2. A reported count for *A. louiseana* of 2n=57 (Wolf 1980) was based upon a misidentification of *A. rydbergii* Greene and is not included in this table. A count of 2n=*ca.* 97 for *A. fulgens*, incorrectly referenced by Barker (1966) from Ornduff *et al.* (1967), is in error and omitted.

Apomixis and poor pollen quality are correlated (Gustafsson 1947). Using pollen quality as an indicator of reproductive mode in *Arnica*, Barker (1966) was able to show that in collections where emasculation procedures and embryological observations indicated amphimixis, the pollen was well formed with better than 90% stainability in lactophenol-cotton blue. When apomixis was demonstrated experimentally, the pollen showed varying degrees of deformity and less than 80% stainability. The relationship between apomixis and polyploidy (Gustafsson 1946, 1947; Stebbins 1950) was demonstrated in Barker's (1966) study in which all amphimicts were diploid and apomicts polyploid. Subgenus *Arctica* contains not only the most highly evolved agamic complex in the genus (*A. angustifolia*), but two of the most widespread amphimictic species (*A. fulgens* and *A. sororia*) (Barker 1966). Only *A. angustifolia* subsp. *tomentosa*, *A. louiseana* subsp. *frigida* and *A. lonchophylla* subsp. *arnoglossa* contain amphimictic

Table 2. Previously reported chromosome numbers in *Arnica* subgenus *Arctica*

Taxon	n=	2n=	Locality	Reference
A. angustifolia subsp. *alpina*		54	NRWY: Batsfjord, Anneelv	Engelskjon & Knaben (1971)
		56	NRWY: Alta, Altaelv	Engelskjon & Knaben (1971)
		56	NRWY: Overbygd, Riidagierdo	Engelskjon & Knaben (1971)
		56	NRWY: No locality information	Nygren (1954)
		56	SPTBRN: Isfjorden	Flovic (1940)
		57	NRWY: Vardo	Löve & Löve (1975)
		57	SPTBRN: No locality information	Löve & Löve (1975)
		60	SWDN: Abisko	Afzelius (1936)
A. angustifolia subsp. *angustifolia*		38	YT: Km 132 Dempster Hwy.	Wolf (1980)
		38	YT: Km 137 Dempster Hwy.	Wolf (1980)
		50-60	GRLD: Clavering Island	Jorgensen *et al.* (1958)
		c.57	NWT: Melville Island	Mosquin & Hayley (1966)
		57	YT: Km 138 Dempster Hwy.	Wolf (1980)
		57	GRLD: Mesters Vig	Engell (1970)
		76	GRLD: Sdr. Stromfjord	Böcher & Larsen (1950)
		76	GRLD: Lyell's Land	Engell (1970)
		76	GRLD: Holsteinborg	Engell (1970)
		76	GRLD: Sdr. Stromfjord	Engell (1970)
		95	GRLD: Marrait	Engell (1970)
A. angustifolia subsp. *attenuata*	19		YT: Dawson	Wolf (1980)
	19		YT: Km 4 Dempster Hwy.	Wolf (1980)
	19		YT: Km 1.6 Mayo Road	Wolf (1980)
	19		YT: 108 km N. Stewart Crossing	Wolf (1980)
	19		YT: Km 270 Klondike Hwy.	Wolf (1980)
	19		AK: Boundary	Wolf (1980)
	19		AK: Km 2098 Alaska Hwy.	Wolf (1980)
		38	YT: Dawson	Wolf (1980)
		38	AK: Km 79 Taylor Hwy.	Wolf (1980)
		38	AK: No locality information	Barker (1967)
		57	BC: Km 132 Haines Hwy.	Wolf (1980)
		57	YT: Dawson	Wolf (1980)

Taxon	n=	2n=	Locality	Reference
		57	YT: 7.5 km S. Haines Junction	Wolf (1980)
		57	YT: 26 km S. Haines Junction	Wolf (1980)
		57	YT: 24 km W. Whitehorse	Wolf (1980)
		57	YT: Km 1788 Alaska Hwy.	Wolf (1980)
		57	AK: 32 km S. Palmer	Wolf (1980)
		57	YT: Whitehorse	Löve & Löve (1975)
		c.57	YT: Ogilvie Mountains	Mulligan & Porsild (1970)
A. angustifolia subsp. *sornborgeri*		76	PQ: Fort Chimo	Löve & Löve (1975)
		76	PQ: No locality information	Hedberg (1967)
A. angustifolia subsp. *tomentosa*	38		ALTA: Banff Park	Wolf (1980)
		57	ALTA: Banff Park	Wolf (1980)
	38		ALTA: Mountain Park	Wolf (1980)
		57	YT: Mackenzie delta	Löve & Löve (1975)
		76	ALTA: Banff Park, Peyto Lake	Straley (1979)
A. angustifolia subsp. *iljinii*	19		USSR: No information given	Barker (1967)
		56	USSR: Baranikha, W. Chukotka	Zhukova (1966)
		56	USSR: Aljarmagtji R., Chukotka	Zhukova (1967)
		56	USSR: Basseyna R., Komi	Sokolovskaya (1970)
		56	USSR: Yagodniy R.	Zhukova & Petrovsky (1976)
		56	USSR: Cherskiy	Zhukova *et al.* (1977)
		56	USSR: Wrangell Island	Zhukova & Petrovsky (1972)
		56	USSR: Siberia	Zhukova, Petrovsky & Plieva (1973)
		57	USSR: Archangelsk	Löve & Löve (1975)
A. frigida subsp. *frigida*		38	AK: Hatcher's Pass	Wolf (1980)
		38	AK: Caribou Creek	Wolf (1980)
		38	AK: Donnelly Dome	Wolf (1980)
		38	AK: 11 km S. Delta Junction	Wolf (1980)
		38	AK: Km 35 Denali Hwy.	Wolf (1980)
		57	AK: Km 63 Taylor Hwy.	Wolf (1980)
		58	USSR: Gusinaya R.	Zhukova & Petrovski (1971)
		60	USSR: Arcto-Alpine Botanic Garden	Zhukova (1964)

Taxon	n=	2n=	Locality	Reference
		60	USSR: Lorino	Zhukova (1965)
		70	USSR: No locality information	Zhukova & Tikhonova (1971)
		c.76	AK: Ogotruk Creek	Johnson & Packer (1968)
		76	YT: Kluane Lake	Löve & Löve (1975)
		76	USSR: Mt. Ulakhan-Tas	Zhukova *et al.* (1977)
A. frigida subsp. *griscomii*		76	PQ: Mt. Logan	Gervais (1979)
A. louiseana		c.67	ALTA: Jasper Park, Mt. Edith Cavell	Ornduff *et al.* (1967)
		76	ALTA: Jasper Park, Mt. Edith Cavell	Wolf (1980)
		76	ALTA: Jasper Park, Columbia Icefields	Wolf (1980)
		76	ALTA: Jasper Park, Maligne Lake	Wolf (1980)
		76	ALTA: Banff Park, Peyto Lake	Wolf (1980)
		95	ALTA: Banff Park, Moraine Lake	Straley (1982)
A. fulgens	19		ID: Lewis Co.	Ornduff *et al.* (1967)
	19		WASH: Kittitas Co.	Barker (1967)
		38	WYOM: Crook Co.	Straley (1979)
		38	BC: Grasmere	Taylor & Brockman (1966)
		52-57	SASK: Cypress Hills Park	Taylor & Brockman (1966)
A. sororia	19		WASH: Kittitas Co.	Barker (1967)
	19		WASH: Douglas Co.	Ornduff *et al.* (1967)
		38	ORE: Union Co.	Straley (1979)
A. rydbergii	19		MONT: Lincoln Co.	Wolf (1980)
		38	ALTA: Km 148 Kananaskis Frstry. Rd.	Wolf (1980)
		38	WASH: Clallam Co.	Wolf (1980)
		76	WASH: Clallam Co.	Straley (1979)
A. plantaginea		c.70	USSR: Arcto-Alpine Botanic Garden	Zhukova (1964)

Taxon	n=	2n=	Locality	Reference
A. lonchophylla subsp. *lonchophylla*	38		ALTA: Muskiki Lake	Wolf (1980)
		57	ALTA: 12.8 km N. Nordegg	Wolf (1980)
		56	ONT: North Fowl Lake	Morton (1981)

Locality abbreviations: AK, Alaska; ALTA, Alberta; BC, British Columbia; GRLD, Greenland; ID, Idaho; MONT, Montana; NRWY, Norway; NWT, Northwest Territories; ONT, Ontario; ORE, Oregon; PQ, Quebec; SASK, Saskatchewan; SPTBRN, Spitsbergen; SWDN, Sweden; USSR, U.S.S.R.; WASH, Washington; WYOM, Wyoming; YT, Yukon Territory.

populations. However, Barker (1966) could only provide a somewhat cursory overview of the genus due to the wide scope of his study and the limited availability of material. The evolution of subgenus *Arctica* has been profoundly affected by glaciation for its members are ubiquitous on all major arctic land masses (Barker 1966). A thorough cytotaxonomic survey of this complex should provide further insight into the relationships between ploidy level, reproductive behaviour and distribution.

In an investigation into the embryology of *A. angustifolia* subsp. *angustifolia* from Greenland, Engell (1970) observed "a number of apomictically propagating subunits". Gustafsson (1947) and Ornduff *et al.* (1967) have suggested that apomixis and polyploidy are probably largely responsible for the morphological variability encountered within *Arnica*. Barker (1966) has suggested that the agamic complexes within subgenus *Arctica* most closely resemble the *Taraxacum* pattern, in which many apomictic microspecies exist with few related sexual elements being present.

Flavonoids have been used extensively to support taxonomic revisions (Gornall and Bohm 1980; Harborne and Green 1980) and to document changes in chemical complexity (both in flavonoid number and structural diversity) as a result of geographical isolation (Mears 1980; Wolf 1981; Vogelmann 1984), hybridization (Alston and Turner 1963; Belzer and Ownbey 1971; Wolf 1981), polyploidy (Levy and Levin 1971, 1975) or plant migrations (Mastenbroek *et al.* 1983). In addition, flavonoids can provide useful data for inferring phylogenetic relationships (Stuessy and Crawford 1983). Phytochemical investigations in *Arnica* have dealt primarily with floral chemistry, e.g. *A. montana* L. and *A. chamissonis* Less. (Borkowski *et al.* 1966; Willuhn *et al.* 1983, 1984; Merfort 1984, 1985; Merfort *et al.* 1986; Kostennikova *et al.* 1985) whilst others have dealt with leaf flavonoids, e.g. *A. montana* (Saner and Leupin 1966) in which kaempferol 3-O-glucoside, quercetin 3-O-glucoside and quercetin 3-O-glucogalacturonide were found. Wolf (1981) was able to identify 12 glycosides and 14 free aglycones in *Arnica* subgenus *Austromontana* with the glycosides of quercetin 3-O-gentiobioside and quercetin 3-O-diglucoside (viscosin)[2] being nearly ubiquitous in

[2] A diglucoside of quercetin with unusual chromatographic characteristics and an unknown sugar linkage. Isolated first from *A. viscosa* (Wolf 1981).

occurrence. Other common glycosides were found to be quercetin 3-O-glucoside and kaempferol 3-O-glucoside with the most frequently occurring free aglycone in the subgenus being apigenin-6-O-methyl ether. Any changes which occurred during the isolation and subsequent evolutionary history of *Arnica* may be manifested in their chemical profiles. A systematic survey of the flavonoids of *Arctica* should be beneficial in providing information of value in interpreting taxonomic and phylogenetic problems.

Within the subgenus are a number of taxa which exhibit disjunct distribution patterns: *Arnica louiseana* with three geographically isolated subspecies; *A. lonchophylla* (including *A. wilsonii*) with four disjunct members; and the seven geographically distinct taxa within the *A. angustifolia* aggregrate. The allopatric distributions of these species suggest that prior to the late Wisconsinan these taxa, or their precursors, had a more continuous distribution across North America, Europe and the U.S.S.R. These taxa pose interesting phytogeographic questions, to which chemical and morphological investigations should be applied. The eastern Canadian representatives of the *Arctica* complex have been treated as derivatives of the arctic or western cordillerean floras (Fernald 1924, 1933; Maguire 1943; Boivin 1952). Maguire's (1943) proposed phylogeny of the five subgenera of *Arnica* is presented in Figure 2. Subgenus *Arctica* appears to represent the closest archetypal major group being derived from a postulated ancestor, *Protoarnica*. The probable relationships of the other subgenera are not at all clear, rendering delineation speculative. In subgenus *Arctica*, *A. angustifolia* has been interpreted as the progenitor of all subsequent taxa (Maguire 1943). Using flavonoid and morphological characters with known plesiomorphic and apomorphic states, it is hoped that this study will provide some insight into the phylogeny of subgenus *Arctica*.

Prior to the revisionary work on subgenus *Austromontana* by Wolf (1981), taxonomic treatments of *Arnica* were largely based on Maguire's (1943) monograph. With our present knowledge on the extent of polyploidy within the genus, and a greater understanding of the chemical and morphological consequences of apomixis, a more thorough evaluation of subgenus *Arctica* can be accomplished. The availability of more herbarium specimens from throughout the range of the aggregate should provide

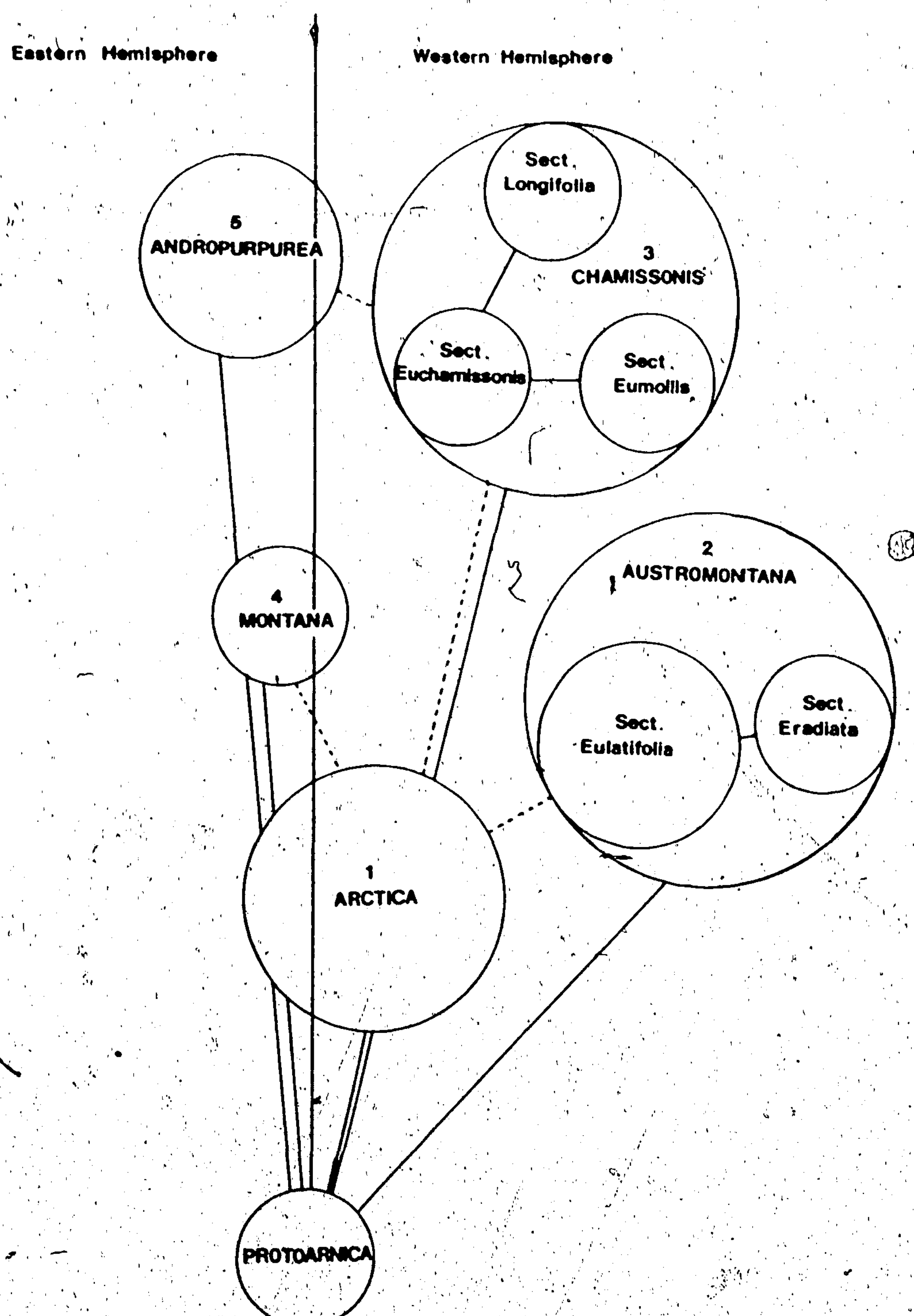

Figure 2 - Relationships of the *Arnica* subgenera (modified from Maguire, 1943).

greater knowledge to the extent of variation found in natural populations. Material grown under environmentally controlled conditions should indicate whether this observed variation is attributable to environmental factors, or has a genetic basis. Artificial crossing experiments also can be conducted. The present study was initiated to investigate the relationships between morphology, cytology, flavonoid chemistry and geographic distribution of the *Arctica* complex to elucidate the nomenclature and classification of the subgenus and the phylogenetic relations between the species. The influence of historical events (*i.e.* glaciation) and the role of polyploidy on the evolution and phytogeographic history will also be investigated.

II. Materials and Methods

A. Field Studies and Collections

Field collections of subgenus *Arctica* were made throughout its range in northwestern North America and in selected sites in the Gaspé Peninsula of Québec and in western Newfoundland. A voucher specimen for each population collected was deposited at the University of Alberta Vascular Plant Herbarium (ALTA). Seeds, if available, were collected and stored in paper bags. Live plant material was transplanted from the field into six-inch plastic pots and transported to the University of Alberta Phytotron for cultivation. The number of pots collected was dependent upon the size of the population and whether permission was received to collect in restricted areas. Achenes of Scandinavian, U.S.S.R. and eastern Canadian taxa were provided by the following botanic gardens: V.L. Komarov Botanical Institute, Leningrad; Main Botanic Garden, Moscow; Botanical Garden of Bochum, West Germany; Botanical Garden of the University of Uppsala, Sweden and the Botanic Garden of the University of Copenhagen.

B. Morphology

A study of specimens from throughout the entire range of the complex comprising approximately 2200 specimens involved material from, or visitations to, the following herbaria: University of Alaska (ALA); University of Alberta (ALTA); Herbarium of Brigham Young University (BRY); Herbarium of the University of Copenhagen (C); National Museum of Canada, Ottawa (CAN); Department of Agriculture, Ottawa (DAO); The Gray Herbarium of Harvard University (GH); Museum of Natural History, Iceland (ICEL); Kluane National Park Herbarium (here designated KLUANE); Herbarium of the Komarov Botanical Institute, Leningrad (LE); Herbarium of Montana State University (MONT); Herbier Marie-Victorin, Montréal (MT); The New York Botanical Garden (NY); Botanical Museum, Oslo (O); The Academy of Natural Sciences, Philadelphia (PH); Herbarium of the University of Nevada (RENO); Rocky Mountain Herbarium, University of Wyoming (RM); The W.P. Fraser Herbarium, University of Saskatchewan (SASK); University of British Columbia

(UBC); Herbarium of the University of California at Berkeley (UC) and the United States National Herbarium (US). These data, in addition to published information obtained (Maguire 1943; Douglas 1982; Moss 1983), was used to plot distribution maps.

Herbarium specimens were examined initially for morphological differences and to see whether or not these differences correlated with geographic distribution or habitat. The specimens used in the phenetic analyses were chosen to reflect the apparent morphological variability exhibited by each taxon and to represent collections from throughout the range of the complex. The characters used to assess phenetic relationships within *Arnica* subgenus *Arctica* were selected from previous authors' treatments (Rydberg 1927; Maguire 1943; Ediger and Barkley 1978) and my own observation of characters in the field and greenhouse. Each quantitative character represented a mean of 3 to 10 measurements, the total dependent upon number of plants per herbarium sheet. Characters were scored at the same relative position and developmental stage on each plant.

The TAXMAP classification program developed by Carmichael and Sneath (1969) and recently modified by Carmichael (1980) is a completely non-hierarchical method of cluster analysis. TAXMAP attempts to represent the OTUs (operational taxonomic unit) as points in *n*-dimensional space, where *n* is the number of characters. The information obtained is readily amenable to a two-dimensional diagrammatic representation (taxometric map) which preserves the maximum intracluster variation and the minimum intercluster discontinuity (Carmichael 1980). In this way, the main relations among all the OTUs are in a concise and interpretable form. The clustering procedure is outlined in detail in Carmichael *et al.* (1968).

The TAXMAP classification program was chosen over other classification programs because of its ability to cluster OTUs, using the information directly from the undistorted similarity matrix table. In this way all the OTU relations are specified, unlike that of models with reduced dimensionality. It can handle ordered and non-ordered classes simultaneously and easily cope with missing data. It also allows for the weighting of characters according to their relative information content. Binary and continuous scale data are processed as the base 2 log of one more than the number of 95% confidence intervals included in the range between the largest and smallest values for that character (Carmichael 1980). Non-ordered characters are processed as the base 2 log of the number of classes.

Four separate TAXMAP analyses have been carried out: (1) *Arnica frigida-louiseana*, (2) *A. fulgens* and *A. sororia*, (3) *A. angustifolia (s.l.)* and *A. plantaginea*, and (4) OTUs representing all taxa within the subgenus. Each of these analyses is treated separately in the next section. Using the TAXMAP program, data were standardized (Carmichael *et al.* 1965) and used to calculate the pairwise similarity matrix. Isolated subsets of similar items were then clustered. Carmichael *et al.* (1968) have defined these clusters to be continuous, relatively densely populated regions of space surrounded by continuous, relatively empty regions of space. Taxometric maps were drawn with the aid of the Calcomp plotter at the University of Alberta. In addition, cluster and principal component analyses (PCA) were performed on OTUs within the *A. angustifolia* aggregate using the CLUSTAN Cluster Analysis Package (Wishart 1978). Data were standardized and used to calculate the dissimilarity matrix using squared Euclidean distance. Phenograms were prepared using average linkage clustering (UPGMA), for it gave the least amount of distortion between the matrix and the phenogram, as indicated by the highest cophenetic correlation coefficient, than other similarity-dissimilarity coefficients. Standardized data were also used in the PCA to observe variation within the data set.

C. Chromosome Numbers

Acetocarmine root tip squashes were based upon a modification of the Chambers (1955) technique. Actively growing root tips were removed from greenhouse material, prefixed in a 0.002 *M* 8-hydroxyquinoline (0.116g in 400 mL H_2O) solution for 2-2.5 hours at 13°-16°C. and then fixed in absolute ethanol: glacial acetic acid (3:1,v/v). Following fixation (24 hours) root tips were rinsed thoroughly with distilled water, blotted dry, and immersed in a small amount of snail cytase ("glusulase") for 15 minutes at room temperature. The enzyme was used in prepared form. Details for use of this enzyme are in Roy and Manton (1965) and Soltis (1980a). A longer period of time in the enzyme tended to digest the cells thoroughly and made staining more difficult. Subsequent to glusulase digestion, the root tips were placed in a small beaker of distilled water for a few minutes before being removed, blotted dry, and squashed using the conventional acetocarmine technique.

Slides were made semipermanent by ringing the cover slip with a melted mixture of gum mastic: paraffin wax (1:1,v/v). Chromosomes were examined and counted using an Olympus BHA, PM-10M photomicrographic system and photographed with an Olympus C-35 camera. A voucher slide for each examined collection was deposited at ALTA.

D. Pollen Viability

Pollen grain viability was determined by staining fresh pollen in a drop of lactophenol-cotton blue stain for 24 hours. Pollen was collected in the field or greenhouse and placed directly into vials containing the stain. Vials were stored in the refrigerator prior to examination. Pollen grains were considered viable if they took up the stain and appeared a dark blue colour (Radford *et al.* 1974). Viability was estimated on the percentage of stained grains in the 500-600 grains examined per specimen. When fresh material was not available, pollen was judiciously removed from herbarium specimens upon the approval of the curators concerned.

E. Greenhouse Studies

Plants in the greenhouse were maintained under a 16-hour photoperiod throughout the year. High-energy discharge lamps provided a minimum light intensity of 365 $uEm^{-2}s^{-1}$. Temperature was maintained at 22°C. during the day and 18°C. during the night. Relative humidity was maintained between 40 and 50%. At the end of their growing cycle, all leaf and stem tissue was removed and the pots containing the rhizomes were placed in the dark at 3°C. for 1 - 3 months. Afterwards, the pots were removed and returned directly into the greenhouse. Vegetative growth began immediately. To differentiate between genetic and environmentally induced traits, plants from all collections were grown in identical environmental conditions. Achenes were sown under a thin layer of sand in 3-inch clay pots and later transplanted to 5-inch plastic pots. Achene germination percentages for amphimictic collections were very low and pretreatment was necessary. In these cases, achenes were either scarified or placed in a freezer five to nine days prior to sowing. Representative specimens of these cultivated plants have been preserved at ALTA.

Reproductive behaviour in *A. fulgens* and *A. sororia* was assessed using the procedures of Raunkiaer (1903), Barker (1966) and Heyn and Joel (1983). Both emasculation and crossing experiments were carried out in an insect-free growth room. To determine if the ovaries would produce seed without pollination, the entire capitulum was excised with a razor blade to remove the stamens, corolla, stigma and part of the style of each floret leaving only the epigynous ovary and a style remnant. Disc florets which had already reached anthesis were removed prior to emasculation. As an alternative technique, all the disc florets were removed, leaving only the peripheral rays, prior to the opening of the capitulum. The capitulum had to be cut on one side to reach the disc florets. The plants were left to mature and were monitored for achene formation.

Crosses were made between species and within the same species but from different localities. Ray florets from emasculated plants were pollinated upon stigma emersion by transferring a clump of pollen on to the stigma with tweezers or by rubbing the pollen directly from a disc floret. Each head was pollinated only once. Control was by artificial pollination of the ray florets in emasculated heads with the pollen from flowers of the same plant. Fertility was estimated in two ways: pollen stainability in lactophenol-cotton blue and/or the percentage of viable achenes produced.

F. Flavonoid Chemistry

Determination of flavonoid constituents within *Arnica* subgenus *Arctica* was accomplished using the modified procedures of Mabry *et al.* (1970), Ribéreau-Gayon (1972), Neuman *et al.* (1979) and Markham (1982). Plants collected in the field were air or oven dried in paper bags with only leaf material being used in this study. Fresh leaf material from greenhouse-propagated plants was also analyzed and compared with dried material. There were no observable flavonoid differences between fresh and dried material.

For each population, 15 - 20 g (dry weight) of ground leaf material was extracted with approximately 500 mL of 85% aqueous methanol (MeOH). The slurry was placed on a shaker for 24 hours, filtered through a Buchner funnel, and re-extracted with another 500 mL of 85% MeOH. The same procedure was repeated twice more with 50% MeOH and the four filtrates were combined and evaporated *in vacuo* until approximately 100 mL of filtrate remained. The aqueous fraction was partitioned against a three-volume excess of chloroform to remove low polarity contaminants such as chlorophylls, xanthophylls, fats, terpenes and some flavonoid aglycones. This process was repeated until no colour remained in the solvent. Subsequent chromatographic analysis revealed that the chloroform fraction contained no flavonoids and it was discarded. The solvent-extracted aqueous layer, containing the flavonoid glycosides, was again reduced *in vacuo* to remove all traces of chloroform. This aqueous phase was partitioned further with ethyl acetate (EtOAc). Equal volumes of EtOAc (to water) were added to a separatory funnel and partitioned; this was repeated until the extracting solvent was clear. These two fractions were separated, reduced *in vacuo* to approximately 25 mL, and subsequently used in paper chromatography. Chromatography revealed that the flavonoid content of the EtOAc fraction was identical to that of the water fraction so this last partitioning step was abandoned.

The aqueous fractions were separated by standard paper chromatography techniques using the solvents BAW (butanol: acetic acid: water; 4:1:5; upper phase) and 15% acetic acid (HOAc) (Mabry *et al.* 1970). For a preliminary assessment of flavonoid diversity within the complex, one sheet of Whatman No. 3MM (46 x 57 cm) paper was utilized per population. In this method, the flavonoids present in a population show up as spots when viewed under ultraviolet light (366 nm). To heighten the sensitivity of detection one chromatogram per population was treated with NH_3 vapour and NA (Naturstoffreagenz A; diphenyl- boric acid- ethanolamine complex) spray reagent. These methods will produce colour changes of structural significance (see Markham 1982, pp. 19 - 20), in addition to aiding in locating minor constituents. All colour changes and spots were recorded on these chromatograms.

After this preliminary survey, 20 sheets of 3MM paper were run per population. Equivalent spots from each paper chromatogram were cutout, combined and eluted in 80% MeOH for 24 hours on a shaker. In addition, because the apparent absence of a compound may be due to low flavonoid concentration, equivalent areas on the chromatogram where a flavonoid was presumed to occur were also cut out and eluted. This was done by comparing the chromatogram with the absent compound(s) to ones in which most compounds were present. Afterwards, the solution was filtered and the filtrate evaporated *in vacuo* to approximately 10 mL. These now-concentrated extracts obtained from flavonoids which were weakly concentrated on a single sheet of paper, or obtained from areas on a chromatogram from which a flavonoid was presumed to exist but could not be seen, were spotted on another chromatogram and rerun. These results, and those obtained from the preliminary flavonoid analysis were used to compare taxa and prepare the presence/absence table.

Flavonoid extracts were subsequently purified by chromatography through a 5.5 X 60 cm column of Polyclar AT polyamide packed in the elution solvent. The column was first eluted in 100% MeOH and monitored using a UV lamp. The polarity of the solvent was gradually increased by adding water. Final purification was achieved on smaller columns (2.5 X 30 cm) packed with Sephadex LH-20 and eluted with 100% MeOH.

Fraction purity was assessed using thin-layer chromatography on polyamide, cellulose, and silica gel coated plates. Solvent systems for polyamide consisted of water: methyl ethyl ketone (MEK): MeOH: acetyl acetone (13:3:3:1) or chloroform: MeOH: MEK (9:4:1) for glycosides and benzene: MEK: MeOH (60:26:14) for non-polar flavonoids

(Neuman *et al.* 1979). Solvent systems for cellulose consisted of 40% HOAc for aglycones to 15% HOAc for glycosides. Solvent systems for silica gel consisted of EtOAc: MEK: formic acid: water (5:3:3:1) for glycosides and toluene: ethyl formate: formic acid (5:4:1) for the aglycones (Randerath 1963).

Once isolated, flavonoids were identified using one-dimensional descending chromatography, cochromatography with standards, and standard spectral and hydrolytic procedures (Mabry *et al.* 1970; Markham 1982). Hydrolysis was carried out by heating (at 100° C) an equal volume of 10% HCl to flavonoid dissolved in methanol for 60 minutes. The mixture was subsequently partitioned with ethyl acetate. The ethyl acetate fraction contains the aglycone, whereas, the acid-aqueous fraction contains the sugars. The solvents Forestal (HOAc: water: HCl; 30:10:3) on Whatman No. 1 paper (Ribéreau-Gayon 1972) and toluene: ethyl formate: formic acid (5:4:1) on silica gel thin-layer plates (Randerath 1963) were used for aglycone identification after acid hydrolysis. The cleaved sugars were isolated by chromatography in isopropanol: n-butanol: water (140:20:40) (Smith 1969) and identified by cochromatography with standards and their colour reaction with aniline hydrogen phthalate solution after spraying and developing (Ribéreau-Gayon 1972).

G. Ranking of Taxa

The most pragmatic approach to species recognition is in using the morphological - geographical species concept (Davis and Heywood 1963). To fulfill this concept, a complete undertaking of biosystematics is inevitable, bringing together evidence from morphological, geographical, cytological, phytochemical and reproductive studies. Davis and Heywood, however, insist that the species recognized must also be delimitable by morphological characters. The arbitrariness of specific delimitation is lessened when species can be separated by a number of discontinuous, independent character differences.

Recognition of taxa at infraspecific ranks is also based on a synthesis of all accumulated evidence. Davis and Heywood (1963) defined subspecies as regional representatives of a species. A subspecies may differ in chromosome number, or be isolated geographically or ecologically. The entities lack, however, a sufficient degree of morphological differentiation to be treated as separate species. Davis and Heywood (1963) have further chosen the varietal rank to represent "local facies of a species (apparently comprising a few biotypes)". A variety differs morphologically, and may also be found to differ cytologically, ecologically or geographically, but is restricted to small, localized areas. These entities lack a sufficient degree of morphological differentiation to be treated as species, or not distributed widely enough to be treated as subspecies. I accept Davis and Heywood's usage of these taxonomic ranks, and upon examination of evidence accumulated during this study, the assignment of individuals to these ranks will be based on their meeting the above criteria.

H. Phylogenetic Techniques

Criteria used to determine polarity in a series of homologous characters influence the resulting reconstructed phylogeny. Many treatments of phylogenies are based solely on concepts of previously accepted dicta, character correlation, or on describing a trait as plesiomorphous because it is commonly found within the taxon. Outgroup comparison is presently the most reliable (Wiley 1981; Donoghue and Catino 1984) and logically defensible (Stevens 1980; Watrous and Wheeler 1981) criterion for assessing character polarity. Synapomorphies provide evidence of common ancestry, and hence of monophyly. A cladogram, created solely on the insertion of structural, ecological, and flavonoid synapomorphies will be used to discuss phylogenetic relationships.

III. Results

In the present investigation, seven species (which include six infraspecific taxa) are recognized in subgenus *Arctica*. No new taxa are proposed; however, names of seven taxa previously recognized by Maguire (1943) are placed in synonymy. One new combination, *A. frigida* subsp. *griscomii*, is presented. *Arnica fulgens, A. sororia* and *A. rydbergii* are maintained at the specific level. In the following discussion, evidence will be presented to justify the recognition of subspecies *louiseana* and *frigida* of *A. louiseana* at the specific level, and *A. louiseana* subsp. *griscomii* as a subspecies of *A. frigida*. The subspecies name *chionopappa* is synonymized with *A. lonchophylla*; *Arnica lonchophylla* subsp. *arnoglossa* is maintained. Names of six of the seven previously recognized subspecies of *A. angustifolia*, and *A. plantaginea* are synonyms with *A. angustifolia* subsp. *angustifolia*. *Arnica angustifolia* subsp. *tomentosa* is maintained as a distinct taxon. Consequently, to avoid confusion, the taxa are referred to by their new treatments (Table 3).

A. Morphology

An initial examination of herbarium specimens was carried out to gain an overall view of the structural variability within subgenus *Arctica*. The wide range exhibited in plant height, leaf size, pubescence, and floral characters is evident in *A. angustifolia (s.l.)*, *A. frigida* subsp. *frigida* and *A. lonchophylla (s.l.)*. In contrast, specimens identified as *A. louiseana, A. frigida* subsp. *griscomii*, *A. fulgens, A. sororia* and *A. rydbergii* showed marked uniformity in their morphological attributes. The close similarity of *A. fulgens* to *A. sororia* resulted in considerable confusion with respect to plant identification. Many specimens of *A. sororia* had previously been misidentified as *A. fulgens*. Characters useful in distinguishing the taxa are: the presence or absence of short-stipitate glands on the leaves, achenes and involucral bracts; capitulum type; petiole length (if present); leaf margin, and achene pubescence.

Table 3. Proposed treatment of *Arnica* subgenus *Arctica*.

Arnica louiseana Farr

Arnica frigida Meyer ex Iljin ssp. *frigida*

Arnica frigida ssp. *griscomii* (Fern.) S.R. Downie

Arnica rydbergii Greene

Arnica fulgens Pursh

Arnica sororia Greene

Arnica angustifolia Vahl ssp. *angustifolia*

Arnica angustifolia ssp. *tomentosa* (Macoun) G.W. Dougl. and G. Ruyle-Dougl.

Arnica lonchophylla Greene ssp. *lonchophylla*

Arnica lonchophylla ssp. *arnoglossa* (Greene) Maguire

To gain familiarity with specific and subspecific delimitations within the subgenus, a number of type specimens, and specimens annotated or determined by Maguire, were examined. Although some species of subgenus *Arctica* are markedly polymorphic, a combination of several morphological characters in conjunction with ecological, phytochemical and distributional data are sufficient to distinguish among them with confidence. Comparative morphological characters for the seven species of subgenus *Arctica* are presented in Tables 4 and 5. Difficulties arose while trying to distinguish between the subspecies of *A. angustifolia* (*sensu* Maguire). Characters previously used to separate these taxa include the presence of long-stipitate glandular hairs within the periclinium;[3] plant height; number of pairs of cauline leaves; number of capitula; leaf and

[3] The periclinium in the Asteraceae, as defined by Maguire (1943), is the area

Table 4. Comparative morphological characters in *Arnica frigida*, *A. louiseana*, *A fulgens* and *A. sororia*,

	A. frigida subsp. *frigida*	*A. frigida* subsp. *griscomii*	*A. louiseana*	*A. fulgens*	*A. sororia*
Plant height (dm)	0.6-4.0	0.5-2.5	0.4-2.0	1.1-7.2	1.5-4.9
Stem branching	-	-	-	-	-(+)
Leaf apex	acute(obtuse)	acute / obtuse	obtuse / acute	obtuse	obtuse
Leaf margin	undlte. / dentate	undlte. / dentate	ent. / dnticul.	entire	entire
Number leaf pairs	2-4	1-2	0-3	3-5	3-6
Leaf shape	lan. / spath.	spath. / ovate	ell. / ovt.-lan.	oblg. / obl.	oblg. / obl.
Leaf pubescence	- / +	- / +	- / +	++	++
Leaf petiole	broad, short	broad, short	broad, short	broad, short	broad, short
Leaf length (cm)	1.2-10.0	1.5-8.0	1.3-7.5	4.5-20.0	3.5-14.5
Leaf width (cm)	0.5-3.5	0.6-2.5	0.4-2.0	0.6-2.4	0.6-2.4
Leaf L / W ratio	1.5-7.0	2.8-5.0	2.9-4.5	4.1-17.0	1.7-15.0
Capitulum number	1(3)	1	1	1(3)	1-5
Capitulum shape	hmsp.-cmpn.	hmsp.-cmpn.	hmsp.-cmpn.	brd. hmsp.	brd. hmsp.
Capitulum position	nodd. / erect	nodding	nodding	erect	erect

	A. frigida subsp. *frigida*	*A. frigida* subsp. *griscomii*	*A. louiseana*	*A. fulgens*	*A. sororia*
Capitulum width (mm)	18.0-20.0	11.0-20.0	8.0-17.0	14.0-30.0	11.0-27.0
Capitulum height (mm)	11.0-30.0	12.0-23.0	9.0-20.0	11.0-17.0	9.0-17.0
Ligule number	7-17	6-11	7-10	8-16	9-17
Ligule length (mm)	10.0-39.0	15.0-22.0	12.0-20.0	16.0-32.0	15.0-31.0
Ligule width (mm)	2.3-8.0	3.0-6.0	2.5-4.6	2.9-8.0	2.5-7.5
Ligule L/W ratio	3.3-8.1	3.5-5.2	3.8-5.7	3.4-5.9	4.0-6.4
Tooth length (mm)	1.0-5.0	0.4-1.8	0.2-1.5	0.3-2.1	0.2-1.8
Disc cor. ln. (mm)	6.2-10.3	7.5-8.6	7.3-8.4	6.0-9.1	6.9-10.0
Disc tube ln. (mm)	2.0-3.6	2.4-3.2	2.5-3.0	2.5-5.0	3.0-5.5
Disc pubescence	+++	+++	++	++	+
Disc glandularity	-	-	-	+++	+++
Periclinium pubes.	+/+++	++	+/++	++	++
Periclinium gland.	-(+)	+	+++	+++	+++

	A. frigida subsp. *frigida*	*A. frigida* subsp. *griscomii*	*A. louiseana*	*A. fulgens*	*A. sororia*
Bract pubescence	++(at base)	++(at base)	-/+(at base)	++	++
Bract shape	nrw. to brd. lan.	brd. lan./obl.	nrw. lan.	brd. lan. to ell.	brd. lan.
Bract glandularity	-(+)	+	+++	+++	+++
Bract length (mm)	7.0-14.5	9.0-13.5	8.0-12.0	10.0-15.5	9.5-14.2
Bract width (mm)	1.8-4.9	2.5-4.6	1.5-3.0	1.5-4.5	1.2-3.1
Bract L/W ratio	1.7-4.3	2.7-3.9	3.3-6.3	3.1-5.8	3.6-8.7
Achene length (mm)	3.2-6.0	2.5-4.5	3.2-5.0	3.5-7.0	3.0-5.5
Achene pubescence	+(summit only)	+(summit only)	+(summit only)	++	++
Achene glandularity	-	-	++	-	-
Chromosome # (2n)	38,57,76,95	76	76,95	38 (57)	38

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* Range values
** Character state variable
*** Parentheses indicate rare occurrence

Abbreviations: brd, broad; cmpn, campanulate; dnticul, denticulate; ell, elliptic; ent, entire; hmsp, hemispheric; lan, lanceolate; nodd, nodding; nrw, narrow; obl, oblanceolate; oblg, oblong; ovt, ovate; spath, spathulate; undlte, undulate.

Table 5. Comparative morphological characters in *Arnica angustifolia*, *A. lonchophylla* and *A. rydbergii*.

	A. angustifolia subsp. *angustifol.*	*A. angustifolia* subsp. *tomentosa*	*A. lonchophylla* subsp. *lonchophyl.*	*A. lonchophylla* subsp. *arnoglossa*	*A. rydbergii*
Plant height (dm)	0.5-5.4	0.6-3.0	1.2-5.0	1.7-4.5	0.8-3.5
Stem branching	-(+)	-	-(+)	-	-(+)
Leaf apex	acute / acuminate	acute	acute	acute	acute / obtuse
Leaf margin	ent. / dentate	entire	dnticul. / dentate	dnticul. / dentate	ent. / dnticul.
Number leaf pairs	2-5	3-5	3-7	3-5	2-4
Leaf shape	lin. / lan. / obl.	lanceolate	lan. / ovate	brd.-lan. / ovate	obl. / spath.
Leaf pubescence	- / ++	+++	++	- / +	- / +
Leaf petiole	broad, short	broad, short	narrow, long	narrow, long	sessile, short
Leaf length (cm)	2.3-14.0	3.5-10.5	3.5-14.0	4.5-11.0	2.0-7.0
Leaf width (cm)	0.3-2.6	0.3-1.2	0.5-3.7	1.2-3.0	0.5-2.5
Leaf L/W ratio	3.6-19.3	4.2-12.0	3.0-11.4	3.2-4.6	2.8-6.6
Capitulum number	1-3(5)	1(3)	1-7(8)	3-7(8)	1-3(5)
Capitulum shape	hmsp.	hmsp.	cmpn.-trbn.	cmpn.-trbn.	cmpn.-trbn.
Capitulum position	erect	erect	erect	erect	erect

	A. angustifolia subsp. *angustifol.*	*A. angustifolia* subsp. *tomentosa*	*A. lonchophylla* subsp. *lonchophyl.*	*A. lonchophylla* subsp. *arnoglossa*	*A. rydbergii*
Capitulum width (mm)	10.0-30.0	15.0-25.0	7.0-20.0	7.0-13.0	9.0-15.0
Capitulum height (mm)	9.0-21.0	11.0-18.0	8.0-15.0	9.0-13.0	7.0-22.0
Ligule number	6-16	7-12	6-14	7-10	6-10
Ligule length (mm)	10.1-40.0	14.5-30.0	13.0-26.0	10.0-17.5	13.5-29.0
Ligule width (mm)	3.0-9.1	4.5-9.5	3.0-7.1	3.0-5.0	4.0-8.5
Ligule L/W ratio	1.2-5.5	2.6-4.4	2.3-5.4	3.0-4.8	3.2-6.9
Tooth length (mm)	0.2-7.0	0.5-3.5	0.1-2.1	0.2-1.1	0.1-0.5
Disc cor. ln. (mm)	5.0-9.5	6.1-10.0	5.1-9.5	5.0-8.5	6.1-9.1
Disc tube ln. (mm)	1.9-4.1	2.5-3.7	1.9-4.0	2.0-3.2	2.3-3.7
Disc pubescence	++/+++	+++	+++	++	+++
Disc glandularity	-	-	-(+)	+++	+++
Periclinium pubes.	++/+++	+++	++	-/+	++
Periclinium gland.	-/+/++	+++	+++	+++	+++

	A. angustifolia subsp. *angustifol.*	*A. angustifolia* subsp. *tomentosa*	*A. lonchophylla* subsp. *lonchophyl.*	*A. lonchophylla* subsp. *arnoglossa*	*A. rydbergii*
Bract pubescence	-/+++	+++	++	-/+	-/+
Bract shape	lan./obl.	nrw./brd. lan.	nrw. lan. to lan.	nrw. lan. to lan.	nrw. lan.
Bract glandularity	-/++	+++	+++	+++	+++
Bract length (mm)	6.5-17.6	9.0-14.5	7.0-11.5	6.1-10.0	7.3-14.5
Bract width (mm)	1.6-4.0	2.2-4.1	1.3-3.5	1.2-2.4	1.3-3.1
Bract L/W ratio	2.8-6.9	3.2-4.5	2.3-6.4	3.9-5.5	3.1-4.9
Achene length (mm)	3.2-7.0	4.5-7.6	3.0-5.9	3.0-5.0	3.8-7.1
Achene pubescence	++	++	++	++	++
Achene glandularity	-(+)	-	+	++	-
Chromosome # (2n)	38,57,76,95	38,57,76	57,76	38	38,76

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* Range values
** Character state variable
*** Parentheses indicate rare occurrence

Abbreviations: brd, broad; cmpn, campanulate; dnticul, denticulate; ent, entire; hmsp, hemispheric; lan, lanceolate; lin, linear; nrw, narrow; obl, oblanceolate; spath, spathulate; trbn, turbinate.

periclinium pubescence; and the lengths of the achenes, disc corollas, and teeth of the ligulate florets. However, I have observed that these characters are confluent and variable, suggesting that the subspecies may not be very well separated. In addition, a great deal of variability was evident within each taxon.

Arnica plantaginea Pursh, a taxon closely related to *A. angustifolia*, has been distinguished from the latter solely on possession of oblanceolate involucral bracts (Maguire 1943). During this study, I have found that the morphological differences between these taxa are minimal, and these oblanceolate bracts characteristic of *A. plantaginea* can be found in *A. angustifolia*. For this reason, specimens annotated as *A. plantaginea* have been included within the *A. angustifolia* aggregate.

Since taxonomic boundaries among the previously recognized infraspecific taxa of *A. angustifolia* were difficult to ascertain due to the polymorphism exhibited by these plants, the specimens used in the phenetic analyses were selected from six broadly delimited geographic areas throughout the aggregate's range. These specimens were also selected to reflect the apparent morphological variability encountered within each area. Delimitation of these areas were as follows: (1) eastern Canada, (2) central Canada and Montana, (3) arctic Canada and Alaska, (4) northern Scandinavia and Spitsbergen, (5) U.S.S.R., and (6) Greenland. The occurrence of regional morphological differentiation in *A. angustifolia* and *A. plantaginea* was investigated by determining the means, standard deviations, and ranges for fourteen quantitative characters (Table 6). Using Gabriel's modification of the GT2-method for multiple comparisons among pairs of means for unequal sample sizes (Sokal and Rohlf 1981), no significant differences ($P=0.05$) were found between the means of these fourteen characters. These characters have been previously used to delimit infraspecific taxa within *A. angustifolia* (Maguire 1943).

[1](cont'd) between the transition of peduncle into capitulum and the base of the involucral bracts, and is usually characterized by excessive pubescence.

Table 6. Data summary for 14 morphological characters in six geographically delimited samples of *Arnica angustifolia*. Geographic areas are defined in text. $\overline{x}$=mean, s.d.=standard deviation.

	Area 1 (n=28)			Area 2 (n=34)			Area 3 (n=16)		
Character	$\overline{x}$	s.d.	range	$\overline{x}$	s.d.	range	$\overline{x}$	s.d.	range
Plant height (cm)	21.8	6.59	10.5-41.0	28.7	10.47	5.0-54.0	18.2	7.46	7.0-39.0
Basal leaf blade length (cm)	7.4	1.94	4.0-14.0	8.6	2.42	4.0-14.5	5.9	1.99	2.0-13.0
Basal leaf blade width (cm)	0.9	0.43	0.3-2.2	1.1	0.38	0.5-2.0	0.9	0.32	0.3-1.9
Capitulum width (mm)	20.5	3.29	13.0-27.0	19.7	3.43	13.0-25.0	18.9	2.93	15.0-30.0
Capitulum height (mm)	15.1	2.33	10.0-21.0	14.7	2.83	10.0-20.0	13.7	2.08	10.0-20.0
Achene length (mm)	4.9	0.59	3.9-7.0	4.9	0.50	4.0-5.8	4.7	0.80	3.5-7.6
Involucral bract length (mm)	12.2	1.78	7.5-17.6	10.7	1.73	7.0-15.0	11.3	1.20	8.5-14.5
Involucral bract width (mm)	2.5	0.38	2.0-3.6	2.5	0.51	1.5-3.5	2.6	0.53	1.8-4.1
Ligulate floret tooth length (mm)	1.4	0.73	0.3-5.0	1.4	0.66	0.5-3.0	1.8	1.10	0.4-5.6
Ligulate floret length (mm)	26.0	4.28	10.1-40.0	22.8	4.64	11.5-29.0	22.1	4.12	13.0-30.0
Ligulate floret width (mm)	5.9	0.95	4.0-8.5	5.7	1.21	3.8-9.1	6.0	1.29	4.0-9.5
Ligule number (per capitulum)	10.7	1.59	7.0-13.0	10.2	1.89	6.0-14.0	9.6	1.80	6.0-16.0
Disc corolla length (mm)	8.0	0.71	5.5-9.1	7.9	0.85	6.5-9.5	7.3	0.69	6.0-10.0
Disc corolla tube length (mm)	3.4	0.35	2.4-4.1	3.0	0.26	2.5-3.5	2.8	0.38	2.0-4.0

Table 6 cont'd. Data summary for 14 morphological characters in six geographically delimited samples of *Arnica angustifolia*. Geographic areas are defined in text. $\overline{x}$=mean, s.d.=standard deviation.

	Area 4 (n=20)			Area 5 (n=12)			Area 6 (n=22)		
Character	$\overline{x}$	s.d.	range	$\overline{x}$	s.d.	range	$\overline{x}$	s.d.	range
Plant height (cm)	16.4	6.52	7.0-30.0	23.2	9.83	10.0-51.0	16.0	5.84	5.0-30.0
Basal leaf blade length (cm)	5.3	1.45	2.0-10.5	6.8	2.72	3.0-14.0	5.4	1.65	2.3-12.0
Basal leaf blade width (cm)	0.9	0.33	0.4-2.1	1.0	0.50	0.3-2.6	0.8	0.20	0.4-1.2
Capitulum width (mm)	18.0	2.49	13.0-23.0	18.5	2.29	15.0-23.0	16.7	2.59	12.0-23.0
Capitulum height (mm)	12.6	1.86	10.0-17.0	13.0	1.80	10.0-17.0	13.1	2.35	9.0-19.0
Achene length (mm)	4.3	0.41	3.5-5.2	4.5	0.51	3.8-5.6	4.2	0.56	3.1-6.0
Involucral bract length (mm)	10.1	0.95	7.3-11.6	9.9	1.48	6.5-12.2	10.1	1.24	7.9-14.0
Involucral bract width (mm)	2.5	0.40	2.0-3.9	2.6	0.55	1.7-4.0	2.5	0.40	1.6-3.5
Ligulate floret tooth length (mm)	2.7	1.40	0.6-7.0	1.8	0.80	0.5-4.0	1.1	0.42	0.2-3.0
Ligulate floret length (mm)	18.8	3.60	10.0-25.0	20.6	4.03	13.0-27.0	18.8	4.32	12.7-32.0
Ligulate floret width (mm)	4.8	0.71	3.5-6.5	5.8	1.09	4.0-8.0	5.3	1.17	3.0-8.5
Ligule number per capitulum	10.9	1.83	7.0-15.0	10.1	1.98	7.0-14.0	9.9	1.56	7.0-14.0
Disc corolla length (mm)	6.8	0.72	5.0-8.0	7.1	0.66	6.0-8.5	6.9	0.80	5.2-9.0
Disc corolla tube length (mm)	2.8	0.42	1.9-3.5	2.7	0.29	2.3-3.2	2.8	0.40	2.0-3.5

B. Numerical Analyses

To aid in cluster interpretation, each OTU (operational taxonomic unit) was assigned a code indicating where the specimen was collected (e.g. A=Alberta, MO=Montana, NY=Norway) and the number of the collector, or if absent, the herbarium accession number. The OTUs in each of the following numerical analyses are listed in Appendix 1. The characters chosen for each numerical analysis were dependent upon the taxon being investigated; thus, certain characters were declared superfluous if the taxon possessing them were not included in the analysis. The characters chosen, and the numerical analyses in which they were used, are presented in Appendix 2. The data matrices for the four numerical analyses are in Appendix 3.

Analysis 1. *Arnica frigida - louiseana*

Specimens representing 122 members of the *A. frigida - louiseana* complex were scored for 31 attributes and analyzed with the TAXMAP classification program. TAXMAP recognizes six clusters and six isolated OTUs, or single member clusters. The resulting taxometric map appears in Figure 3. Evident from the taxometric map is the separation of *A. louiseana* and *A. frigida* subsp. *griscomii* into discrete clusters and the close similarity of the latter with *A. frigida* subsp. *frigida*. Within the *A. frigida* subsp. *frigida* group are ten clusters. Many of these clusters simply represent extremities in morphological attributes, or several unique characters which are not normally found within this group. The clusters are described as follows. Cluster 1 is the largest group and contains 63 OTUs of *A. frigida* subsp. *frigida*. Clusters 2 and 3 consist of all 11 OTUs of *A. frigida* subsp. *griscomii* and all 11 OTUs of *A. louiseana* respectively. Cluster 4 is most similar to cluster 1 and contains 7 specimens which have a dense periclinium, achene, and involucral bract pubescence. Most members of this cluster have been previously described as *A. louiseana* var. *pilosa* (Maguire 1942). Cluster 5 includes 15 OTUs all represented by a high pollen viability (2n=38). This cluster is most similar to cluster 4, which although characterized by dense periclinium pubescence, is also represented by high pollen viability. Cluster 6 includes 2 OTUs. With the exception of its prominent leaf glandularity and its high pollen stainability, it is

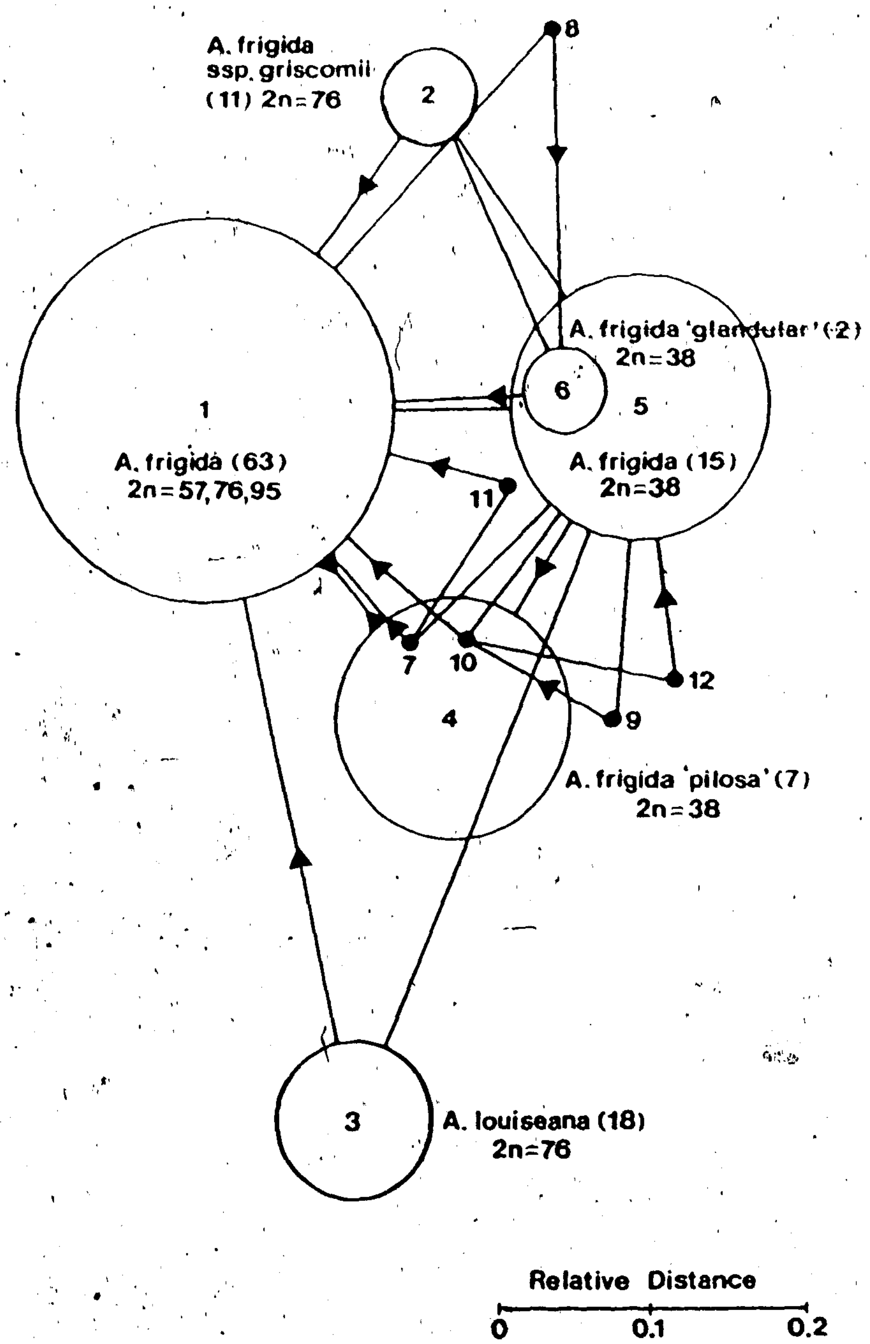

Figure 3 - Taxometric map showing the similarities between members of the *Arnica frigida - louiseana* complex based on morphological, cytological, and distributional data. The numbers in parentheses represent the number of OTUs within the cluster. The diameters of the circles represent the maximum distance between any pair of OTUs included in the cluster. The lines connecting the margins of the circles represent the undistorted phenetic distance between the nearest neighbours in the two clusters. The arrows indicate the nearest neighbour to each cluster. Two arrows facing each other indicate the clusters are equidistant from each other.

identical with *A. frigida* subsp. *frigida* in cluster 1.

Isolated clusters 7, 10 and 11 are most similar to *A. frigida* subsp. *frigida*. Cluster 7 is characterized by a specimen with very wide leaves. Cluster 10 is a plant with evident achene glandularity and cluster 11 is a plant with a very large capitulum and long ligulate florets. Since TAXMAP clusters OTUs on the basis of relative discontinuities in the proximities between OTUs, these three plants are isolated. Cluster 8 represents the type specimen of *A. illiamnae* Rydb., characterized by a branching habit, three heads and prominent glands on the achenes and leaves. Maguire (1943) reports three specimens (*Mackis 4, Hagelbarger 258* and *Palmer 55*) which have a branching habit and entirely oblanceolate leaves. On the annotation labels of these specimens, he suggests that these forms may represent a new species. I found the oblanceolate leaf shape quite common in *A. frigida* subsp. *frigida*. Plants showing a tendency to branch were quite rare, were sporadic in distribution, and represent no more than abnormal growth forms. These anomalous specimens were not included in the TAXMAP analysis. Cluster 9 contains a plant which is most similar to the isolated OTU in Cluster 10, due to its achene and involucral bract glandularity. Cluster 12 comprises an OTU which is characterized by its evident leaf glandularity and high pollen viability. Cluster 12 is most similar to cluster 5.

On the basis of morphological evidence, *A. louiseana (sensu* Maguire) appears to consist of three distinct entities. Although additional evidence is forthcoming, this complex is best treated as *A. louiseana, A. frigida* subsp. *frigida* and *A. frigida* subsp. *griscomii*.

Analysis 2. *Arnica fulgens* and *A. sororia*

Eighty-six representative specimens of *A. fulgens* and *A. sororia* were scored or measured for 26 floral and 17 vegetative attributes. In addition, three specimens each of *A. lonchophylla* subsp. *lonchophylla* and *A. angustifolia* subsp. *angustifolia* have been included in the phenetic analysis to elucidate the morphological similarities amongst the taxa. Locality information for these six OTUs have also been included in Appendix 1.

TAXMAP recognizes three clusters and eight isolated OTUs, or single member clusters (Figure 4). Evident from the taxometric map is the separation of *A. fulgens* and *A. sororia* into discrete clusters and the close similarity of these two taxa with *A. angustifolia* subsp. *angustifolia*. The clusters can be described as follows: Cluster 1 contains 27 OTUs of *A. fulgens*. Cluster 2 contains all 34 OTUs of *A. sororia*. Cluster 3 is most similar to cluster 1 and contains two anomalous specimens of *A. fulgens* which are characterized by a very tall habit and a long leaves. Isolated clusters 4 and 5 are most similar to *A. fulgens*. Cluster 4 represents a plant with a low number of large ligulate florets and large involucral bracts. The OTU in cluster 5 is a tall plant bearing wide leaves and a rather large capitulum. Isolated clusters 6,7 and 8, and 9,10 and 11 represent the six OTUs of *A. lonchophylla* subsp. *lonchophylla* and *A. angustifolia* subsp. *angustifolia* respectively. Morphologically, *A. fulgens* and *A. sororia* are two clearly defined taxa.

Analysis 3. *Arnica angustifolia*

To assess phenetic similarities, 17 floral and 10 vegetative characters (comprising 16 strictly continuous characters and 11 ordered multi-state characters) were chosen. Ninety-nine specimens included in the circumscription of the *A. angustifolia* aggregate, were used in the phenetic analyses.

Sixteen clusters and 15 isolated OTUs, or single member clusters, were recognized in the TAXMAP analysis of the *A. angustifolia* aggregate. The large number of clusters and superimposed lines on the resultant taxometric map made similarities amongst the taxa very difficult to interpret, thus is not presented. This is, however, indicative of the highly polymorphic nature of these plants. The common occurrence of two or more subspecies (*sensu* Maguire), or collections from widely separated geographic areas, in a cluster denote that these taxa are morphologically very similar. Subspecies *alpina*, *angustifolia* and *iljinii* were combined quite frequently, corroborating observations by Raup (1947), Jorgensen *et al.* (1958) and Ediger and Barkley (1978) that these subspecies are not very well separated. Other associations included: subspecies *angustifolia* and *sornborgeri*, subspecies *sornborgeri* and *A.*

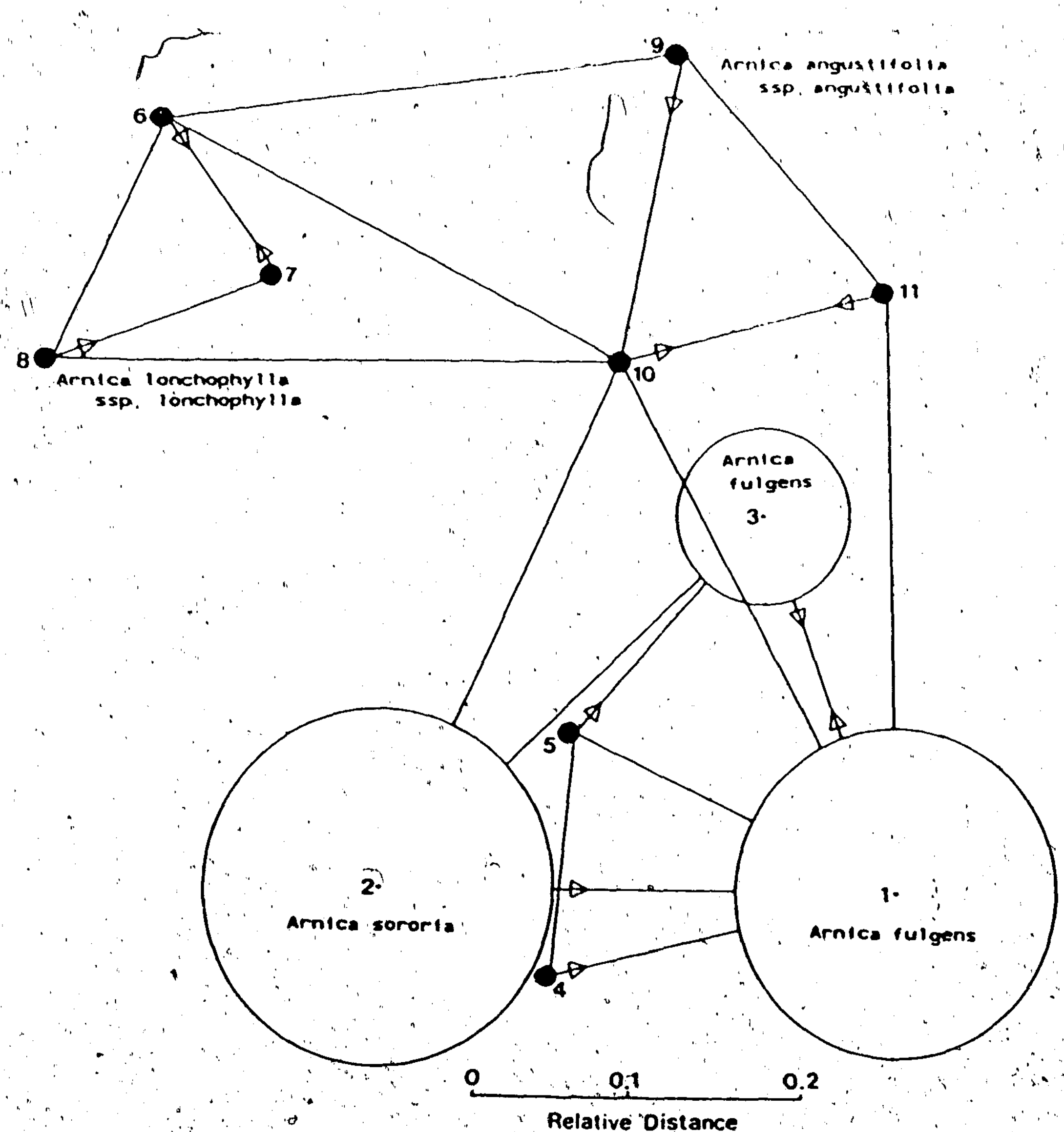

Figure 4 - Taxometric map showing the similarities between *Arnica fulgens* (42 OTUs), *A. sororia* (44 OTUs), *A. angustifolia* (3 OTUs), and *A. lonchophylla* (3 OTUs), based on morphological data. See Figure 3 for TAXMAP interpretation.

plantaginea, subspecies *angustifolia* and *attenuata*, subspecies *attenuata*, *iljinii* and *sornborgeri* and subspecies *angustifolia*, *attenuata* and *iljinii*. The only taxon which did not combine with any other was *A. angustifolia* subsp. *tomentosa*. One cluster containing the majority of *A. angustifolia* subsp. *tomentosa* OTUs was most closely linked to a cluster containing two anomalous specimens of subsp. *tomentosa* from Newfoundland.

To better explore the taxonomic structure of the aggregate, principal component and UPGMA cluster analyses were performed using the CLUSTAN Cluster Analysis Package.

CLUSTER ANALYSIS

A phenogram for the 99 OTUs of the *A. angustifolia* aggregate was constructed using UPGMA (Figure 5). The cophenetic correlation coefficient between the original dissimilarity matrix and the phenogram was 0.78. Seven major clusters of OTUs were established by arbitrarily drawing a phenon line at the 1.90 level. Cluster 1 is a rather large homogeneous group comprised of 58 OTUs of *A. angustifolia* from throughout its range. These OTUs represent collections obtained from Scandinavia, U.S.S.R., Spitsbergen, and across North America from Alaska to Greenland and south to Ontario, and have been previously recognized as subspecies *angustifolia*, *alpina*, *attenuata*, *iljinii*, *intermedia*, and *sornborgeri*. Cluster 2 includes 13 OTUs possessing densely villous leaves, stems and involucral bracts. These plants have been referred to as *A. angustifolia* subsp. *tomentosa*. Cluster 3 represents an isolated OTU from the U.S.S.R. characterized by abundant involucral bract glandularity, and numerous narrow ligulate florets. With the exception of bearing these two anomalous traits, this plant is similar to those in cluster 1. Cluster 4 includes 5 OTUs from eastern Canada. With the exception of possessing only one capitulum, no discernible differences are apparent between these plants and those in cluster 5. All 18 OTUs in cluster 5 possess three to five capitula per stem, and are slightly larger in habit than those OTUs in cluster 1. Although most OTUs in this cluster represent plants from the southern and eastern North American ranges of *A. angustifolia*, some are representative of the U.S.S.R. and

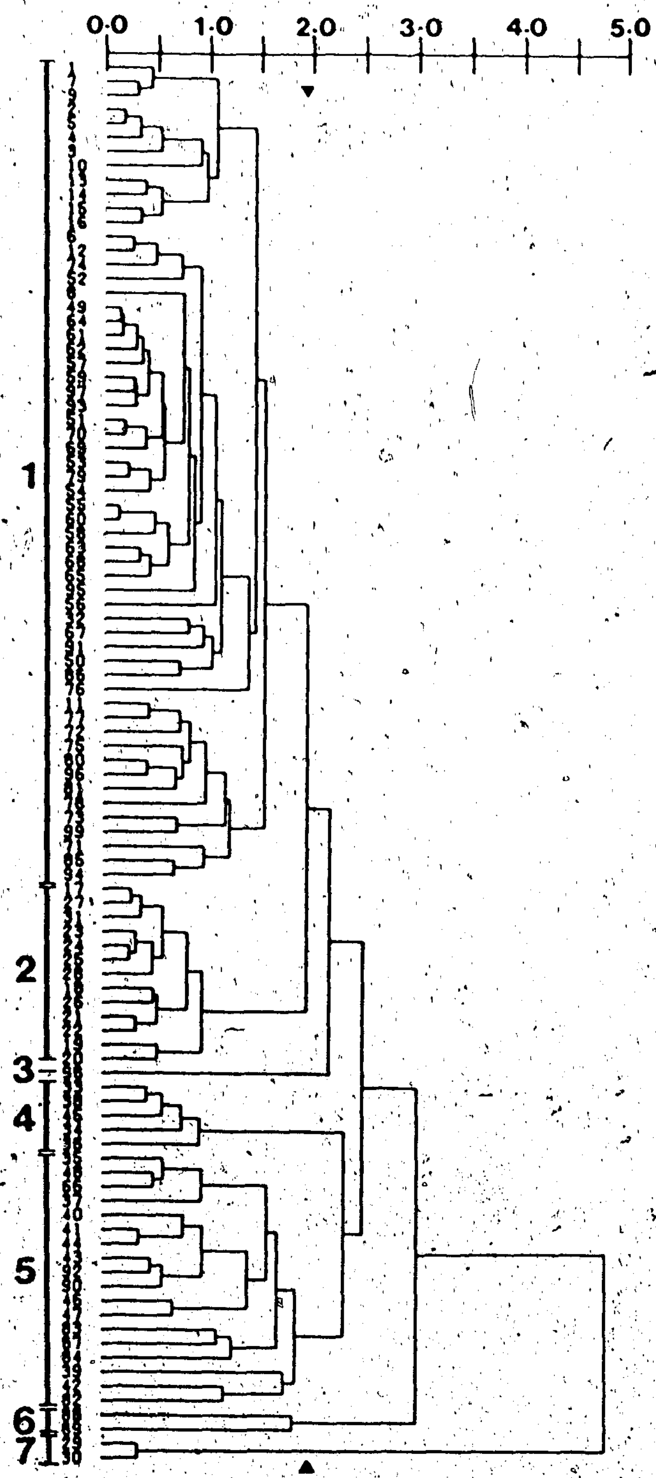

Figure 5 - Phenogram of 99 OTUs of the *Arnica angustifolia* aggregate produced by UPGMA clustering. Base nodes are labelled with OTU identity. The seven clusters defined at the 1.90 phenon level are described in text.

Greenland. These OTUs have been previously recognized as *A. plantaginea*, and subspecies *angustifolia, alpina, attenuata, iljinii* and *sornborgeri* of *A. angustifolia*. The number of capitula and height of the plant have traditionally been used to distinguish between some of the subspecies of *A. angustifolia*. However, I have observed that when plants collected from throughout the range of the aggregate are grown alongside one another, all are morphologically indistinguishable and possess three or more capitula.

The hierarchical ordering prevalent during phenogram production cannot specify all inter-OTU similarities. In addition, some linear ordering is necessary when the phenogram is produced on the printed page. Adjacent OTUs may be quite dissimilar, or OTUs in widely separated parts of the phenogram may be more similar to one another than to their neighbours. Cluster 6 comprises two OTUs from Alberta and Yukon which are characterized by smaller achenes and narrower involucral bracts than those plants in cluster 1. They represent no more than an end-point in a continuum of morphological variation. Cluster 7 contains two anomalous specimens of *A. angustifolia* subsp. *tomentosa* collected in Newfoundland. These two specimens are characterized by large capitula, broadly lanceolate bracts which are not densely villous, and wide ligulate florets, and should be most closely similar to those OTUs in cluster 2.

PRINCIPAL COMPONENT ANALYSIS

Of the 26 components which accounted for the total variance of the data, the first three principal component axes accounted for 49.8 % (26.0 %, 14.8 %, and 9.0 %, respectively). The remaining 23 component axes each accounted for 8.1 % or less of the remaining variance. The best group separation was achieved by plotting the component scores for the first two axes (Figure 6). The 13 OTUs comprising *A. angustifolia* subsp. *tomentosa* formed an isolated group, with OTUs 29 and 30 marginal to the main group. These two deviant OTUs also failed to cluster with subspecies *tomentosa* in the phenogram. All remaining OTUs could not be separated by the PCA, but rather formed a large, loose group. The outlying OTUs 88 and 89 also clustered separately in the phenogram. Six characters contributed greatly to the total variance in principal component axis 1. In decreasing order of importance, these characters were

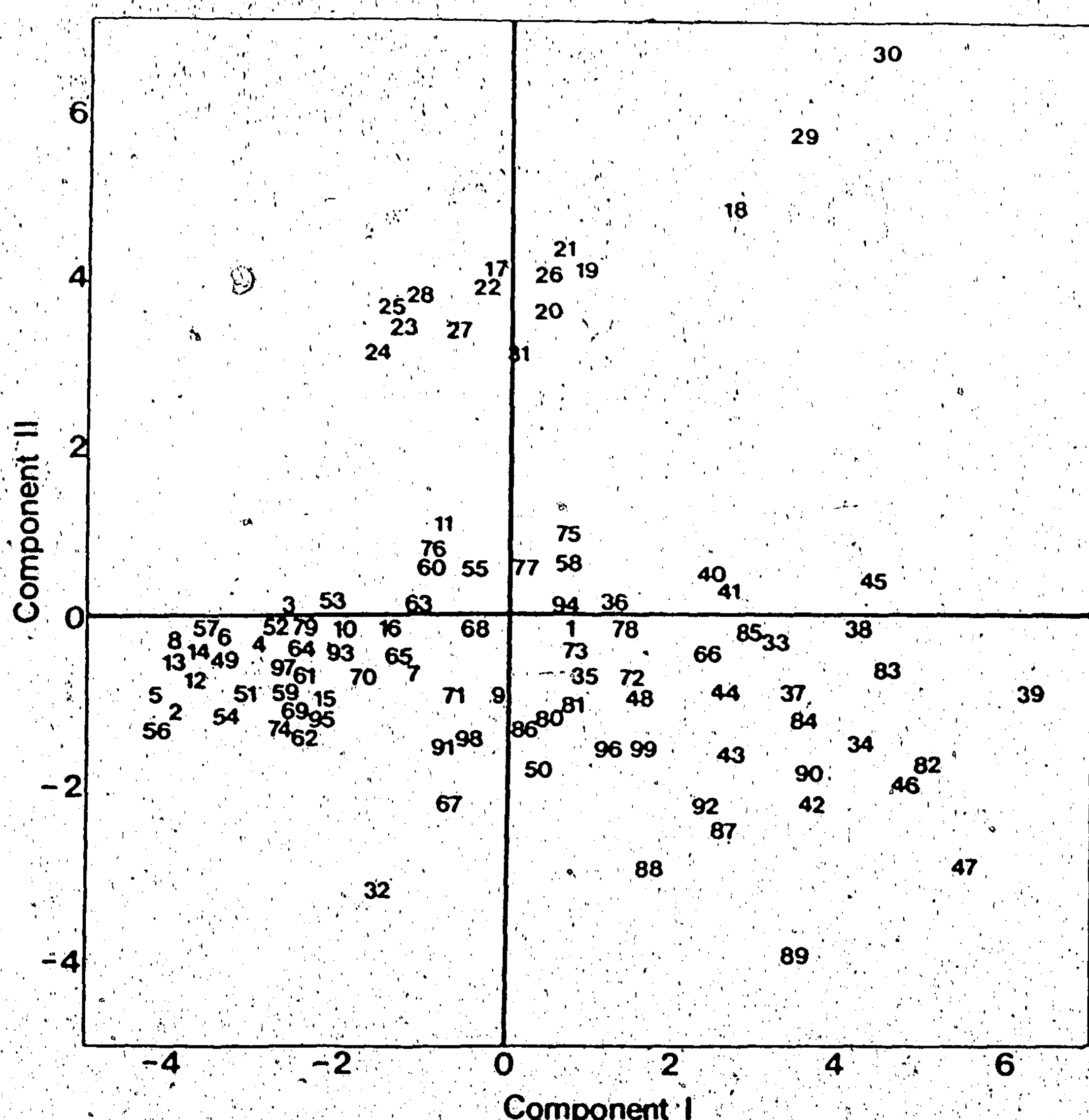

Figure 6 - Principal components ordination of 99 OTUs of the *Arnica angustifolia* aggregate. Numbers refer to OTU identity.

disc corolla length, capitulum height, basal leaf length, disc corolla tube length, involucral bract length, and ligule length. OTUs with high positive loadings (e.g. OTUs 30, 39, 47) had large capitula, disc corollas, ligulate florets, involucral bracts, and basal leaves. Conversely, OTUs with high negative loadings (e.g. OTUs 5, 13, 56) possessed low values with respect to these characters.

Characters having a pronounced effect on the ordination of OTUs in principal component axis 2 included, in descending order of importance; stem, leaf, involucral bract, and periclinium pubescence, and involucral bract width and achene length. OTUs with loadings greater than 4.6 (e.g. OTUs 18, 29, 30) possessed densely villous stems, leaves and involucral bracts, long achenes and wide involucral bracts. OTUs with loadings lower than -3.0 (e.g. OTUs 32, 47, 89) were characterized by sparse stem pubescence and glabrous leaves as well as shorter achenes and narrower involucral bracts. These densely villous OTUs from Newfoundland and western Canada are effectively separated from all other OTUs and are sufficiently distinct to suggest taxonomic recognition. These OTUs have been previously recognized as *A. angustifolia* subsp. *tomentosa*. All remaining OTUs will be treated as *A. angustifolia* subsp. *angustifolia*.

Comparisons can be made between results of the cluster and principal component analyses. The OTUs comprising cluster 1 had loadings greater than 2.5 on principal component axis 1; whereas, the OTUs forming clusters 4 and 5 had loadings less than 1.0 on the same axis. Sixteen OTUs were confluent between these values, suggesting that these clusters are not very well separated. It is virtually impossible to separate the OTUs forming clusters 4 and 5 in the PCA. With the exception of OTUs 29 and 30, cluster 2 includes all OTUs in the PCA with loadings greater than 3 on principal component axis 2. These OTUs have been defined as *A. angustifolia* subsp. *tomentosa*. OTUs 29 and 30 in cluster 6 were found to have the highest positive loadings on principal component axis 2, and as observed in the PCA, are most similar to *A. angustifolia* subsp. *tomentosa*.

It is evident from this discussion, and results of TAXMAP, UPGMA and principal component analyses where no *a priori* grouping is assumed, that two major groups are distinguishable: a polymorphic *A. angustifolia* subsp. *angustifolia* and *A. angustifolia* subsp. *tomentosa*.

Analysis 4. ***Arnica*** **Subgenus** ***Arctica***

To ascertain the correct name for each of the resolved taxa, and to show similarities amongst the taxa previously discerned and the remaining taxa of subgenus *Arctica*, a fourth TAXMAP analysis was carried out. Twenty-four type specimens were included in this analysis. However, due to the limited amount of data which could be obtained from this material, similarities amongst the types were derived from a restricted number of characters. In this respect, the similarities amongst the taxa are less precise than previously determined so proper interpretation can only be made in conjunction with the prior TAXMAP analyses. The resulting taxometric map obtained for 43 characters and 136 OTUs within subgenus *Arctica* is presented in Figure 7.

Cluster 1 contains those specimens identified as *A. frigida*. Included here are OTUs representing *A. frigida* subsp. *griscomii* and four types: *A. frigida* var. *glandulosa*, *A. brevifolia*, *A. griscomii* and *A. mendenhallii*. The type of *A. frigida* was not included in the phenetic analysis since only a photograph was available. Results from TAXMAP Analysis 1 suggest that *A. frigida* subsp. *frigida* and *A. frigida* subsp. *griscomii* be treated as separate taxa. This cluster is most closely related to *A. louiseana* var. *pilosa*. Cluster 2 is characterized by specimens representing *A. angustifolia* subsp. *tomentosa* and two type specimens, *A. tomentosa* and *A. pulchella*. Members of this cluster are most closely related to *A. angustifolia* subsp. *angustifolia* in cluster 4. Cluster 3 includes all OTUs and the holotype of *A. louiseana*. The members of this cluster are closely linked to the isolated OTU representing the type of *A. illiamnae*. Cluster 4 contains all OTUs of *A. angustifolia* subsp. *angustifolia* and the types of *A. angustifolia*, *A. attenuata* and *A. iljinii*. This cluster is most closely related to *A. angustifolia* subsp. *tomentosa* in cluster 2. Cluster 5 represents all OTUs of *A. lonchophylla* subsp. *lonchophylla* and *A. lonchophylla* subsp. *chlonopappa*. Also included in this cluster are the type specimens of *A. lonchophylla*, *A. chlonopappa*, *A. fernaldii* and *A. gaspensis*. This cluster is closely linked to the holotype of *A. iljinii* in cluster 4. OTUs representing *A. lonchophylla* subsp. *arnoglossa*, including its holotype,

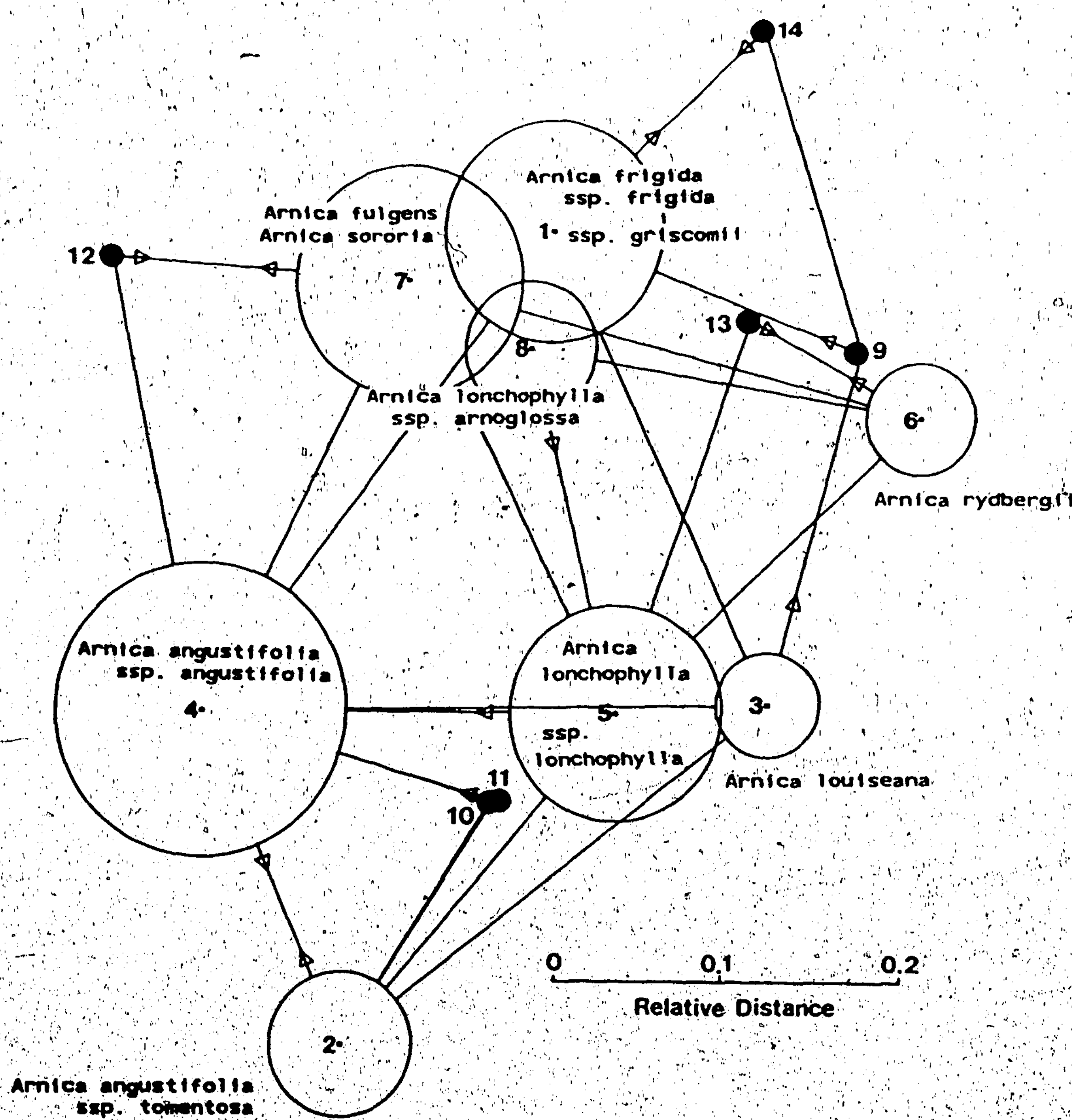

Figure 7 - Taxometric map showing the similarities between the species of subgenus *Arctica* based on morphological data. Isolated clusters are defined in text. See Figure 3 for TAXMAP interpretation.

are contained within cluster 8, with this cluster being most closely related to cluster 5. Cluster 6 comprises all OTUs of *A. rydbergii*, and is closely related to *A. ovalis*, a taxon which has since been placed in synonymy under the former. Cluster 7 contains all OTUs representing both *A. fulgens* and *A. sororia*, and their respective types. The specimens within this cluster are most closely related to *A. stricta*. Results from TAXMAP Analysis 2 indicate these two taxa are discrete. Isolated clusters 9, 10, 11, 12, 13 and 14 contain the type specimens of *A. illiamnae*, *A. sornborgeri*, *A. plantaginea*, *A. stricta*, *A. ovalis* and *A. louiseana* var. *pilosa*, respectively.

Results of this TAXMAP analysis, in conjunction with prior numerical analyses, suggest subgenus *Arctica* consists of seven species (including six infraspecific taxa) (see Table 3).

C. Chromosome Numbers

Somatic chromosome numbers have been determined for 193 populations within subgenus *Arctica* (Table 7). All counts were multiples of the previously reported base number of 19 in the genus (Böcher and Larsen 1950; Ornduff *et al.* 1967; Wolf 1980). Although the chromosomes in *Arnica* are small and numerous, with persistence and repetition accurate counts can be made. No evidence of aneuploidy was found. Four ploidy levels are apparent within subgenus *Arctica*: 2n=38, 57, 76 and 95. Barker (1966) has noted that polyploidy in *Arnica*, especially when associated with meiotic irregularities, is indicative of apomictic reproduction. On the other hand, the diploid level indicates amphimixis (Barker 1966). Ornduff *et al.* (1967) and Wolf (1981) have observed a number of univalents, bivalents, multivalents, chains, bridges and lagging chromosomes in *Arnica* during meiosis. The difficulty in obtaining a good PMC squash in this study precluded an attempt to view these meiotic irregularities in subgenus *Arctica*.

A. FRIGIDA

The chromosome numbers of twenty-three populations within *A. frigida* subsp. *frigida* were determined. Counts of 2n=95 from populations collected at Summit Lake,

Table 7. Chromosome numbers determined for the members of *Arnica* subgenus *Arctica*.

Taxon	2n=	Locality and voucher
A. louiseana	76	**Canada, Alberta**: Banff Natl. Park, Moraine Lake *Downie 449*; Banff Natl. Park, Peyto Lake *Downie 450*; Jasper Natl. Park, Columbia icefields *Downie 544*; Jasper Natl. Park, Maligne Lake *Downie 546*; Jasper Natl. Park, Maligne Lake *Downie 547*.
A. frigida subsp. *frigida*	38	**U.S.A., Alaska**: South of Delta Junction *Downie 503*; Mile 250 Richardson Hwy. *Downie 504*; Mile 84.8 Steese Hwy. *Downie 505*; Mile 105 Steese Hwy. *Downie 506*; Mile 39 Elliott Hwy. *Downie 508*; Mile 39.3 Elliott Hwy. *Downie 508A*; Healy *Downie 509*; Mile 106 Glenn Hwy. *Downie 514*; Mile 13 Denali Hwy. *Downie 515*; Mile 22 Denali Hwy. *Downie 516*; Mile 11 Denali Hwy. *Downie 517*; Donnelly Dome *Downie 519*; South Mt. McKinley Natl. Park *Downie 524*.
	57	**Canada, Yukon**: Km 32.5 Taylor Hwy. *Downie 468*; Km 34.5 Taylor Hwy. *Downie 470*; Km 38.5 Taylor Hwy. *Downie 471*; Km 73.5 Dempster Hwy. *Downie 474*; Km 75 Dempster Hwy. *Downie 476*; Km 80 Dempster Hwy. *Downie 477*; Km 76 Dempster Hwy. *Downie 478*. **U.S.A., Alaska**: Mile 40 Taylor Hwy. *Downie 475*;
	95	**Canada, British Columbia**: Stone Mountain Prov. Park, Summit Lake *Downie 452*; Stone Mountain Prov. Park, Summit Lake *Downie 525*.
A. frigida subsp. *griscomii*	76	**Canada, Québec**: Forillon Natl. Park, Mt. Saint-Alban *Downie 531*. **Newfoundland**: Southwest Port-Au-Choix *Downie 533*; Pointe Riche *Downie 534*.
A. rydbergii	76	**Canada, Alberta**: Jasper Natl. Park, Bald Hills *Downie 723*; Banff Natl. Park, Wah-wah Ridge, vic. Sunshine Ski Lodge *Downie 731*; Waterton Lakes Natl. Park, Upper Lake Carthew on Carthew-Allison Trail *Downie 732*; Waterton Lakes Natl. Park, Carthew summit *Downie 733*. **U.S.A., Wyoming**: Hwy. 30 at Nash Fork Campground *Downie 691*; Medicine Bow Natl. Forest, Rd. to Medicine Bow Peak *Downie 693*; Medicine Bow Natl. Forest, Mirror Lake *Downie 694*; Medicine Bow Natl. Forest, 3 km W. Mirror Lake *Downie 695*; Medicine Bow Natl. Forest, 2 km W. Mirror Lake *Downie 696*.
A. sororia	38	**Canada, Alberta**: E. Suffield *Downie 557*; Hwy. 41, E. Medicine Hat *Downie 558*; Manyberries *Downie 568*; Pendant Orielle *Downie 569*; N. Aden *Downie 571S*; Milk River Ridge Reservoir *Downie 573*.

		British Columbia: Wasa, N. Cranbrook *Downie 703*; S. Kamloops, Hwy. 5 *Downie 707*; Tranquille, N.W. Kamloops *Downie 708*. **U.S.A., Montana**: N. Harlowton *Downie 715*; 12 mi. W. Harlowton *Downie 716*; E. Shawmut *Downie 717*.
A. fulgens	38	**Canada, Alberta**: N. Calgary near Balzac *Downie 548*; Lee Creek, N. Police Outpost Prov. Park *Downie 552*; S.E. Hanna *Downie 555*; S. junction Hwys. 1 & 41 near Medicine Hat *Downie 559*; S. Cypress Hills *Downie 562*; Bare Creek Reservoir *Downie 565*; N. Aden *Downie 571F*. **U.S.A., Montana**: 2 km W. Sweetgrass *Downie 709*; 15 km W. Sweetgrass *Downie 710*; Port of Whitlash *Downie 712*; S.W. Conrad *Downie 713*; Junction hwys. 80 & 87 *Downie 714*. **Wyoming**: Mile 38 Hwy. 14A, Big Horn Natl. Forest *Downie 697*; S.W. Buffalo *Downie 699*; N. Savageton *Downie 700*.
A. angustifolia subsp. *angustifolia*	38	**Canada, Yukon**: Km 471 Klondike Hwy., N. Pelly Crossing. *Downie 466*; Km 610.5 Klondike Hwy., N.W. McQuesten. *Downie 467*; Km 5 Dawson Boundary Rd. No. 9, *Downie 472*; Km 12 Dempster Hwy. *Downie 473*; Km 646 Klondike Hwy. *Downie 479*; Km 547 Campbell Hwy. *Downie 487*; Carmacks. *Downie 682*; Kluane Natl. Park. *Downie 499*. **U.S.A., Alaska**: 3 km N. Circle Hot Springs *Downie 507*; Mile 314 Parks Hwy., N. Nenana *Downie 649*; 1 km N.W. Circle Hot Springs *Downie 654*; Circle Hot Springs Rd. *Downie 655*; Mile 339 Hwy. 2, S.E. North Pole *Downie 658*; Mile 267 Parks Hwy. *Downie 646*; Mile 275 Parks Hwy. *Downie 647*.
	57	**Canada, Alberta**: Jasper Natl. Park, Columbia Icefields *Downie 544*; Jasper Natl. Park, Mt. Edith Cavell *Downie 721*; Jasper Natl. Park, Bald Hills *Downie 722*; Cardinal Divide *Downie 725*; 5 km S. Pine Lake Campground *Downie 583*. **British Columbia**: Summit Lake *Downie 616*; Muncho Lake Prov. Park *Downie 619*; S. Muncho Lake Prov. Park *Downie 618*; Km 750 Alaska Hwy. *Downie 621*; Km 895 Alaska Hwy. *Downie 623*; Km 906 Alaska Hwy. *Downie 624*; Km 625 Alaska Hwy. *Downie 625*. **Northwest Territories**: Km 174 Hwy. 3 *Downie 602*; Km 160 Hwy. 3 *Downie 604*; Km 327 Hwy. 3 *Downie 596*; Km 308 Hwy. 3 *Downie 597*; Km 282 Hwy. 3 *Downie 598*; Km 180 Hwy. 3 *Downie 601*; 5 km E. Hay River, Hwy. 2 *Downie 575*; Km 76 Hwy. 5 *Downie 578*; Km 133 Hwy. 5 *Downie 579*; 46 km N. Enterprise, Hwy. 1 *Downie 588*; 1 km N. Blue Fish Creek, Hwy. 3 *Downie 591*; Fort Providence *Downie 606*; Km 233 Hwy. 1 *Downie 608*; Km 299 Hwy. 1 *Downie 610*; 1 km E. junction Hwy. 7 and Hwy. 1 *Downie 612*; Km 145 Hwy. 7 *Downie 614*.

Yukon: Km 1193 Alaska Hwy. *Downie 459*; Km 1341 Alaska Hwy. *Downie 461*; 16 km S. Haines Junction *Downie 480*; 88 km S. Haines Junction *Downie 481*; Km 134 Klondike Hwy. *Downie 484*; Km 218 Canol Road *Downie 489*; Km 174 Canol Road *Downie 491*; Km 13 Canol Road *Downie 522*; Km 2 Canol Road *Downie 521*; Km 380 Campbell Hwy. *Downie 496*; Km 1618 Alaska Hwy. *Downie 497*; Beaver Creek *Downie 672*; Km 1878 Alaska Hwy., Koidern *Downie 676*; Km 272 Klondike Hwy. *Downie 686*; Km 36 Hwy. 8, S.W. Tagish *Downie 687*.
U.S.A. Alaska: Mile 1239 Alaska Hwy. *Downie 631*; Mile 1264 Alaska Hwy., Northway *Downie 633*; 2 miles S. Tetlin Junction *Downie 635*; 12 miles S. Tok, Hwy. 1 *Downie 637*; Mile 66.5 Hwy. 1 *Downie 641*; Mile 263 Richardson Hwy., S. Delta Junction *Downie 659*; Mile 1372 Alaska Hwy. *Downie 669*; Mile 1324 Alaska Hwy. *Downie 671*.
Greenland: Scoresby Sund, Nordvestfjord *Böcher 10796*.
Sweden: Torne lappmark, Jukkasjarvi, Loupakkte *Nilsson s.n.* (Botanical Garden, U. of Uppsala).
Norway: T[illegible], Tromso, Mt. Flojfjell. *Nilsson s.n.* (Botanical Garden, U. of Uppsala).
U.S.S.R.: Gydan Peninsula, Sibiria (V.L. Komarov Botanical Institute, Leningrad); No locality information, Coll. No. 2965. (Main Botanic Garden, Moscow); No locality information, Coll. No. 632. (Main Botanic Garden, Moscow).

76 **Canada, British Columbia**: Muncho Lake Prov. Park *Downie 622*.
Northwest Territories: Km 379 Hwy. 1 *Downie 611*; 56 km N. Fort Liard, Hwy. 7 *Downie 615*; Km 222 Hwy. 3 *Downie 599*; Km 1912 Alaska Hwy. *Downie 675*.
Québec: Fort Chimo *Hedberg 1959* (Botanic Garden, U. of Copenhagen); No locality information. *Böcher 10050* (Botanic Garden, U. of Copenhagen); No locality information. *Böcher 13666* (Botanic Garden, U. of Copenhagen).
Yukon: Km 1074 Alaska Hwy. *Downie 456*; Km 1790 Alaska Hwy. *Downie 678*; Km 354 Klondike Hwy. *Downie 684*.
U.S.A., Alaska: 60 km E.S.E. Tok Junction *Downie 501*; Mile 1396 Alaska Hwy. *Downie 502*.
Greenland: Holsteinborg *Böcher 4749*; Sdr. Stromfjord *Böcher 12080*; Sdr. Stromfjord, Sandflugtdalen *Böcher 13354*; Lyell's Land, Polhemsdal *Böcher 6059*; Disko, Godhavn *Böcher 8158*; Disko, Brededal *Böcher 8895*; Nugssuaq peninsula, Agatdalen *K.J.47*.

95 **Greenland**: Nugssuaq peninsula, Marrait *Böcher 1*.

A. angustifolia subsp. *tomentosa* 57 **Canada, Alberta**: Ram Mountain *Downie 535,536*; Jasper Natl. Park, Signal Mtn. *Downie 724*; Cardinal Divide *Downie 728,729*; Mile 92 Hwy. 4, N. Coleman *Downie 734*.
British Columbia: Muncho Lake Prov. Park *Downie 620*.

Northwest Territories: Hwy. 7 near Liard River *Downie 746*.

76 **Alberta**: Ram Mountain *Downie 535A*; Cardinal Divide *Downie 541A*.

A. lonchophylla subsp. *lonchophylla*

57 **Canada, Alberta**: Wood Buffalo Natl. Park, Km 26 Hwy. 5 *Downie 581*; Wood Buffalo Natl, Park, 2 km N. Pine Lake Campground *Downie 582*; Wood Buffalo Natl. Park, S. Pine Lake *Downie 584*; Wood Buffalo Natl. Park, 20 km S. Pine Lake *Downie 585*.
Northwest Territories: 13 km E. Hay River, Hwy. 2 *Downie 576*; 11 km N.W. Enterprise, Hwy. 1 *Downie 586*; 20 km N.W. Enterprise, Hwy. 1 *Downie 587*; 64 km N.W. Enterprise, Km 148 Hwy. 1 *Downie 589*; 43 km N. Fort Providence, Hwy. 3 *Downie 592*; 60 km N. Fort Providence, Hwy. 3 *Downie 593*; Km 92 Hwy. 3 *Downie 594*; Km 118 Hwy. 3 *Downie 595*; Km 167 Hwy. 3 *Downie 603*; Km 192 Hwy. 1, W. Hwy. 3 junction *Downie 607*.
Québec: St. Joachim-de-Tourelle *Downie 530*.
Yukon: Km 1409 Alaska Hwy., N.W. Jakes Corner *Downie 462*.

76 **British Columbia**: Km 935 Alaska Hwy. *Downie 455*.
Northwest Territories: Km 212 Hwy. 7 *Downie 613*.
Yukon: Km 245 Klondike Hwy., Fox Lake *Downie 463*; Km 378 Campbell Hwy., 15 km S. Ross River *Downie 480*.

B.C., are the first reported pentaploids for this species. Within this taxon is the full polyploid series, ranging from 2n=38 to 2n=95. The chromosome numbers of 2n=58 (Zhukova and Petrovsky 1971) and 2n=60 (Zhukova 1964, 1965) for *A. frigida* in the U.S.S.R. are presumed to have been derived from trisomic and pentasomic aneuploidy from the triploid 2n=57. Polyploids contain much duplication of genetic material and can tolerate the loss of one or more chromosome pairs (Grant 1971). This can lead to what Darlington (1963) has called a polyploid drop and may account for the 2n=70 in *A. frigida* (Zhukova and Tikhonova 1971) and the 2n=*ca.*67 in *A. louiseana* (Ornduff *et al.* 1967), presumably having originated from the tetraploid 2n=76. Ornduff *et al.* (1967) have suggested that due to the small chromosome size in *Arnica*, counts which do not correspond to the base number of 19 are in error and are best treated as approximations. The difficulty in determining an accurate count for *A. frigida* from Ogotoruk Creek, Alaska (Johnson and Packer 1968) may be due to some unusual cytological behaviour which accounts for the lack of pollen produced by this specimen.

The three tetraploid counts for *A. frigida* subsp. *griscomii* from Québec and Newfoundland are similar to a count previously reported by Gervais (1979), suggesting that this eastern disjunct of *A. frigida* may be comprised solely of tetraploid individuals.

When assessed for pollen viability, all diploid *A. frigida* exhibited 90% or greater stainable pollen, whereas the triploids and tetraploids possessed 0 to 15% viable pollen. This corroborates Barker's (1966) hypothesis that low pollen quality (less than 90% viability) is indicative of polyploidy in *Arnica*.

A. LOUISEANA

The five counts determined for this species were all 2n=76, confirming previous counts by Wolf (1980). Two ploidy levels are apparent in this taxon: tetraploids, and the one previously reported pentaploid (Straley 1982).

A. FULGENS

Fifteen collections of *A. fulgens* exhibited chromosome numbers of 2n=38, corroborating Barker's (1966) hypothesis that this taxon is wholly amphimictic. The count of 2n=52-57 from Cypress Hills Provincial Park, Saskatchewan (Taylor and Brockman 1966), is presumably triploid and is the only report of polyploidy in this species. However, without further evidence, polyploidy in this taxon is indeed rare.

A. SORORIA

Twelve collections of *A. sororia* exhibited 2n=38, again corroborating the amphimictic nature of these plants (Barker 1966).

A. RYDBERGII

Nine counts of *A. rydbergii* from Alberta and Wyoming were all 2n=76, similar to a count previously reported by Straley (1979) for plants collected in Washington. Previously reported diploid populations (Wolf 1980) demonstrate two ploidy levels in this taxon: 2n=38 and 2n=76. Diploid counts by Wolf (1980) are inconsistent with Barker's (1966) conclusion that this taxon is wholly apomictic and polyploid.

A. ANGUSTIFOLIA

Diploid chromosome numbers were determined for 102 populations within this aggregate. The predominant chromosome number for this species is 2n=57 (Federov 1969; Moore 1977; Wolf 1980); however, all ploidy levels from 2n through 5n have been found. Four ploidy levels are apparent in *A. angustifolia* subsp. *angustifolia*, in agreement with published counts by Engell (1970) and Wolf (1980). The counts of 2n=57 for Scandinavian material corroborate Engell's (1970) observation that these plants are most probably all triploid. Tetraploid counts for *A. angustifolia* subsp. *angustifolia* from western North America are, to my knowledge, the first published counts. Three counts of 2n=57 for plants collected in the U.S.S.R., and three tetraploid counts for plants from eastern Canada suggest that these taxa may be entirely triploid and tetraploid, respectively. A diploid count for *A. angustifolia* from the U.S.S.R. has been reported by Barker (1967), but with no locality information given. Chromosome counts of 2n=57 and 2n=76 for *A. angustifolia* subsp. *tomentosa* are in agreement with those previously published by Löve and Löve (1975), Straley (1979) and Wolf (1980).

Plants having diploid chromosome numbers show a very close correlation with non-glaciated areas (Figure 8). The sexual phase is prevalent throughout unglaciated Alaska and west-central Yukon with some colonization of the glaciated areas (or perhaps a glacial relict) in Kluane National Park, Yukon Territory. Triploid and tetraploid individuals are widely scattered throughout previously glaciated areas. Ploidy was not related to any particular habitat type.

A. LONCHOPHYLLA

Two ploidy levels, 2n=57 and 2n=76, obtained from 20 collections of *A. lonchophylla* subsp. *lonchophylla* corroborate similar ploidy levels obtained for this taxon by Wolf (1980). Barker (1966) reported that the eastern disjunct of *A. lonchophylla* is polyploid and apomictic, but did not determine the exact ploidy level. A count of 2n=57 was also obtained for a single population of *A. lonchophylla* subsp. *chionopappa* from Gaspé, Québec. No counts were made from the putative amphimictic, *A. lonchophylla* subsp. *arnoglossa*, from South Dakota and Wyoming.

Whether the polyploids represent autoploids or amphiploids is difficult to ascertain. Although amphiploidy is far more common in vascular plants (Stebbins 1950), the origin of the polyploid races in *Arnica* subgenus *Arctica* is debatable. Since a close morphological resemblance between a polyploid and a diploid is not a valid criterion for autoploidy (Grant 1971), other criteria must be used. These include observations of chromosome pairing, fertility, and segregation ratios (Grant 1971) and chemical comparisons (Harborne 1975). Ornduff *et al.* (1967) and Engell (1970) have observed some unusual cytological characteristics in meiotic chromosome pairing in *Arnica*, suggestive of an autoploid origin. Stebbins (1959, 1985) stated that autoploids may have been created by hybridization between differently adapted diploids of the same species. Grant (1971) described three primary factors necessary to promote polyploidy. These are: (1), diploid species with different genomes; (2), natural hybridization between

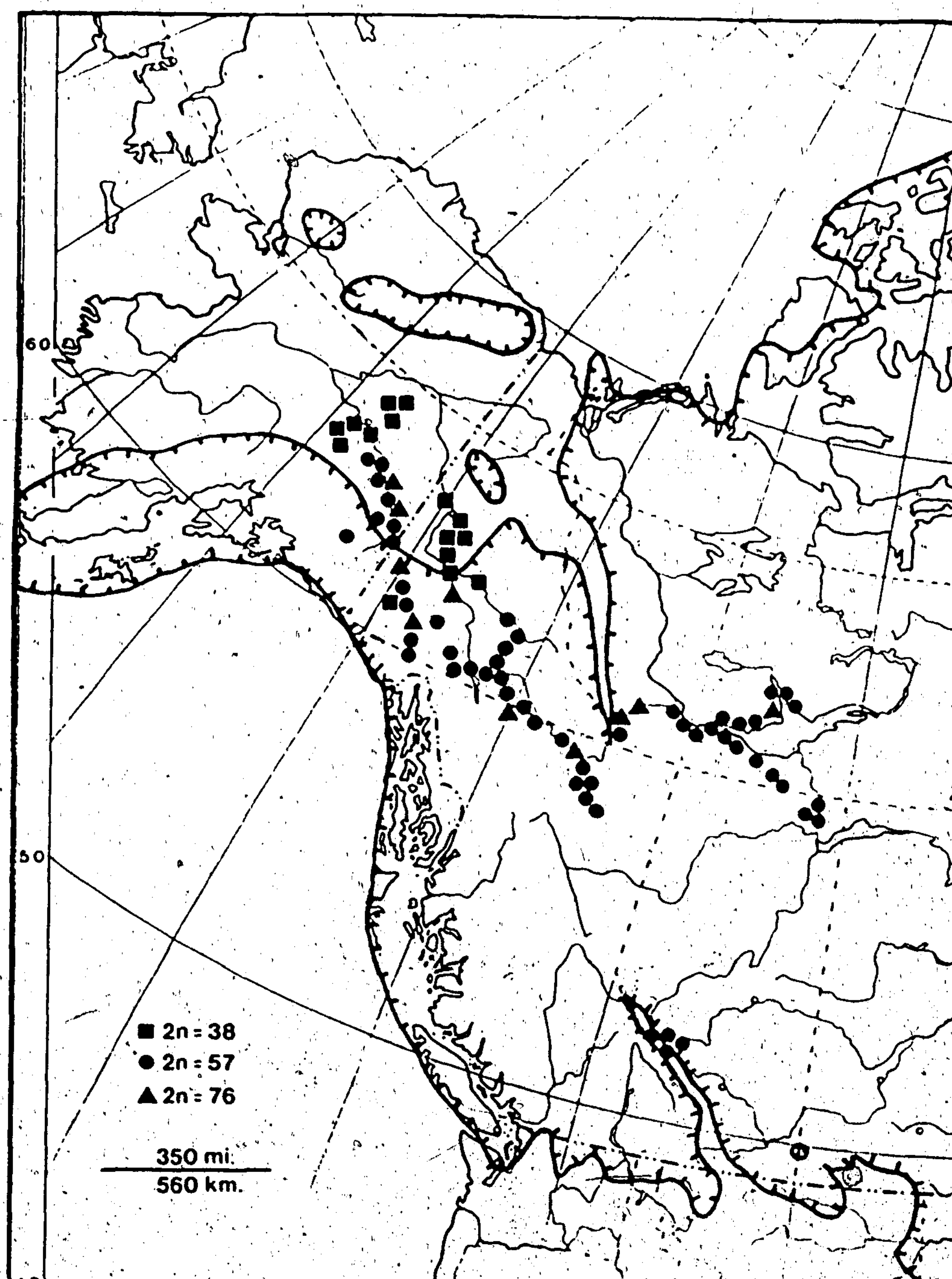

Figure 8 - Distribution of *Arnica angustifolia* subsp. *angustifolia* cytotypes in northwestern North America in relation to the approximate maximum extent of the late Wisconsinan glacier complex (modified from Prest 1984). Kodiak Island refugium (Karlstrom and Ball 1969) not shown.

species or adapted forms of the same species; and (3), a long-lived growth habit to increase the chances of somatic doubling. Along with the severe arctic climate and the exposed disturbed habitats of Quaternary origin, these three factors may have created the complex polyploid series prevalent within subgenus *Arctica*.

D. Pollen Viability

The pollen quality of 990 specimens within subgenus *Arctica* was determined. A complete listing of collections examined and their respective pollen viability is presented in Appendix 4. These specimens were chosen to represent collections from throughout the range of the subgenus.

A. FRIGIDA

Of 290 specimens of *A. frigida*, 182 specimens from Alaska, British Columbia, Northwest Territories, Yukon Territory, and the U.S.S.R. possessed pollen which was less than 16% viable when stained with lactophenol-cotton blue. Nine collections from Alaska produced pollen between 16% to 89% viable. In Alaska, sixty-one collections exhibited a pollen viability greater than 95%. In collections with pollen viability less than 80%, the pollen grains showed varying degrees of deformity.

No pollen was observed in the four collections from Summit Lake, British Columbia (*Downie 452,525, Raup & Correll 10507, Rose 78430*), which represent the most southerly limit of the range of *A. frigida* subsp. *frigida* and are isolated by at least 200 km from the major northern populations. Because of the geographical isolation of this group of pentaploids, it is not surprising that pollen is not produced. Barker (1966) suggested that faulty chromosome pairing in pentaploids, meiotic disturbances in microsporocyte divisions and accumulation of random deleterious mutations may have caused this deterioration in microsporogenesis. Engell (1970) reported degeneration of pollen mother cells in pentaploid populations of *A. angustifolia*, a closely related species to *A. frigida* (Maguire 1943). In these cells, all meiotic chromosomes appeared to be markedly contracted with chromosomal divisions stopping at prophase.

In Alaska and the U.S.S.R., 16 collections did not produce pollen. Collections from Alaska (*Cantlon & Gillis 57-452, Geist s.n., Hettinger 367, Murray & Johnson 6687, Packer 2654, Spetzman 835, Ward 1478*) were collected above 68° latitude, north of the Brooks Range. In the U.S.S.R., nine collections from north and central Chukotsky are represented by *Afonina et al. s.n., Korobkov s.n.* (3 collections), *Karenin & Petrovsky s.n., Nechayev, Plieva & Yurtsev s.n.* (2 collections), *Yurtsev s.n.* and *Zimarskaya, Korobkov & Yurtsev s.n.*.

All eighteen collections of *A. frigida* subsp. *griscomii* exhibited pollen viability between 0% and 3%.

Herbarium collections having a pollen viability greater than 95% showed a very close correlation with non-glaciated areas (Figure 9). The sexual phase is well developed throughout unglaciated central and southwestern Alaska with some colonization of the glaciated area in southcentral Alaska. The location for the refugium of these sexual elements has been confirmed and is more extensive than Barker (1966) realized. Plants which have recolonized this glaciated area in the region of Lake Iliamna, are represented by five collections used in the TAXMAP analysis. These collections (*Hagelbarger 71, Donaldson 184a, Gorman 163, Schofield 2129, Gorman s.n.*) were morphologically distinct from the typical *A. frigida* subsp. *frigida* and characterized by obvious leaf, achene and involucral bract glandularity. This glandularity was restricted only to this area.

A. LOUISEANA

Thirty collections of *A. louiseana* exhibited pollen viability of 0 to 3%.

A. FULGENS AND *A. SORORIA*

The pollen quality of 191 specimens, representing 43 field collections and 148 herbarium specimens, was determined. Within *A. fulgens*, 29 out of 86 collections

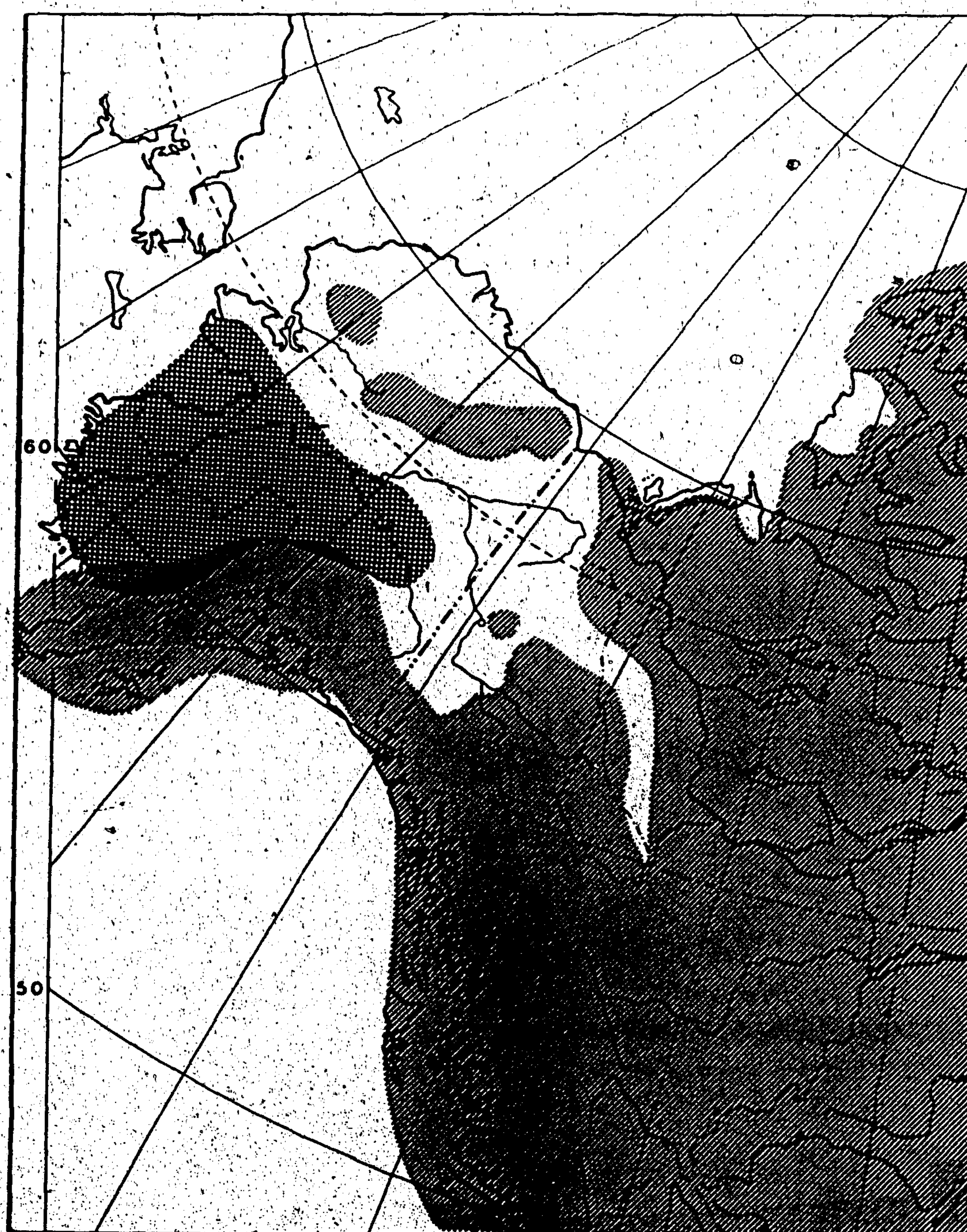

Figure 9 - Distribution of amphimictic *Arnica frigida* (grid) in relation to the approximate maximum extent of the late Wisconsinan glacier complex (hatched area). Modified from Prest (1984). Kodiak Island refugium (Karlstrom and Ball 1969) not shown.

(34%) exhibited pollen viability less than 90% and 9 collections (10%) less than 75% viability. Within *A. sororia*, 36 out of 105 collections (34%) exhibited pollen viability less than 90%, with only 13 collections (12%) less than 75%. All unstainable pollen in *A. fulgens* and *A. sororia* maintained its normal size and shape, unlike *A. frigida*, in which pollen grains exhibiting less than 80% stainability showed varying degrees of deformity This report of low pollen stainability, suggestive of apomictic elements in *A. fulgens* and *A. sororia*, is in contrast to Barker's (1966) study in which all pollen was greater than 90% viable. In contrast to *A. frigida* in which high pollen grain viability is correlated closely with non-glaciated areas, there is no such correlation in *A. fulgens* and *A. sororia*. In both taxa, plants producing unstainable grains were scattered throughout the whole range of the species. The presence of low pollen stainability suggests that *A. fulgens* and *A. sororia* may be partially apomictic. However, chromosome counts obtained for two collections having low pollen stainability (*Downie 555* and *Downie 569*) were 2n=38. Barker (1966) observed that all apomictic collections showed varying degrees of pollen deformity whereas amphimictic collections had normally formed pollen. All collections of *A. fulgens* and *A. sororia* exhibiting low pollen viability had grains normal in size and form. As Barker (1966) suggests, determination of reproductive mode based on pollen quality estimates cannot be considered infallible, particularly with pollen stainability between 70 and 89 percent. Barker (1966) has shown diploid apomicts for *A. amplexicaulis*. Diploid apomicts in *A. fulgens* and *A. sororia* are subject to further investigation.

A. RYDBERGII

Seventy out of 75 collections had less than 12% stainable pollen, with five collections exhibiting ~~between 20% and~~ 62% stainable pollen. All pollen was irregularly shaped. Barker (1966) examined 21 specimens of this taxon and reported all pollen to be of low quality (less than 50% stainable). This species appears to be entirely apomictic, as previously suggested by Barker (1966).

A. ANGUSTIFOLIA

Of 312 specimens, only 22 of *A. angustifolia* subsp. *angustifolia* possessed pollen more than 95% viable, indicative of amphimictic reproduction and a diploid ploidy level. These specimens were collected from areas in central Alaska and west-central Yukon Territory which were largely free of ice during the time of the last glaciation. Specimens representing the disjunct populations of *A. angustifolia* subsp. *angustifolia*, comprising 34 collections from eastern Canada, 33 collections from Scandinavia and Spitsbergen, 10 collections from the U.S.S.R., and 33 collections from Greenland, all had less than 10% viable pollen. However, five plants from Greenland had between 25% and 51% viable pollen. Jorgensen *et al.* (1958) reported Scandinavian and Greenland tetraploids with fairly regular PMC meiosis that produce well-formed pollen, suggestive of a polyploid amphimict. Barker (1966), on the other hand, reports 0% pollen viability in all Greenland taxa investigated. In this study, all Greenland tetraploids possessed very little viable pollen and irregularly shaped grains. Of the remaining 124 collections in *A. angustifolia* subsp. *angustifolia*, representing plants from northwestern North America, 59 collections (48%) had pollen which was 0% viable, 56 collections (45%) exhibited a pollen viability less than 50%, and nine collections (7%) had between 50% and 85% stainable pollen. All 51 collections of *A. angustifolia* subsp. *tomentosa* possessed pollen which was less than 50% viable after staining. The pollen obtained from 32 of these collections (63%) was less than 10% viable. Throughout this study, in those collections where pollen viability was less than 80%, the pollen showed varying degrees of deformity.

A. LONCHOPHYLLA

All 83 collections of *Arnica lonchophylla* subsp. *lonchophylla* examined had less than 64% viable pollen. Of these, 53 collections had less than 20% viable pollen; 26 collections had between 21% and 50% viable pollen; and the remaining four collections had greater than 50% stainable pollen. Twenty-seven specimens of *A. lonchophylla* subsp. *lonchophylla* were examined by Barker (1966) and reported to have less than 30% stainable pollen. This taxon is apomictic.

Nine collections of *A. lonchophylla* subsp. *arnoglossa* were examined for pollen quality. Five had greater than 85% stainable pollen, suggestive of amphimictic populations, and the remaining four collections had between 36% and 75% stainable pollen. Four specimens of *A. lonchophylla* subsp. *arnoglossa* have been previously reported to be amphimictic (Barker 1966). The mode of reproduction in this taxon is questionable, for Barker found two collections in which the pollen was between 51% and 65% viable, suggesting apomixis. Since no chromosome counts were made for this taxon, and pollen viability studies seem to indicate both amphimictic and apomictic populations, the reproductive mode within this taxon is still questionable.

E. Field and Greenhouse Observations

Phenological differences were observed between parental populations and greenhouse-propagated material. Plants produced from achenes collected in the field and plants which had reestablished after a cold period showed a reduction in periclinium and involucral bract pubescence. In some instances the periclinium pubescence disappeared altogether. In the vicinity of Mt. McKinley National Park, Alaska, plants have been found which Maguire (1942, 1943) believed were hybrids between *A. frigida* and *A. angustifolia* subsp. *tomentosa*. These plants are characterized by a dense periclinium and involucral bract pubescence, and have been treated as *A. louiseana* var. *pilosa*. When collections described as var. *pilosa* were brought back to the University of Alberta and observed after reestablishment, the dense pubescence of the peduncle, periclinium and involucral bracts disappeared. In addition, the characteristic yellow periclinium pubescence of *A. frigida* subsp. *frigida*, so common in the field, was now white. Maguire (1943) has stated that the periclinium frequently furnished an excellent character for the delimitation of specific and subspecific categories. However, results of this study indicate the degree of periclinium pubescence is undoubtedly inadequate, and taxonomic delimitations based upon this character would have to be re-evaluated in the light of this environmentally induced trait.

Greenhouse-propagated material of *A. frigida* subsp. *frigida* was morphologically indistinguishable from *A. frigida* subsp. *griscomii*; whereas, *A.*

louiseana and *A. rydbergii* maintained their diagnostic morphological features in the greenhouse (see Tables 3 and 4).

The morphological variability in *A. angustifolia* appeared to be a function of latitude and elevation. Arctic and alpine plants are generally smaller, with fewer and smaller leaves, and exhibit smaller capitulum characters. In contrast, the more southern populations are often taller, possess larger capitulum characters, and have more pairs of leaves. However, the transferal of field-collected plants to the greenhouse resulted in diminution of morphological differences, indicating that much of the observed variation in this taxon is attributable to phenotypic plasticity. Davis and Heywood (1963) described good diagnostic characters as not being subject to wide variation nor being easily susceptible to environmental modification. Within *A. angustifolia* subsp. *angustifolia*, characters such as plant height; leaf, stem and periclinium glandularity; capitula number, length and width; and leaf size, were highly plastic and extremely variable. Taxonomic difficulty for this species in the past was primarily due to the frequent use of these characters.

The number of capitula has traditionally been used to delimit the southern subspecies of *A. angustifolia* from the more northern taxa (Maguire 1943). I have observed, however, that when plants from Alaska, Greenland, Scandinavia and the U.S.S.R. are grown alongside plants obtained from eastern Canada and the southern regions of the Northwest Territories in the greenhouse, the plants are morphologically indistinguishable and all possess three or more capitula.

Subtle differences in the ecology of *A. fulgens* and *A. sororia* were observed in the field, but made obvious when both species were in the same locality. *Arnica fulgens* characteristically occurs in slightly moist to mesic depressions in the prairie. The more moisture available, the taller and more robust the plants. Populations of *A. fulgens* were generally quite large and formed dense rhizomatous clumps. On the higher and drier portions of the prairie *A. sororia* was common. At one locality *A. sororia* was observed to be common around a depressed moister area containing *A. fulgens*. Populations of *A. sororia* were not as dense as *A. fulgens* and were very widely scattered. With respect to phenology, *A. fulgens* generally produces buds, flowers and fruits before *A. sororia*, the timing being dependent upon the local environmental conditions. Both *A. fulgens* and *A. sororia* maintained their differentiating morphological and chemical differences in the greenhouse.

In most collections, flowering often occurred after a two to three week period of vegetative growth. However, *A. fulgens* and *A. sororia* maintained their vegetative condition two to three months prior to flowering. This may reflect the longer growing season in the prairies as opposed to that of the arctic or alpine, or the cool greenhouse conditions.

In the field, numerous pollinating vectors were observed on the flowers. These included bees, flies, spiders and butterflies, with no apparent insect specificity. Even though the pappus on the achenes of *Arnica* greatly enhances their dispersability, very few seedlings were observed. Most *Arnica* populations are found in dense mats.

REPRODUCTIVE STUDIES

Five capitula from *A. fulgens* and four from *A. sororia* were emasculated and the epigynous ovaries permitted to mature. In all instances no seeds were found within the small, fragile achenes. Similar results were obtained when the disc florets were removed and the ligulate florets allowed to develop. The achenes from the ligulate florets of two collections each of *A. fulgens* (*Downie 571F, 559*) and *A. sororia* (*Downie 571S, 703*) were devoid of seeds. Agamospermy was not evident.

Few artificial hybridization experiments were attempted. Non-synchronous flowering periods between the two species and even between populations of the same species made immediate pollen transfer difficult. Most interpopulational crosses of *A. fulgens* (*Downie 571F X 712, 559 X 562, 554 X 697*) and *A. sororia* (*Downie 573 X 570, 703 X 571S*) were successful with percentage of viable achenes between 65 and 85%. Unsuccessful intraspecific crosses (*Downie 555 X 571F, 569 X 570*) may be due to non-viable pollen or to incomplete fertilization. Five interspecific crosses were attempted but no viable achenes resulted (*Downie 571F X 571S, 558 X 559, 699 X 558, 699 X 703, 554 X 703*). Studies of reproductive behaviour indicate that both taxa are completely amphimictic and self-incompatible, corroborating the studies of Barker (1966). Artificial hybridization experiments between the two species were unsuccessful.

F. Flavonoid Chemistry

Twelve flavonoids (including seven flavonol and three flavone glycosides, one flavone aglycone and one unknown) were isolated from 198 collections of *Arnica* subgenus *Arctica*. A composite two-dimensional chromatogram of all compounds is illustrated in Figure 10, and the chromatographic and spectral data for these compounds are presented in Table 8. The collections examined for flavonoid content are listed in Appendix 5, and flavonoid characterization and distribution within each of these collections is presented in Table 9.

Flavonoid profiles within *Arnica* subgenus *Arctica* are relatively simple, with two to six compounds found per population; however, considerable populational variation is found with respect to flavonoid content. The prevalence of quercetin and kaempferol glycosides is not unusual for they are widely distributed throughout the angiosperms (Harborne 1975); however, they do suggest a somewhat primitive biochemical profile (Harborne 1972). The complex, highly methylated derivatives of the flavones apigenin and luteolin, as found in subgenus *Austromontana* (Wolf 1981), were not detected in the species under consideration here. Similarly, complex glycosylation patterns which are prevalent in some members of the Asteraceae (Harborne 1977), were also not found. The lack of glycoside variability in the Asteraceae (Harborne 1977) is reflected in this complex for only two sugars occur; glucose and galactose. Of restricted occurrence are two methylated flavonoids: luteolin 6-0-methoxy 7-0-glucoside and kaempferol 6-0-methoxy 3-0-glucoside, both previously reported from subgenus *Austromontana* (Wolf 1981). Sugar linkages are most commonly found at the 3 position in the flavonols and at the 7 position in the flavones. The presence of quercetin 3-0-diglucoside (viscosin) and quercetin 3-0-gentiobioside in many members of the *Arctica* aggregate negate Wolf and Denford's (1984) claim that these compounds are only found in *Arnica* subgenus *Austromontana*.

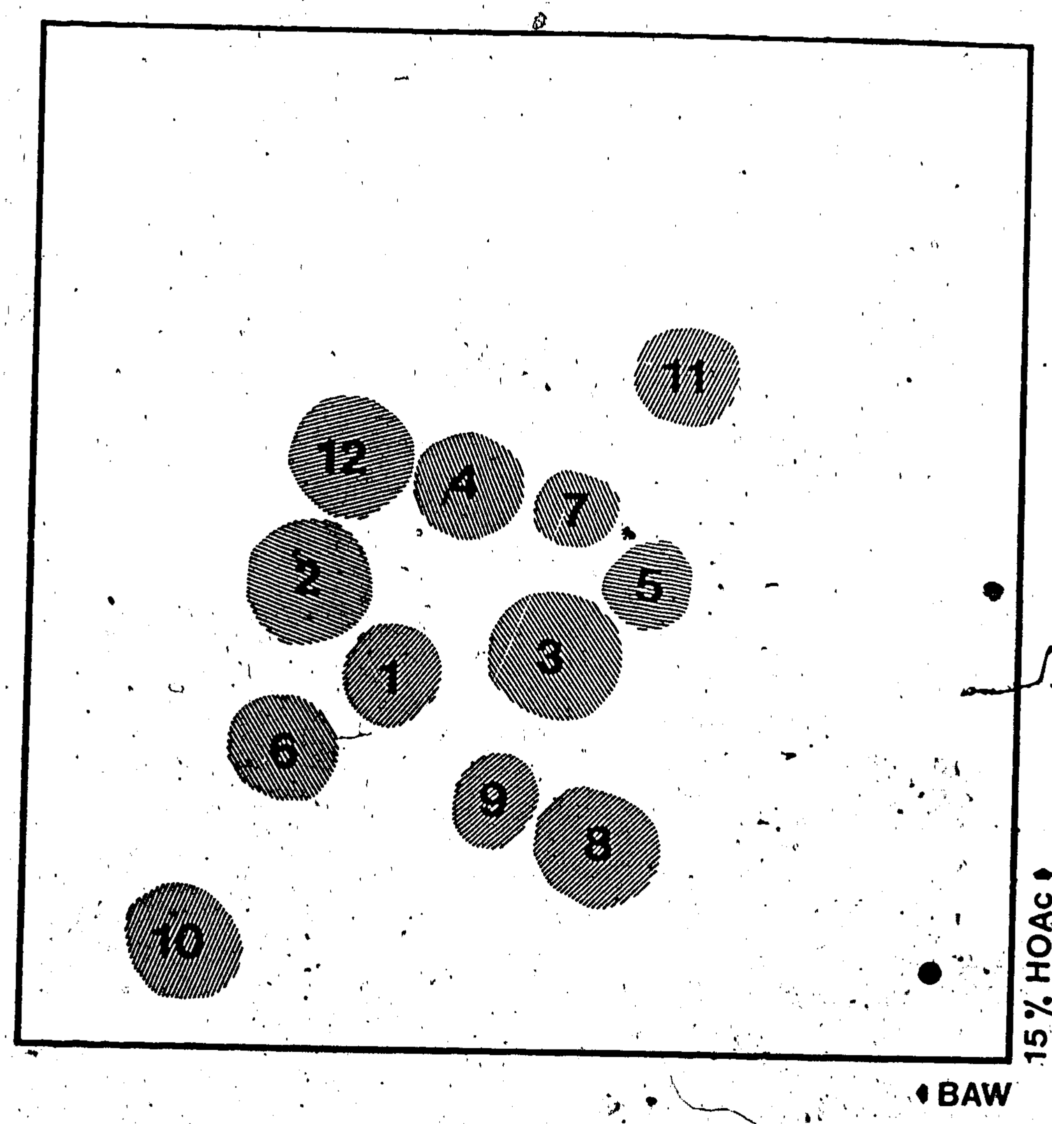

Figure 10 - Composite chromatogram for the flavonoids of *Arnica* subgenus *Arctica*. Numbers refer to flavonoid compounds defined in Table 8.

Table 8. Spectral, chromatographic and Rf data for the flavonoids of *Arnica* subgenus *Arctica*.

Flavonoid[3]	Spectral Data[1]: MeOH Band II	MeOH Band I	NaOMe Band I	$AlCl_3$ Band I	$AlCl_3$ & HCl Band I	NaOAc Band II	NaOAc & H_3BO_3 Band I	Colours[2] at 350 nm: UV	UV/NH_3	UV/NA	Rf's X 100: BAW	H_2O	HOAc	PhOH
Apigenin	268	336	+49	+48	+44	+5	+2	P	YG	G	90	00	09	85
A 7-0 glu	268	338	+54	+61	+63	+7	+6	P	YG	G	76	07	34	56
K 3-0 gal	268	347	+53	+53	+53	+34	+1	P	G	G	58	10	53	87
K 3-0 glu	268	350	+50	+42	+48	+6	+5	P	G	G	70	14	47	58
K 6-0-me, 3-0 glu	270	346	+50	+16	+10	+5	+2	P	G	G	65	30	57	45
L 7-0 glu	255	350	+46	+85	+40	+5	+20	P	Y	O	46	01	14	59
L 6-0-me, 7-0 glu	257	341	+61	+67	+18	+9	+19	P	Y	O	49	01	17	65
Q 3-0 gal	258	361	+65	+50	+20	+8	+20	P	Y	O	68	14	37	61
Q 3-0 gen	258	359	+50	+72	+44	+12	+20	P	Y	O	40	26	46	39
Q 3-0 diglu	258	348	+57	+57	+36	+15	+26	P	Y	O	42	22	41	26
Q 3,7-0 diglu	256	355	+41	+85	+47	+5	+25	P	YG	O	30	31	65	31
Unknown	----	----	----	----	----	----	----	P	G	O	42	----	50	----

[1]Spectral data: MeOH data indicates maximum wavelength (nm) in 100% MeOH. All other data indicate change in maximum wavelength due to corresponding shift reagent.
[2]Colour key: P=Purple, Y=Yellow, G=Green, O=Orange.
[3]Flavonoid compounds: A=Apigenin, K=Kaempferol, L=Luteolin, Q=Quercetin
glu=glucose, gal=galactose, me=methoxyl, gen=gentiobioside, diglu=diglucoside.

Table 9. Collection number, locality and flavonoid distribution in *Arnica* subgenus *Arctica*. Locality abbreviations defined in Table 2.

Taxon, locality and voucher	Flavonoid compound 1	2	3	4	5	6	7	8	9	10	11	12
A. frigida subsp. *frigida*												
AK:504, 506, 514, 519, 645, 656, 662, 668.	+		+									
AK:475, 508, 508A, 638, 639, 640, 663, 666; YT:470, 471, 474, 674.	+	+	+									
AK:505, 509, 515, 516, 517, 642, 644, 650; YT:469, 477, 478.	+	+	+		+							
BC:452, 525; YT:476.	+	+	+	+								
AK:503, 660.	+	+	+		+	+						
AK:657.	+	+	+			+						
YT:628.	+		+	+								
A. frigida subsp. *griscomii*												
PQ:531.	+	+	+									
NFLD:533, 534.	+	+	+		+							
A. louiseana												
ALTA:449, 450, 544.	+	+	+	+		+						
ALTA:546, 547.	+	+	+	+		+	+					
A. fulgens												
ALTA:554, 559, 562, 563, 565, 571F; MONT:710, 712, 713, 714; WYOM:698, 699.	+	+	+					+	+	+		
A. sororia												
ALTA:558, 569, 570, 571S, 572, 573; BC:703, 707, 708; MONT:716, 717.	+	+	+					+				

Taxon, locality and voucher	1	2	3	4	5	6	7	8	9	10	11	12
A. sororia cont'd.												
ALTA:557, 568	+	+	+					+	+	+		
A. angustifolia subsp. *angustifolia*												
BC:619, 621, 625; PQ:1959, 13666; YT:456, 466, 481, 484, 489, 491, 494, 496, 522, 523; AK:501, 502, 520.	+	+	+									
ALTA:544, 721, 722, 725; BC:454; NWT:577, 575, 579, 591, 596, 598, 601, 602B, 605, 612; PQ:10050; YT:459, 461, 686, 687; AK:647, 655, 659, 671; GRLD:1, 4749, 8895, 12080, 13354; SWDN:s.n.; NRY:s.n.; U.S.S.R.:s.n.; 2965.	+	+	+	+								
ALTA:580, 583; BC:623, 624; NWT:590, 597, 599, 602A, 608, 611, 615; YT:521.	+	+	+	+				+				
BC:622; NWT:578, 604, 606, 610; YT:480.	+	+	+					+				
YT:467, 472, 473, 479, 487.	+		+			+		+				
NWT:609; YT:497, 629, 676, 678, 684; AK:633, 669.		+	+									
YT:675; AK:631, 635; GRLD:6059, 8158, 10796; U.S.S.R.:632.	+		+									
YT:672.	+		+					+				
AK:649.	+		+	+								
AK:636.	+		+		+							
BC:618.		+		+								
A. angustifolia subsp. *tomentosa*												
AB:535, 535A, 536; BC:620.	+	+	+									
AB:54[illegible]A, 724, 728, 729, 734; NWT:746.	+	+	+	+								

Taxon, locality and voucher	1	2	3	4	5	6	7	8	9	10	11	12
A. lonchophylla subsp. *lonchophylla*												
AB:581, 582.	+	+	+	+				+				
AB:584; NWT:576, 592, 593, 613.	+	+	+	+								
AB:585; BC:455; PQ:530; NWT:586, 594; YT:463, 488.	+	+	+									
NWT:607.	+	+	+					+				
NWT:603.	+	+	+		+			+				
A. rydbergii												
AB:731, 732, 733; WYOM:691, 695, 696.		+						+			+	+
AB:693.	+	+	+					+			+	+
WYOM:723.		+	+					+			+	+

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1. Quercetin 3-0-galactoside; 2. Kaempferol 3-0-glucoside;
3. Quercetin 3-0-diglucoside; 4. Kaempferol 3-0-galactoside;
5. Quercetin gentiobioside; 6. Apigenin 7-0-glucoside; 7. Unknown;
8. Luteolin 7-0-glucoside; 9. Luteolin 6-0-methoxy 7-0-glucoside; 10. Apigenin;
11. Quercetin 3,7-0-diglucoside; 12. Kaempferol 6-0-methoxy 3-0-glucoside

A. FRIGIDA

Six flavonoid glycosides (five flavonols and one flavone) were isolated from forty-one populations of *A. frigida* (Table 9). Quercetin 3-0-galactoside and quercetin 3-0-diglucoside were ubiquitous. Seven profile types are distinguished, with *A. frigida* subsp. *frigida* exhibiting the most diverse, and in some populations the most depauperate flavonoid profiles. The two profile types obtained from *A. frigida* subsp. *griscomii* matched the two most common flavonoid patterns in *A. frigida* subsp. *frigida*, corroborating morphological evidence as to the close affinity between these two taxa. In many instances the flavonoid profiles obtained from this taxon matched those of *A. angustifolia*. However, chemical differences included the presence of luteolin 7-0-glucoside and the paucity of quercetin 3-0-gentiobioside in *A. angustifolia*.

The possibility that a taxon exhibiting a reduced flavonoid profile represents the remnant of a refugial entity has been suggested by Denford (1973). Eight populations of *A. frigida* subsp. *frigida*, each possessing only two flavonoids, were collected from localities in Alaska which were free from ice during the Wisconsinan glaciation. Implications of this find are discussed further in the phytogeography chapter.

A. LOUISEANA

Six flavonoids were isolated from five collections of *A. louiseana*. Two of these collections produced a flavonoid (Compound 7) in such minute quantities that full characterization could not be accomplished. Preliminary Rf data and colour reaction are presented in Table 8. This compound was found only within this species. Flavonoid profile similarities with *A. frigida* and *A. angustifolia* suggest close genealogical relationships with both these taxa. However, in conjunction with morphological evidence, *A. louiseana* appears to be more closely related to *A. frigida*.

A. FULGENS

Five flavonoid glycosides (three flavonols and two flavones) and one flavone aglycone were isolated from twelve collections of *A. fulgens*. All flavonoid profiles were unvarying, a feature perhaps attributed to its invarient morphology and single ploidy level. The presence of luteolin 7-0-glucoside in *A. fulgens, A. sororia* and *A. angustifolia* corroborate morphological evidence as to the close affinities among these three taxa, and the close affinites of these taxa to *A. lonchophylla* and *A. rydbergii*. Luteolin 6-0-methoxy 7-0-glucoside and apigenin were only in this taxon and *A. sororia*. The presence of a methoxyl group is interesting for it has phylogenetic implications. This is discussed further in the appropriate chapter.

A. SORORIA

Four flavonoids were identified from 11 populations in *A. sororia*. Quercetin 3-0-galactoside, quercetin 3-0-diglucoside, kaempferol 3-0-glucoside and luteolin 7-0-glucoside were ubiquitous. Two collections, however, possessed, in addition to the four previously mentioned compounds, luteolin 6-0-methoxy 7-0-glucoside and apigenin. The flavonoid complement of these two collections is identical to that of *A. fulgens*, attesting to their close morphological and genetic similarity.

A. ANGUSTIFOLIA

Seven flavonoid glycosides, comprising five flavonols and two flavones, were isolated from 103 collections within the *A. angustifolia* aggregate. Due to the limited availability of material from the U.S.S.R., Europe and eastern Canada, extensive chemical analyses were only carried out for those taxa from western North America. Collections from Greenland have also been included, but again, because of sparse material, flavonoid determination was not accomplished through exhaustive extraction and examination but rather by comparing the profiles obtained to those of *A. angustifolia* from western Canada and Alaska.

Flavonoid profiles within the *A. angustifolia* aggregate are relatively simple, with two to five compounds per population. Within *A. angustifolia* subsp. *angustifolia*, 11 different flavonoid profiles are apparent, whereas *A. angustifolia* subsp. *tomentosa* has only two profile types. Flavonoid profile similarities between these two taxa allude to their close affinity. No differences were apparent between *A. angustifolia* from North

America, Scandinavia and the U.S.S.R.

Arnica angustifolia exhibits the most divergent and numerous flavonoid profiles within the subgenus, no doubt a reflection of its polymorphic nature, many cytotypes, and the diversity of habitats in which it is found. Unlike *A. frigida*, no correlation was found between flavonoid depauperate plants and unglaciated areas.

A. LONCHOPHYLLA

Six flavonoids were isolated and identified from sixteen collections of *A. lonchophylla* subsp. *lonchophylla*. No collections of *A. lonchophylla* subsp. *arnoglossa* were examined. With the exception of one collection, all profile types obtained matched with those found in *A. angustifolia*. In total, five different profile types were discerned. The one collection examined from eastern Canada, previously treated as *A. lonchophylla* subsp. *chionopappa*, had a flavonoid profile similar to the most common profile obtained from northwestern North America.

A. RYDBERGII

Two compounds, quercetin 3,7-O-diglucoside and kaempferol 6-O-methoxy 3-O-glucoside, were unique to *A. rydbergii*. Of common occurrence in the eight collections investigated were luteolin 7-O-glucoside and kaempferol 3-O-glucoside, with flavonols quercetin 3-O-galactoside and quercetin 3-O-diglucoside of lesser occurrence. Six flavonoids (five flavonols and one flavone), representing three different profile types, were found from these Alberta and Wyoming populations.

It is obvious from the previous discussion that flavonoids are of restricted use in delimiting taxa within subgenus *Arctica*. One exception, however, is *A. rydbergii*, which is easily recognized by its unique flavonoid chemistry. It is also clearly delimitable by its structural features. *Arnica fulgens* and *A. sororia* also possess unique flavonoid profiles, but distinguishing between these two taxa with only flavonoid data can be problematic, since their respective profiles may be identical.

The compounds quercetin 3-0-galactoside, quercetin 3-0-diglucoside and kaempferol 3-0-glucoside are virtually ubiquitous in subgenus *Arctica*, indicative of a close genealogical relationship amongst all taxa. Other compounds were specific to a particular taxon, i.e. the unknown compound 7 in *A. louiseana*, and quercetin 3,7-0-diglucoside and kaempferol 6-0-methoxy 3-0-glucoside in *A. rydbergii*. The occurrence of compounds luteolin 6-0-methoxy 7-0-glucoside and apigenin in *A. fulgens* and *A. sororia*, and kaempferol 6-0-methoxy 3-0-glucoside and a 3,7-0-diglucoside of quercetin in *A. rydbergii* has phylogenetic implications and are discussed in the appropriate section of this thesis.

Flavonoid variation in subgenus *Arctica* did not correlate with ploidy. Such lack has been reported in other taxa (Glennie *et al.* 1971; Wolf 1981; Soltis and Bohm 1986).

Flavonoid diversity precludes a chance to see if hybridization has occurred between any of the taxa. Possible flavonoid similarities between *A. angustifolia* and *A. lonchophylla* may be due to past hybridization events or present-day introgression.

With the exception of *A. frigida*, in which plants exhibiting depauperate flavonoid profiles occurred only in previously unglaciated areas, all compounds in all other taxa were randomly distributed. The six major flavonoid profiles delimitable in *A. frigida* and *A. louiseana*, along with an indication as to whether the collection represents a diploid or a polyploid, is illustrated in Figure 11. The large number and divergence of flavonoid profiles in *A. frigida*, *A. angustifolia* and *A. lonchophylla* may be a function of many different genotypes present. A further study into the genetic diversity of these entities, using isozymes, would shed more light on the origin and subsequent evolution of these taxa.

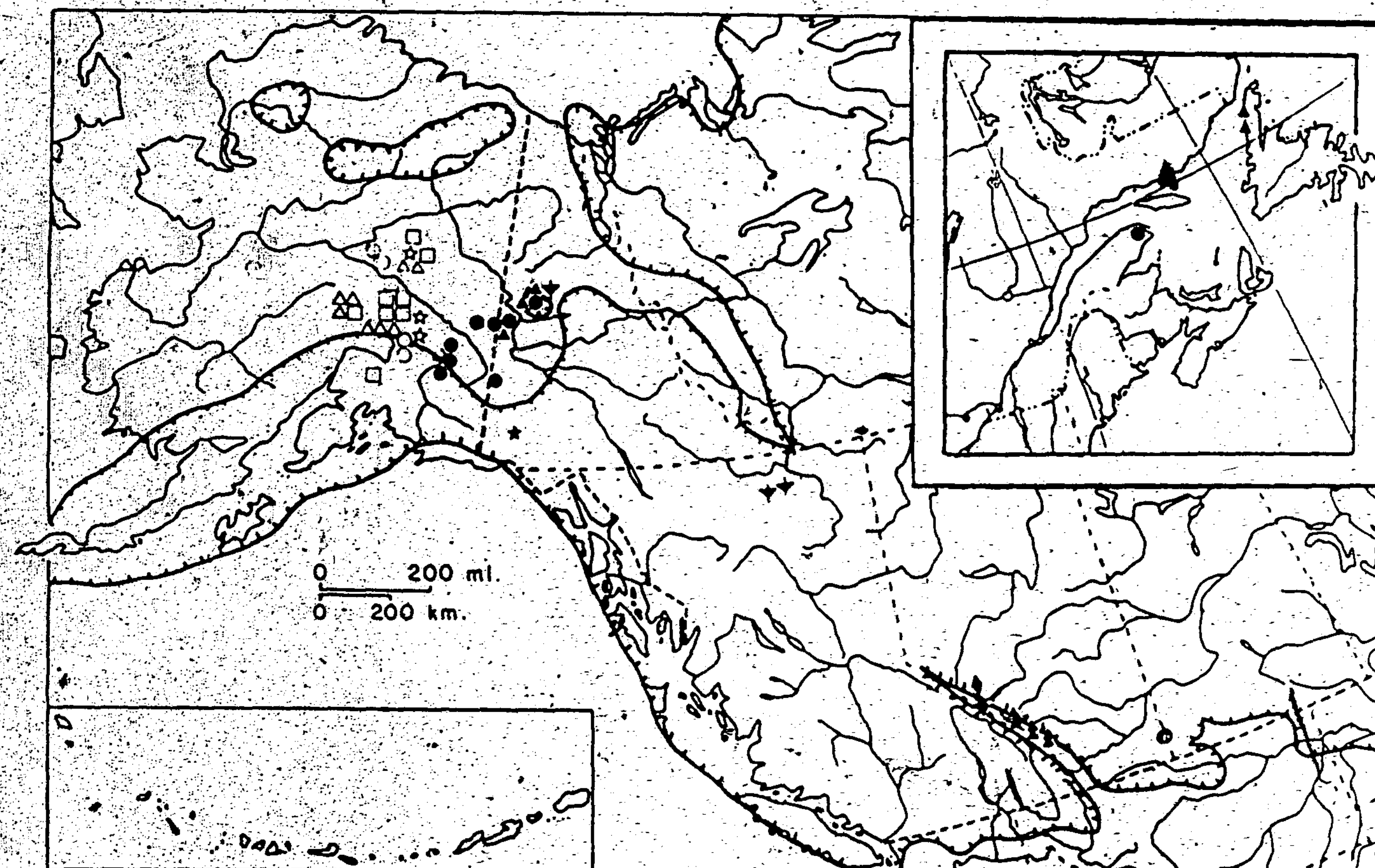


Figure 11 - Distribution of flavonoid profile types and associated ploidy level in the *Arnica frigida - louiseana* complex in relation to the approximate maximum extent of the late Wisconsinan glacier complex (solid line). Kodiak Island refugium (Karlstrom and Ball 1969) not shown. Open symbols = 2n (diploid); closed symbols = 3n, 4n, or 5n (polyploid). Flavonoid profile characterization: □ = compounds 1 & 3; ○● = compounds 1,2, and 3; △▲ = compounds 1,2,3, and 5; ✦ = compounds 1,2,3, and 4; ▲ = compounds 1,2,3,4, and 6; ♦ = compounds 1,2,3,4,6, and 7; * = miscellaneous.

IV. Phytogeography

The familiar pattern of arctic species, disjunct in the cordillera of western North America, and in extremely localized areas of northeastern North America, has received much attention (Fernald 1925; Wynne-Edwards 1937, 1939; Marie-Victorin 1938; Drury 1969; [illegible]field 1969; Morisset 1971). In order to adequately explain the present-day distribution of subgenus *Arctica*, it is necessary to postulate the survival of these plants during the late Wisconsinan in unglaciated areas north and south of the ice sheet, or perhaps in smaller refugial areas surrounded by ice.

To explain the survival of cordillerean and arctic disjuncts in eastern Canada, Fernald (1925) proposed the nunatak hypothesis. In the past, this hypothesis was subject to much controversy in the light of conflicting geological and ecological evidence (Alcock 1935, 1944; Wynne-Edwards 1937; Marie-Victorin 1938; Flint *et al.* 1942; Morisset 1971). Late Wisconsinan glaciation in Atlantic Canada consisted largely of local ice caps (Fulton *et al.* 1984). Recent geological and geographical evidence corroborates the presence of ice-free areas during this period in the Gaspé Peninsula of Québec (Hétu and Gray 1981; Lafrenière and Gray 1981; Grant and King 1984; Prest 1984), western Newfoundland (Brookes 1977; Grant 1977), northern Labrador and southeastern Baffin Island (Ives 1963; Prest 1984), southwestern Nova Scotia (Grant 1977), and localized coastal and highland areas in New Brunswick (Grant and King 1984), which may have provided refugia for the glacial vegetation. The extreme environment likely to be found during this time may have been detrimental to the survival of many plant species (Morisset 1971). However, conditions would no doubt be milder in refugia bordering upon a sea that was not frozen all year round. In a study of coastal refugia in Iceland, Lindroth (1970) reports that even a large glacier has a small influence upon climate, flora, and fauna, if a warm sea current is adjacent to the ice. According to Liljequist (1956, as cited by Morisset 1971), a warm sea current travelled along the eastern North American coast which would have offered a moderating effect upon the climate of the adjacent coastal refugium. In addition, favourable local microclimatic conditions in refugial areas could permit the survival of some plant species.

Some parts of the continental shelf may have provided refugia for plants during the late Wisconsinan (Ives 1963; Morisset 1971; Terasmae 1973; Grant and King 1984; Prest 1984). Terasmae (1973) has reported that at maximum glaciation, the sea level would have lowered as much as 130 m, and that during the period of deglaciation this level would have only increased 50 to 60 m. Environmental conditions would no doubt be milder in refugia bordering upon a sea that was not frozen all year round (Morisset 1971). The presence of late glacial vegetation on the continental shelf (Emery *et al.*, 1965; Sirkin 1967; Livingstone 1968; Terasmae 1973) indicates that at least some parts of the shelf provided refugia from which vegetation later recolonized eastern North America as the ice sheet melted.

In Alberta, it is suggested that some portions of the Rocky mountains remained ice-free during the Wisconsinan glaciation. The concept of an ice-free corridor, a strip of land positioned between the Laurentide and Cordillerean glaciers, has received much attention. There is increasing geologic (Rutter 1984), stratigraphic (Alley 1973; Stalker 1977) and palynological (Ritchie 1984) evidence for its existence. Present-day plant distributions have also been used as evidence for unglaciated refugia in Alberta (Packer and Vitt 1974).

During the late Wisconsinan (23,000 to 10,000 years ago), extensive unglaciated refuges existed in eastern Siberia (Isayeva 1984; Velichko *et al.* 1984), northern Alaska (Hultén 1937; Prest 1984), northern and central Yukon (Rutter 1984), Banks Island, N.W.T. (Vincent 1984), and the Queen Elizabeth Islands, N.W.T. (Prest 1984), which acted as centres of biotic dispersal after glaciation. Portions of Kodiak Island, Alaska (Karlstrom and Ball 1969), and coastal Greenland were also unglaciated during this time (Böcher 1963). Also, recent geological evidence (Faustova and Chebotareva 1979; Velichko *et al.* 1984) corroborate botanical evidence (Gjaerevoll 1963) for nunatak and coastal refugia in western Scandinavia during the late Wisconsinan.

The eastern Canadian representatives of subgenus *Arctica* have been treated as derivatives of the arctic or western cordillerean floras (Fernald 1924, 1933; Maguire 1943; Boivin 1952). The disjunct distribution of *Arnica frigida*, *A. angustifolia* and *A. lonchophylla* suggest that prior to the late Wisconsinan these taxa, or their precursors, had a more continuous distribution across North America, Europe and the U.S.S.R. With the advance of the late Wisconsinan glaciation, their intervening ranges were eradicated, leaving the plants to survive in northeastern North America, in the alpine of western North America, and in the unglaciated areas of northwestern North America.

Another explanation to account for the eastern disjuncts is long-distance dispersal. The ingestion of achenes by birds, or the presence of a pappus to facilitate wind dispersal, may have been the method by which these arctic plants reached eastern Canada. With the exception of a few scattered populations of *A. lonchophylla* in northeastern Minnesota and adjacent Ontario, no other intermediate stations are found even though suitable edaphic conditions occur in central Canada (Given and Soper 1981). The isolated populations of plants in the Gaspé Peninsula of Québec, New Brunswick, Nova Scotia and northwestern Newfoundland would have had to involve the successful colonization by a number of propagules.

The prevalence of diploid *A. angustifolia* and *A. frigida* in unglaciated parts of Yukon and Alaska intimates the survival of these species within this area during the late Wisconsinan. The lower sea level during maximum glaciation (Hopkins 1973) resulted in the emergence of the continental shelf between Alaska and the U.S.S.R. During the Wisconsinan, this Bering Platform permitted plant migration between the two continents (Murray 1981). Whether *A. angustifolia* and *A. frigida* migrated westward fro[m] unglaciated refugia in Alaska, or spread from unglaciated refugia in both North America and the U.S.S.R. after the melting of the last ice sheet, is difficult to ascertain.

Arnica louiseana, A. angustifolia, A. rydbergii and *A. lonchophylla* may have survived *in situ* in the Rocky mountains during this time, or perhaps survived glaciation in close proximity to their present-day sites. The establishment of ancestral *A. louiseana* in the Canadian Rockies would have had to be very early, probably during the Tertiary, to create the divergence in morphology observed between this taxon and *A. frigida*, its putative progenitor. Allopolyploids (or amphiploids) sometimes produce non-parental phenolics with structures produced by combining parental biosynthetic capacities (Mears 1979); thus newly created endemics may have a more diverse chemistry than their progenitors (Levy and Levin 1975). *Arnica louiseana* represents a taxon with one of the most complex chemical profiles in subgenus *Arctica* with five or six flavonoids present. Whether *A. louiseana* represents a novel entity created through the events of hybridization or polyploidy which, as previously suggested, may account for its complex chemical profile, or a paleoendemic which survived the Pleistocene either as present-day *A. louiseana* or its ancestor is difficult to ascertain.

Arnica fulgens and *A. sororia* are essentially sympatric in northwestern United States and adjacent southwestern Canada. In the northernmost part of their range these taxa occur in prairies and grasslands, a habitat unique amongst members of the genus, in the southernmost areas they occupy montane habitats. As previously suggested by Barker (1966), both of these taxa occupy the greater part of their range outside the limits of continental glaciation, and thus remain as sexual species.

In North America, numerous centres of glaciation developed in mountain systems south of the Wisconsinan ice sheet. Portions of the Rocky mountains from Alberta to Colorado, the Cascade mountains of Washington and Oregon, and the Uinta mountains of Utah, were subject to severe glaciation (Barker 1966). The present-day distribution of *A. rydbergii* is closely correlated with these previously glaciated alpine areas. Results from cytological investigations and pollen viability tests indicate this taxon to be wholly apomictic, corroborating Barker's (1966) hypothesis that no well-formed amphimictic species occurs in a glaciated area. However, one diploid population has been found in northwestern Montana (Wolf 1980) suggesting existence of diploid populations of *A. rydbergii*.

Arnica lonchophylla subsp. *lonchophylla* is primarily distributed in low lying areas along river basins (e.g. Mackenzie, Athabasca, Peace, Nelson) and lakes (e.g. Athabasca, Great Slave, Great Bear) in northern and central Canada. In addition, small localized populations of this taxon are found near the western shore of Lake Superior. How can these populations be accounted for? It has been suggested that the numerous arctic-alpine plants at Lake Superior are relicts of more widespread distributions (Given and Soper 1981), for this region was completely covered by ice during the Wisconsinan (Karrow 1984; Prest 1984). A strip of tundra-like terrain occurred south of the Laurentide ice sheet in which lived vegetation of an arctic-subarctic nature (Wright 1971;

Birks 1976). With glacial recession these plants migrated northward. The harsh microclimate of the Lake Superior shoreline maintains a suitable arctic-alpine habitat (Given and Soper 1981), resulting in the persistence of vegetation in this region after the ice sheet melted. Boivin (1952) has suggested that *Arnica* first established itself around the temporary lakes fronting the retreating glacier, and then progressively migrated northward along glacial rivers as new shorelines were created. With the subsequent development of the boreal coniferous forest and acidic granite-derived soils, or perhaps simply not being able to cope with the rapid change in shorelines, *A. lonchophylla* was unable to migrate farther north and ultimately established itself near the northwest shore of Lake Superior.

The distribution of *A. lonchophylla* subsp. *arnoglossa* is unique within subgenus *Arctica* for populations are restricted to two geographic areas; the Black Hills of South Dakota, and the eastern slopes of the Big Horn mountains in north-central Wyoming. The morphological similarity between this taxon and *A. lonchophylla* subsp. *lonchophylla* suggest origin from common ancestral stock that was once more widespread across North America. Complete absence of glaciation in the Black Hills (Hayward 1928) provided a glacial refuge for this species during the Wisconsinan. Amphimictic *A. lonchophylla* in the Black Hills suggests that this region was not glaciated (Barker 1966). To the west of the Black Hills are the Big Horn mountains which were subject to some local glaciation (Salisbury 1906). Therein live both amphimictic and apomictic *A. lonchophylla* subsp. *arnoglossa*. The presence of diploid *A. lonchophylla* in South Dakota and Wyoming suggests survival of this species south of the continental ice sheet, with subsequent migration northward, primarily along the major river systems of northwestern Canada, to account for its present-day distribution.

Considering the distribution of chromosome races in *Arnica*, Barker (1966) showed that no well developed sexual species occurs in a glaciated area, and no well developed polyploid series occurs in an unglaciated area. This correlation between polyploids in previously glaciated areas and diploid cytotypes of the same species in unglaciated areas has also been documented in *Iris versicolor* (Anderson 1936), *Calamagrostis* (Stebbins 1984), *Minuartia elegans* (Wolf 1977), and may have existed in the genus *Braya* in North America (Harris 1984). Favarger (1961) and Johnson and Packer (1965) demonstrated that northern polyploids are more common in habitats most directly affected by climatic and edaphic deterioration during glaciation and that these habitats are of prime importance in determining the relative distribution patterns of diploids and polyploids. The greater genetic variability of polyploids in general, particularly when accompanied by ecotype or species hybridization, provides greater adaptability to new ecological conditions (Johnson and Packer 1965; Stebbins 1984, 1985). In contrast, diploids may succumb to these same selective pressures and be eliminated altogether (Stebbins 1971). Barker (1966) stated that within *Arnica*, some previously widespread diploid taxa survived in unglaciated refugia and ultimately suffered biotype depletion. These populations subsequently gave rise to polyploid apomicts from which virtually all post-glacial colonization has taken place.

The polyploid series of *A. angustifolia* and *A. frigida* appear to have radiated geographically and ecologically from this region following melting of glacial ice. Through dispersal and adaptation to different habitats, ecotypic variation, including chemical variation would occur. With the prevalence of apomixis in these two species (Barker 1966), and the marked morphological variability exhibited by both, much of the flavonoid diversity probably reflects genetic heterogeneity from population to population. The marked polymorphism of these taxa is also a function of the variety of adaptive niches which these populations were able to occupy and exploit. The polyploids of these two species have been particularly successful in recolonizing previously glaciated areas. Considerable flavonoid populational variation has already been found in populations of *A. cordifolia*, a widespread polymorphic species consisting of five chromosome races (Wolf 1981). In contrast, *A. fulgens* and *A. sororia*, each comprised of only one chromosome race and with narrow habitat specificity, exhibit little morphological and flavonoid variability.

Narrow endemics are generally characterized by a reduced flavonoid profile composed principally of methylated aglycones, while in contrast, wide-ranging species within the same genus, occurring in a number of different habitats, are characterized by a high flavonoid diversity and few methylated aglycones (Mears 1980; Wolf 1981).

Similarly, in studies using allozymes, genetic variation has been reported to be lowest in narrow endemics (Hamrick *et al.* 1979; Soltis 1982). Mears (1980) has further reported in *Parthenium* a significant positive correlation between the total number of flavonoids per taxon and the area of distribution. An increase in flavonoid number with a corresponding increase in area can be contrasted to isolated island populations derived from mainland taxa in which both fewer and structurally simpler compounds are produced (Mabry 1974). The depletion of the ancestral profile in narrow endemics may be due to such factors as the founder effect, autogamy (leading to a reduction in gene flow), and low environmental heterogeneity. With reference to subgenus *Arctica*, wide-ranging *A. frigida*, *A. angustifolia* and *A. lonchophylla* subsp. *lonchophylla* show a high flavonoid diversity, with two to five flavonoid compounds in any one particular population. *Arnica fulgens*, *A. sororia* and *A. rydbergii*, however, maintain a high degree of flavonoid uniformity over wide geographic areas. The lack of any representative of *A. lonchophylla* subsp. *arnoglossa* preclude observations on flavonoid quality and quantity of this narrow endemic. Of somewhat greater distribution than *A. lonchophylla* subsp. *arnoglossa* is *A. louiseana*, restricted to the Canadian Rockies. This species exhibits one of the most complex flavonoid profiles within the subgenus. No methylated aglycones were found in any taxa of subgenus *Arctica*. The presence of flavonoid-depauperate *A. frigida* in unglaciated Alaska suggests that flavonoid number is of value in establishing plant refugial boundaries. A reduced flavonoid profile would probably reflect a lesser genetic variability, a consequence of biotype depletion created by a diminished range through glaciation. Unfortunately, this correlation between previously unglaciated areas and flavonoid paucity does not hold true for *A. angustifolia*. Flavonoid depauperate plants of this taxon occur throughout the Yukon Territory, Northwest Territories and northern British Columbia. One therefore has to be careful when extrapolating possible past refugial areas from flavonoid data.

V. Phylogeny

Maguire (1943) considered *Arnica* to have originated in the arctic and subarctic regions of western North America from where it spread eastward, westward, and southward. The paucity of *Arnica* species in Europe and Asia, and the presence of about twenty-five species confined primarily to the arctic, boreal and montane regions of northwestern North America, was used to support his hypothesis. However, this postulated geographical origin of *Arnica* may be subject to error, for an area of high species diversity may not necessarily be the center of origin for a particular taxon (Johnson and Raven 1970).

The genus *Arnica* is clearly defined, with the included species held together by similar phytochemistry, chromosome base number and structural characters. It is monophyletic, being derived from a hypothesized ancestor, *Protoarnica*. Based upon principal centers of dispersal and morphological similarity, Maguire (1943) recognized five subgenera, with subgenus *Arctica* representing the most ancestral group. The probable relationships of the other subgenera in *Arnica* are not at all clear, and precise delineation is speculative. These subgenera may have arisen from subgenus *Arctica*, or independently from *Protoarnica* (Maguire 1943).

Maguire's (1943) phylogenetic interpretation for the taxa comprising subgenus *Arctica* is presented in Figure 12. His recognition of seventeen taxa within the subgenus (seven of these being wholly confluent), resulted in a poor phylogenetic interpretation. Little justification was given for the assignment of lineages. The close morphological similarity between *A. fulgens* and *A. sororia* is not reflected in this phylogenetic scheme. Maguire (1943) suggests that *A. fulgens* has closest affinities with *A. angustifolia* due to a similarity in periclinium pubescence and only one capitulum. *Arnica sororia*, on the other hand, superficially resembles *A. lonchophylla* and stated to have close affinities with this species, or as illustrated in his phylogenetic interpretation, may have also originated from *A. frigida*. In the original description of *A. sororia* by Greene (1910), he notes the close affinity with *A. lonchophylla* but also is aware of similarities with *A. fulgens*. Similar confusion exists in determining the lineage of *A. lonchophylla*. *Arnica lonchophylla* is postulated to have arisen either from *A. frigida*, or directly from

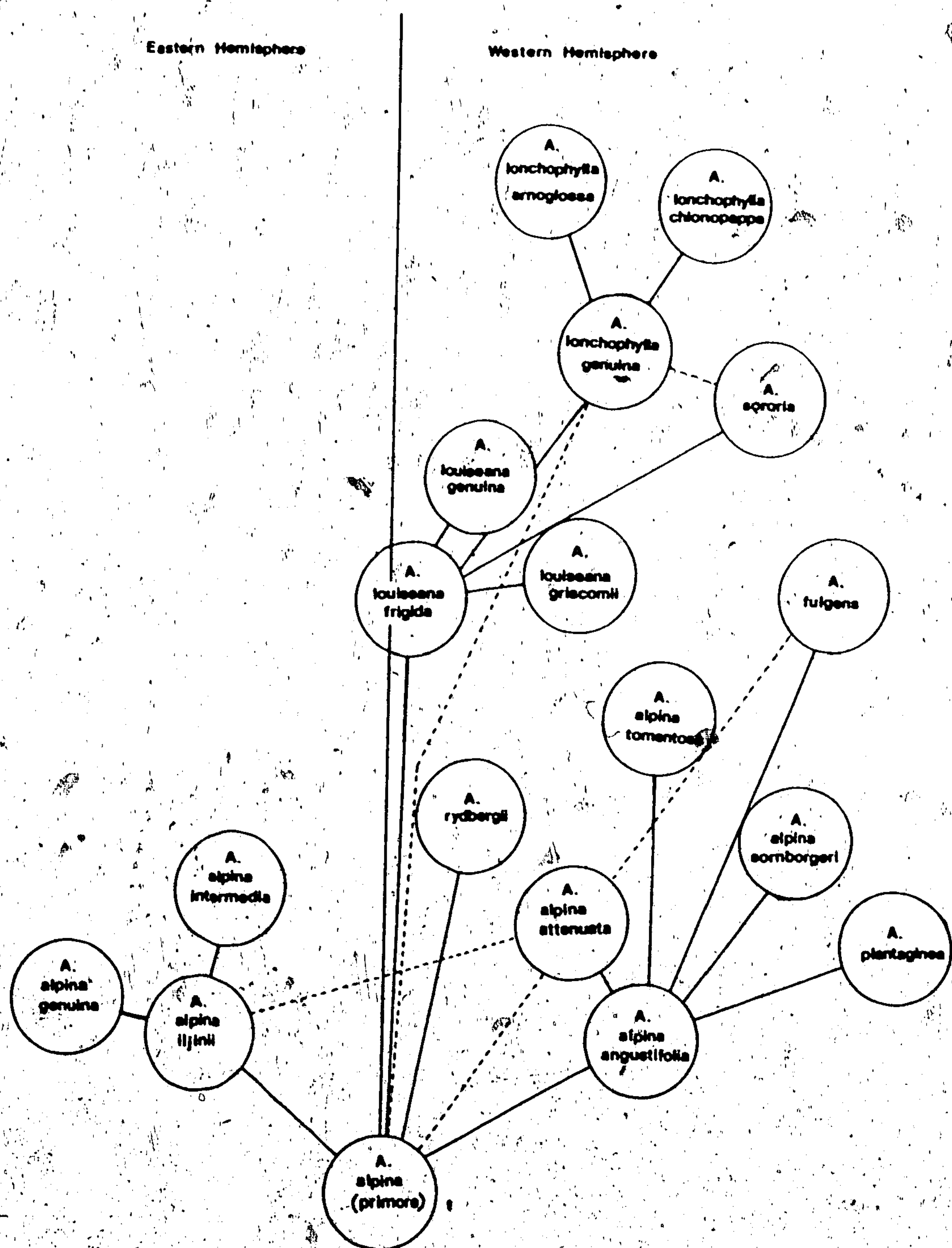


Figure 12 - Relationships of the species of subgenus *Arctica* (modified from Maguire, 1943).

A. angustifolia (Maguire 1943). Needless to say, the delineation of taxa within this complex in the past has been at best highly speculative, with alternative origins proposed.

In the present study, structural, ecological, and flavonoid synapomorphies are used to construct a cladogram from which phylogenetic relations amongst the taxa comprising subgenus *Arctica* can be determined. The prevalence of apomixis, polyploidy and hybridization in *Arnica* makes phylogenetic analyses, and sister group designation for subgenus *Arctica* difficult. The taxa comprising the remaining four subgenera, all plausible sister groups, have been employed as the outgroup in this study. Determining whether a particular character represents an apomorphic or plesiomorphic state is sometimes difficult, but made virtually impossible when variation in critical characters, whether within the ingroup or the outgroup, occurs. Certain characters previously used by Wolf (1981) were eliminated because of uncertainty concerning polarity. In the following discussion, evidence is presented regarding the importance of previously used taxonomic characters, and the discrediting of others, due to their environmental plasticity or variability. Where appropriate, plesiomorphic and apomorphic character states are presented. Phylogenetic relationships are then discussed in light of morphological, ecological and phytochemical evidence accumulated during this study.

I believe subgenus *Arctica* is also monophyletic. All species possess (1) a large, hemispheric to campanulate-turbinate capitulum, (2) a white, barbellate pappus, (3) few pairs of narrow, lanceolate to oblanceolate leaves, (4) a rhizome covered with dark, imbricate scales and leaf base remnants, (5) arctic/alpine ecology (with the exceptions of *A. fulgens*, *A. sororia* and *A. lonchophylla*), and (6) the prevalence of simple flavonols and flavones based on the glycosides of glucose and galactose.

Habit. All species of *Arnica* are herbaceous perennials; consequently habit concerns primarily with underground structures. The amount of branching, length, and indument of the rhizome have been deemed important in distinguishing among the subgenera of *Arnica* (Maguire 1943). In subgenus *Arctica*, many branches of the rhizome are quite short, and for many plants the previous years' shoots are long persistent. In *A. angustifolia* subsp. *angustifolia*, *A. frigida*, *A. lonchophylla*, *A. louiseana* and *A.*

sororia, the rhizomes are generally slender, but appear thicker because of the presence of numerous dark imbricate scales and remnant leaf bases. In *A. angustifolia* subsp. *tomentosa*, most rhizome branches are very short and many appear to be ascending. Many plants of *Arnica rydbergii* grow in caespitose clumps, a result of several branches arising from the rhizome tip. Long, dense tufts of brown woolly hair are in the axils of the old leaves of *A. fulgens*. The uniqueness of this character within the genus, and the correlation of this character in plants living in arid grassland and lower montane regions of western North America, suggest that it may be apomorphic.

Stems. Maguire considered degree of stem branching important for specific delimitation in *Arnica*. Stems are either simple or branched; and if the latter, branched either above or below the center of the stem. Stem branching in subgenus *Arctica* is confined to a few anomalous individuals, which exhibit branching below the middle of the stem. With the exception of *A. rydbergii*, stems of most plants arise singly from the underground rhizome, with both flowering shoots and sterile basal rosettes of leaves (innovations) being produced. Maguire (1943) considered the unbranched habit as plesiomorphous in *Arnica*, and stem branching as apomorphous. However, the paucity of specimens in subgenus *Arctica* possessing branched stems precludes this character from being included in the phylogenetic analysis.

Stem height varies considerably within the subgenus. Depauperate specimens of *A. louiseana* only reach 4 cm, whilst robust *A. fulgens* can attain a height of 72 cm. Stem pubescence and glandularity are more prominent on the peduncle, and somewhat sparser farther down the stem. The assigning of this character into discrete character states was accomplished by determining degree of vestiture just above the topmost pair of leaves.

Leaves. Of primary importance in recognition of species and in determination of intraspecific relationships are number, position, shape, margin, apex, and petiole length and width, of the leaves. Although markedly varied, leaf characters are the most reliable in distinguishing among some species of *Arnica* (Maguire 1943; Wolf 1981).

One to four pairs of cauline leaves are normally apparent, with one to three more pairs of leaves in the taller specimens. In *A. louiseana*, cauline leaves are lacking entirely from some specimens. These cauline leaves essentially occur below the middle of the stem. Within *Arnica*, a general evolutionary trend extends from few pairs of leaves distributed mostly below the middle of the stem, to numerous leaves evenly distributed throughout the stem (Maguire 1943). Leaf shape varies from linear or narrowly lanceolate in *A. angustifolia*, to broadly lanceolate to ovate in *A. lonchophylla* and oblanceolate to spathulate in *A. rydbergii*. *Arnica frigida* and *A. louiseana* leaves are usually elliptic or spathulate to ovate-lanceolate, and the leaves of *A. fulgens* and *A. sororia* are generally oblanceolate to oblong. Leaf margins are entire in *A. fulgens* and *A. sororia*; entire, denticulate or dentate in *A. angustifolia* and *A. rydbergii*, to regularly dentate in *A. lonchophylla*. The leaf margins of *A. frigida* and *A. louiseana* are undulate, entire or dentate. *Arnica lonchophylla* represents the only taxon within the subgenus with a long, narrow petiole equaling the length of the blade. In contrast, *A. rydbergii* is characterized by sessile or subsessile lower leaves. All other species in subgenus *Arctica* are intermediate with respect to petiole length and width, with the majority of taxa exhibiting short and broadly winged petioles. In all *Arnica* taxa, the leaves of the innovations are long and narrowly petiolate. The upper leaves in many specimens are reduced, bract-like, and subopposite in few specimens.

Wolf (1981) noted in subgenus *Austromontana* that broad, coarsely dentate and long narrowly petiolate leaves represent the plesiomorphous state, whereas narrower, entire margined and sessile leaves are more likely apomorphous. If we consider *A. angustifolia* or an *A. angustifolia*-like ancestor (evidence for this will be forthcoming), as the precursor of all taxa within the genus, and the prevalence of narrow, entire to slightly denticulate leaves and short, broadly winged petioles in this taxon, it is unlikely that these taxa possessing broader and more coarsely dentate leaves are plesiomorphous. The presence of both sessile and long, narrowly petiolate leaves in *Arctica* poses a problem. In subgenera *Austromontana* and *Chamissonis*, both long petiolate and sessile (or subsessile) leaves are common. In subgenera *Montana* and *Andropurpurea* all leaves are essentially sessile. There does not appear to be any perceptible evolutionary trend regarding this character, and thus, it is omitted from the variable to be of importance. Both glandular and non-glandular hairs are common.

Maguire (1943) recognized the dense periclinium pubescence as plesiomorphic in the subgenus. However, as previously mentioned, this character was quite variable and environmentally influenced. Maguire used presence (or absence) of long stipitate glandular hairs on the periclinium to delimit infraspecific taxa within *A. angustifolia*. With the exception of *A. angustifolia* subsp. *angustifolia* and *A. frigida*, stipitate glands are obvious in all other taxa. This evident glandularity may again represent an apomorphic state for the subgenus.

Achenes. Achenes in subgenus *Arctica* are variously pubescent, glandular, or glabrous. In *A. angustifolia, A. fulgens, A. sororia, A. rydbergii* and *A. lonchophylla* the achenes are densely hirsute throughout, and rarely glandular. In *A. frigida*, the achenes are glabrous at the base and sparsely hispid at the summit. The achenes of *A. louiseana* are similar to that of *A. frigida*, but are prominently covered in short glandular hairs. Hirsute and glabrous achenes are commonly found in all subgenera of *Arnica*. Wolf (1981) observed in subgenus *Austromontana* gray achenes are probably plesiomorphous, while brown and black represent the apomorphic condition. In subgenus *Arctica*, all achenes are black. Few evolutionary trends are discernible regarding *Arctica* achenes. Perhaps glandular hairs on the achene represents an apomorphous state, since *A. louiseana* and *A. lonchophylla* subsp. *arnoglossa* possess them, and plesiomorphous species, such as *A. angustifolia*, lack them.

Ecology. With about 25 species of *Arnica* confined to the arctic, boreal and montane regions of northwestern North America, it seems more than likely that the genus originated here, inferring that a more southerly distribution and preference for a xeric habitat represents evolutionary advancements. Both *A. fulgens* and *A. sororia* are common throughout prairie and grassland habitats of western North America, hence are considered apotypic.

Flavonoid Chemistry. Two opposing trends are evident for flavonoid complexity and evolutionary advancement within angiosperms. Within a specific genus the dominant flavonoid trend is one of reduction in which fewer and structurally simpler compounds are produced (Averett 1973; Mabry 1974; Bohm and Wilkins 1978; Soltis 1980b; Averett and Boufford 1985). In contrast, another trend of flavonoid evolution is towards increasing complexity with the phyletic advancement of a genus (Whalen 1978; Crawford and Smith 1983a; Pacheco *et al.* 1985). Some studies have demonstrated no clear-cut trends towards reduction or elaboration of flavonoids with phyletic lines (Giannasi 1975; Crawford and Smith 1983b). Further complications arise when diversification of the flavonoid nucleus occurs. The directionality of flavonoid evolution as determined for one group of plants may not be the same for another. These structural modifications can make evolutionary interpretations quite speculative.

Wolf (1981) has suggested that the presence of quercetin 3-0-glucoside, kaempferol 3-0-glucoside and luteolin 7-0-glucoside may represent an ancestral condition in *Arnica*, since they are found in a great number of *Arnica* species from all areas of its distribution. In *A. cordifolia*, a taxon postulated by Maguire (1943) and Wolf (1981) to represent the ancestral species in subgenus *Austromontana*, four additional compounds are present which were also considered plesiotypic. These are quercetin 3-0-gentiobioside, quercetin 3-0-diglucoside, apigenin 6-0-methyl ether and possibly kaempferol 6-0-methoxy 7-0-glucoside. Generally, those species exhibiting predominantly flavonols, or their simple methyl ethers, represent ancestral taxa. The presence of highly methylated flavones and hydroxylation at the 6-position are considered advanced (Harborne 1977), and characterize such species as *A. viscosa*, a volcanic endemic (Wolf 1981). *Arnica* subgenus *Arctica* has kaempferol 3-0-glucoside, luteolin 7-0-glucoside, quercetin 3-0-gentiobioside and quercetin 3-0-diglucoside; all flavonoid compounds previously described as being plesiotypic. In addition, other simple flavonols were noted. Quercetin 3,7-0-diglucoside, a flavonoid not previously reported in *Arnica*, and the compounds luteolin 6-0-methoxy 7-0-glucoside and kaempferol 6-0-methoxy 3-0-glucoside, previously reported only in subgenus *Austromontana*, are considered synapomorphies.

The preponderance of methylated flavonoids (including two compounds never before reported in the Asteraceae) in the flowers of *A. chamissonis* and *A. montana* (Merfort 1984, 1985), belonging to subgenera *Chamissonis* and *Montana*, respectively, and the common occurrence of mono-methyl ethers and highly methylated flavone derivatives in subgenus *Austromontana* (Wolf 1981), strongly suggest that these three subgenera are apotypic to subgenus *Arctica*. As previously mentioned, subgenus *Arctica* represents the closest derivative of a hypothesized archetype, *Protoarnica*, with subgenus *Austromontana* either arising directly from *Protoarnica*, or from subgenus *Arctica* (Maguire 1943). The markedly similar flavonoid properties of these two subgenera, and absence of any highly derived or methylated flavonoids in subgenus *Arctica*, suggest that members of *Arctica* probably represent the most primitive present-day taxa within the genus, with *Austromontana* arising from *Arctica*. Crawford (1978) has cautioned that an evaluation of plesiotypic versus apotypic profiles should only be made in conjuction with all other available information. An investigation into the flavonoids of the three remaining subgenera in *Arnica*, in collaboration with a thorough morphological and cytological study, will have to be completed before phylogenetic relations among all subgenera can be hypothesized.

In the present study, a total of fifteen structural, ecological and flavonoid apomorphies were used in the phylogenetic analysis (Table 10). The resultant cladogram, created solely on the insertion of synapomorphies, is presented in Figure 13.

Arnica angustifolia has been interpreted as the progenitor of all taxa in subgenus *Arctica* (Maguire 1943), and I concur with this view. It is the most widespread and only completely circumpolar species of *Arnica*. This taxon also protrudes in a southerly direction along three major radii: (1) along the coast of eastern Siberia, (2) in the alpine regions of northwestern North America, and (3) along the North Atlantic coast in eastern North America. In these regions it is sympatric, or close to, all other arnicas. With four ploidy races, a seemingly ancient and diverse flavonoid chemistry, an arctic-alpine ecology, a wide geographic distribution, a non-specific habitat preference, an extremely polymorphic habit, and the possession of many plesiomorphous morphological features, *A. angustifolia* is almost certainly the ancestral species in subgenus *Arctica*, and perhaps in the whole genus. Differences between *A. angustifolia* subsp. *angustifolia* and *A. angustifolia* subsp. *tomentosa* have already been discussed, and will be further expanded upon in the taxonomy section of this thesis.

Table 10. Plesiomorphous and apomorphous characters used in the phylogenetic analysis of *Arnica* subgenus *Arctica*. Synapomorphies only were used in cladogram construction.

Character	Plesiomorphous	Apomorphous
A Capitulum shape	broadly hemispheric to hemispheric-campanulate	campanulate-turbinate
B Capitulum colour	yellow	orange-yellow
C Ligulate floret teeth	prominently 3-lobed	entire or minutely 3-lobed
D Disc corolla glandularity	absent	present
E Leaf pubescence	glabrous to moderately pubescent	densely tomentose
F Leaf margin	entire, denticulate to occasionally dentate	regularly dentate
G Leaf shape	linear to lanceolate	broadly lanceolate to ovate
H Dense axillary hair tufts	absent	present
I Achene glandularity	absent	present
J Periclinium glandularity	absent	present
K Involucral bract shape	lanceolate to broadly lanceolate	linear or narrowly lanceolate
L Ecology	arctic/alpine	grassland/montane
M Quercetin 3,7-0-diglucoside	absent	present
N Luteolin 6-0-methoxy 7-0-glucoside	absent	present
O Kaempferol 6-0-methoxy 3-0-glucoside	absent	present

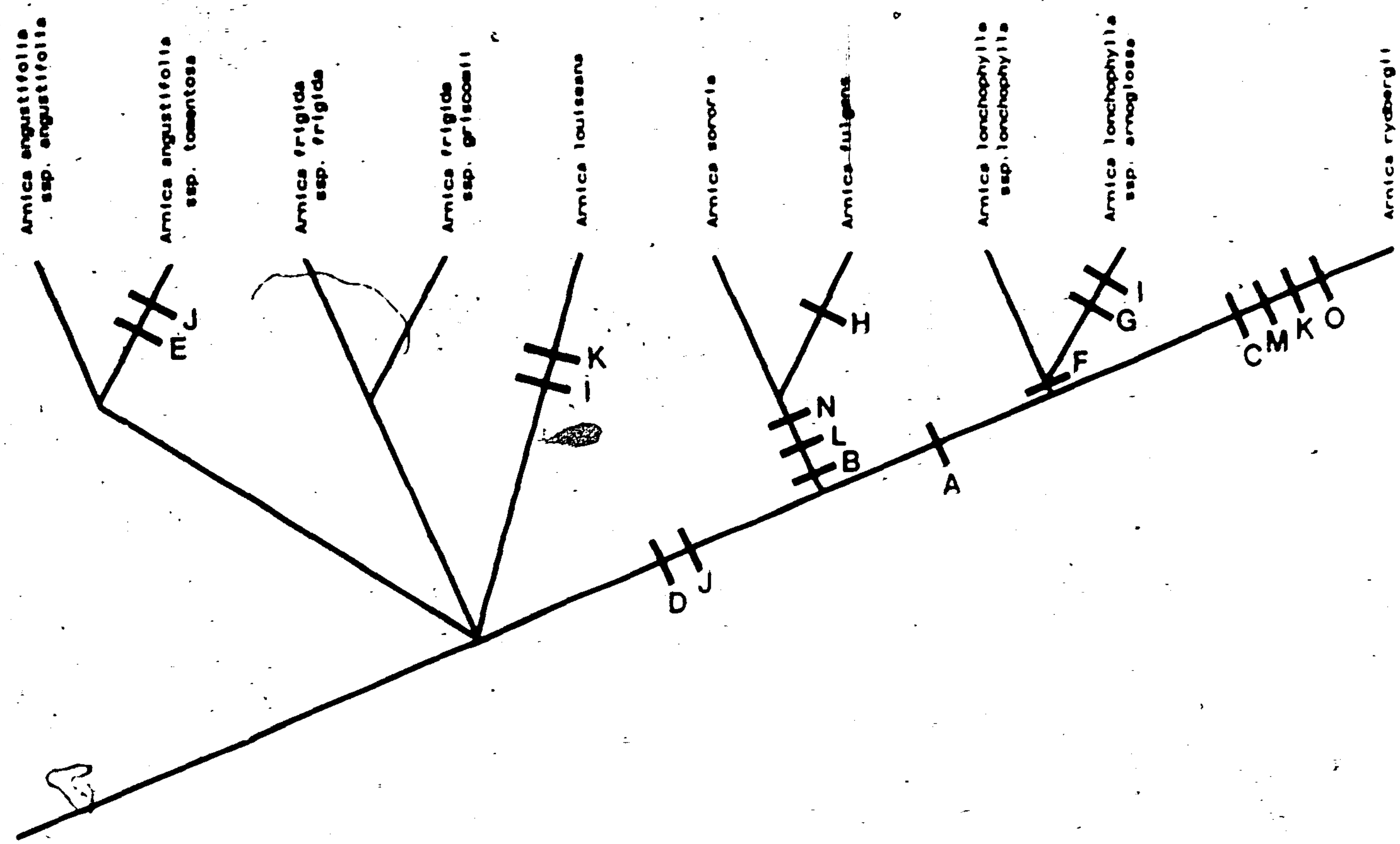


Figure 13 - A hypothesis of the relations within *Arnica* subgenus *Arctica* as shown by structural and flavonoid synapomorphies.

Maguire (1943) stated that *A. frigida* became segregated into two outlying geographical races, subsp. *griscomii* in eastern Canada, and *A. louiseana* (or more likely a precursor to present-day *A. louiseana*) to the south. There appears to be little problem postulating the close genetic affinity between the northern and eastern disjucts of *A. frigida*. Both taxa are similar chemically and morphologically, but are distinguished by geographical distribution, habitat specificity and a few subtle morphological differences (see Taxonomy chapter). *Arnica louiseana*, with its glandular leaves, stems, involucral bracts, periclinium and achenes, is distinctive. The lack of luteolin 7-0-glucoside in *A. frigida* and *A. louiseana*, a flavone prevalent in all other species, and similar morphological characters, are unifying features suggesting that these two taxa originated from a common ancestor.

The marked degree of morphological, cytological, ecological and flavonoid similarity between *A. fulgens* and *A. sororia* suggests that they are sister groups. This is in contrast to Maguire's (1943) proposed phylogenetic interpretation, in which these two taxa were treated as unrelated. All collections of *A. fulgens* had luteolin 6-0-methoxy 7-0-glucoside and apigenin; whereas only two collections of *A. sororia* had these compounds. The presence of these two flavonoids in *A. sororia* is significant; however, a more thorough examination to determine the full range of flavonoid variability thr[illegible]t the entire distribution of these plants is required before phylogenies based on fl[illegible]d data can be positively assured.

Dense axillary tufts, glandular hairs only on the disc corolla, the possibility of polyploidy (a triploid from Cypress Hills, Sask.), and ubiquity of luteolin 6-0-methoxy 7-0-glucoside and apigenin in *A. fulgens* suggests that *A. fulgens* is best considered derived from *A. sororia*.

Arnica fulgens and *A. sororia* are morphologically more similar to *A. angustifolia* than to *A. lonchophylla*. The large, solitary, hemispheric capitulum, entire to irregularly dentate leaves, and the short, narrow or broad-winged petioles of *A. fulgens*, *A. sororia* and *A. angustifolia*, are in contrast to the numerous small campanulate-turbinate capitula, and the long petiolate, regularly dentate leaves of *A. lonchophylla*.

In northwestern Canada, where the ranges of *A. angustifolia* subsp. *angustifolia* and *A. lonchophylla* overlap, some specimens cannot be assigned to any one taxon without difficulty. This similarity in morphology led Douglas and Ruyle-Douglas (1978) to propose *A. angustifolia* subsp. *lonchophylla*. The status of these two taxa is further confounded by their flavonoid chemistry, for no differences are apparent. In addition, both these taxa share similar habitats, and the same ploidy levels. Where the ranges of these two taxa do not overlap, specimens representing *A. lonchophylla* and *A. angustifolia* are separated with ease. *Arnica lonchophylla* subsp. *arnoglossa* and the eastern disjunct of *A. lonchophylla* subsp. *lonchophylla* are evidently long petiolate, have prominent regularly dentate teeth and obvious campanulate-turbinate capitula. Similarly, *A. angustifolia* from Scandinavia, U.S.S.R., Greenland and eastern Canada show great degree of morphological uniformity. Unfortunately, the paucity of live collections from these areas does not permit a comprehensive flavonoid survey to determine probable parental compounds. Nevertheless, in northwestern Canada, evidence suggests that these two taxa may be hybridizing; however, the actual extent of this is unknown.

Sessile leaves, narrowly campanulate-turbinate capitula, minutely denticulate or entire ligulate florets, linear to narrowly lanceolate involucral bracts, and the presence of quercetin 3,7-O-diglucoside and kaempferol 6-O-methoxy 3-O-glucoside in *A. rydbergii* clearly sets this taxon off from the remainder of the subgenus. It still, however, retains all the features characteristic of subgenus *Arctica*, and definitely belongs within this complex.

VI. General Discussion and Conclusions

Arnica subgenus *Arctica*, as circumscribed in the present study, consists of seven species. No new taxa have been proposed; however, seven names previously recognized by Maguire (1943) are synonymized. One new combination, *A. frigida* subsp. *griscomii*, is proposed. Three species within the subgenus are extremely polymorphic, and variable with respect to their ploidy level and foliar flavonoid chemistry. This variation, exhibited by *A. angustifolia*, *A. frigida* and *A. lonchophylla*, no doubt has influenced their complex taxonomy. For each of these species, infraspecific taxa have been recognized; subspecies *tomentosa*, *griscomii* and *arnoglossa*, respectively. *Arnica fulgens*, *A. sororia*, *A. louiseana* and *A. rydbergii* are morphologically clearly defined. *Arnica angustifolia* and *A. lonchophylla*, although each markedly varied and partially confluent, are readily recognized by a combination of morphological, ecological and distributional characters. Similarly, *A. fulgens* and *A. sororia*, two species previously considered inseparable, are clearly separate taxa.

Cluster and principal component analyses have been effective in delimiting groups of taxa within the subgenus. Noteworthy here is the separation of *A. angustifolia*, a taxon previously recognized as comprising seven or more infraspecific taxa, into two groups. I have not seen enough U.S.S.R. material to state unequivocably that subspecies *intermedia* and *iljinii* (sensu Maguire) are identical to North American *A. angustifolia*. Both these taxa are inadequately represented in herbaria, and perhaps are not as widespread in the U.S.S.R. as Maguire (1943) believed. However, the few available specimens annotated by Maguire are wholly confluent with the normal variation in *A. angustifolia*. When more information on chromosome numbers and flavonoid chemistry becomes available from the U.S.S.R., these plants can be assigned to *A. angustifolia* ssp. *angustifolia* with greater certainty. A TAXMAP analysis of the *A. frigida* - *louiseana* complex resulted in recognition of two species, *A. frigida* and *A. louiseana*, the former now comprised of two infraspecific taxa. Similarly, the previously recognized *A. lonchophylla* subsp. *chionopappa* and *A. wilsonii* were treated by TAXMAP as confluent with *A. lonchophylla* subsp. *lonchophylla* and thus, have been combined with the latter.

With respect to chromosome numbers, the base number for all taxa is x=19. Aneuploidy was not evident. Four ploidy races (2n=38, 57, 76, and 95) characterize *A. angustifolia* and *A. frigida*, whereas *A. fulgens*, *A. sororia* and *A. lonchophylla* subsp. *arnoglossa* may comprise solely 2n=38 individuals. Diploid (2n=38) and tetraploid (2n=76) populations comprise *A. rydbergii*, triploid (2n=57) and tetraploid populations comprise *A. lonchophylla* subsp. *lonchophylla*, and tetraploid and pentaploid (2n=95) individuals comprise *A. louiseana*. Ploidy was not related to any particular habitat type.

Investigations of pollen quality in subgenus *Arctica* corroborate Barker's (1966) hypothesis that amphimictic populations produce well-formed pollen grains with greater than 90% stainability, whereas apomictic populations, *i.e.* polyploids, showed varying degrees of pollen deformity and less than 80% stainable pollen. Collections having a pollen viability greater than 90% showed a very close correlation with non-glaciated areas.

Twelve flavonoids were isolated, and eleven identified, from *Arnica* subgenus *Arctica*. Flavonoid profiles are relatively simple, with two to six compounds per population; however, considerable populational variation was exhibited by *A. angustifolia*, *A. lonchophylla* and *A. frigida*. Simple mono-glycosides of quercetin and kaempferol were ubiquitous suggesting a somewhat similar biochemical profile, and a close genealogical relationship amongst all taxa. The presence of quercetin 3,7-O-diglucoside and kaempferol 6-O-methoxy 3-O-glucoside in *A. rydbergii*, and luteolin 6-O-methoxy 7-O-glucoside in *A. fulgens* and *A. sororia* indicate considerable divergence from the ancestral condition.

Studies of the reproductive behaviour of *A. fulgens* and *A. sororia* indicate that both taxa are completely amphimictic and self-incompatible. Artificial hybridization experiments between these two taxa were unsuccessful attesting that they are distinct reproductively, and thus valid species. Reproductive studies for the remaining five species were not made.

Evidence is strong that past glacial events created the complex distribution patterns of subgenus *Arctica*. The circumpolar disjuncts of *A. angustifolia* subsp.

angustifolia, and the North American isolates of *A. frigida*, *A. lonchophylla* and *A. angustifolia* subsp. *tomentosa*, suggest that these taxa were more widespread prior to the last glaciation. These disjunct distributions are probably the result of survival in refugia during the late Wisconsinan, with subsequent colonization of previously glaciated areas by apomictic elements. The more northern species are predominantly apomictic, with amphimictic *A. angustifolia* and *A. frigida* found within unglaciated Alaska and Yukon Territory. *Arnica fulgens* and *A. sororia* are diploid, having survived south of the ice sheet. Although not examined in this investigation, diploids have also been reported in *A. lonchophylla* subsp. *arnoglossa* from the Black Hills of South Dakota, another refugial area. The polyploid races of subgenus *Arctica* have been very successful in recolonizing previously glaciated areas. In *A. frigida*, plants exhibiting depauperate flavonoid profiles occurred only in previously unglaciated areas; in all other taxa flavonoid compounds showed no geographic correlation.

Arnica angustifolia has been interpreted as the most ancestral of all taxa within the subgenus, and perhaps of the whole genus. *Arnica frigida* and *A. louiseana* are early derivatives, for they maintain similar plesiomorphous morphological and phytochemical features, and live in the same geographic areas as *A. angustifolia*. With a habitat specificity to more xeric conditions, *A. fulgens* and *A. sororia* evolved from the more common arctic - alpine regions to prairie and grassland habitats. Of somewhat greater divergence from the ancestral condition are *A. lonchophylla* and *A. rydbergii*, the latter representing the most patristic taxon within the subgenus. All these taxa retain the features characteristic of subgenus *Arctica*. Based upon an examination of structural, phytochemical, ecological and phytogeographical data, this subgenus probably represents the closest archetypal group, being derived from a postulated precursor, *Protoarnica*, and giving rise to subgenus *Austromontana*, and perhaps the rest of the genus.

Barker (1966) demonstrated that the major populations of *A. angustifolia*, *A. lonchophylla* and *A. frigida* are autonomously apomictic; that is, agamospermy (seed production) can proceed without the stimulation of pollen tubes or fertilization of the polar nuclei. One of the effects agamospermy has on a population of plants is formation of microspecies (Grant 1971). Agamospermous microspecies consist of groups of individuals slightly differentiated morphologically from one another. Many are restricted in distribution to relatively small geographical areas (Grant 1971). Since much of the morphological variability encountered in *Arnica* is attributable to apomixis and polyploidy (Afzelius 1936; Gustafsson 1947; Barker 1966), the perplexing morphological and chemical variability in *Arnica* subgenus *Arctica* may be due to microspecies formation via apomixis. Other factors responsible for the complex variation patterns in the subgenus include: (1) phenotypic plasticity, (2) hybridization and introgression (perhaps between *A. angustifolia* and *A. lonchophylla*), (3) pollinator non-specificity, (4) geographical and (5) ecological isolation.

One pragmatic outcome of this study was the development of a workable key. During the initial portions of this investigation it was particularly frustrating not to be able to key out with certainty the infraspecific taxa of *A. angustifolia* and *A. lonchophylla*, for in the absence of geographic data, one taxon was quite easily mistaken for another. In the past, attempts to give taxonomic recognition to every morphological variant, or anomalous individual, resulted in a complicated and confusing treatment. The new arrangement proposed here is thought to reflect more accurately the evolutionary history of the group. In addition, it provides a clearer phenotypic definition for each of the taxa. The characters previously chosen by Maguire and others to delimit taxa within subgenus *Arctica* are subject to much variability. I hope the characters employed in this investigation continue to be diagnostic as new information and collections become available.

Douglas and Ruyle-Douglas' (1978) treatment of *A. sororia* as a variant of *A. fulgens* is rejected. Data from morphology, flavonoid chemistry, ecology, geographical distribution, and reproductive studies, indicate that *A. fulgens* and *A. sororia* are separated by a number of discontinuous, independent character differences. Both are maintained as separate species. Evidence obtained from plants representing *A. louiseana*, *A. frigida*, *A. rydbergii*, *A. lonchophylla* and *A. angustifolia* suggest that these taxa conform to Davis and Heywood's (1963) morphological - geographical species concept. Although *A. frigida*, *A. lonchophylla* and *A. angustifolia* are markedly polymorphic, a combination of several structural characters in conjunction with ecological, phytochemical and distributional data, are sufficient to distinguish among them with confidence. The eastern populations of *A. frigida* and the southern populations of *A. lonchophylla* are best treated as *A. frigida* ssp. *griscomii* and *A. lonchophylla* ssp. *arnoglossa*, respectively. These entities lack a sufficient degree of morphological differentiation to be treated as separate species, but are too widely distributed to be treated as varieties. They are isolated geographically from the more widespread northwestern North American populations; plants of *A. lonchophylla* ssp. *arnoglossa* also differ in chromosome number. The densely tomentose habit of *A. angustifolia* ssp. *tomentosa* clearly delimits it from *A. angustifolia* ssp. *angustifolia*. However, these taxa have similar flavonoid constituents and chromosome numbers, and, I feel, are best treated at the subspecific rank.

VII. Taxonomy

Arnica Linnaeus, Sp. Pl. 884. 1753.

Type species: *Arnica montana* L.

Stems herbaceous, simple or branched, arising from a perennial rhizome; *leaves* 1 to 12 pairs, simple, opposite (or apparently all basal), sessile or narrowly to broadly petiolate, the uppermost leaves sessile and reduced, rarely alternate; *capitula* solitary to many in a cymose inflorescence, radiate or discoid, broadly hemispheric to turbinate, the periclinium obvious; *involucral bracts* biseriate, or loosely one seriate; *receptacle* convex, naked or with conspicuous tawny or stramineous hairs; *ligulate florets* pistillate, yellow to orange, entire or dentate; *disc florets* uniform, perfect, yellow to orange, tubular or goblet-shaped; *anthers* yellow or purple, the base minutely auriculate; *styles* exserted, bifurcate, revolutely coiled, the tip somewhat broadened and truncate, the outer surface papillose; *achenes* cylindrical or tapered, 5 to 10 nerved, with a conspicuous white annulus at base, variously pubescent with short-bifid or trifid double hairs, glandular or glabrous; *pappus* of numerous white to tawny, barbellate to plumose capillary bristles; *chromosome number* x=19. A circumboreal, predominantly boreal and montane genus of about 27 species.

Subgenus **Arctica** Maguire, Brittonia 406. 1943.

Stems simple to branched, arising from a short branched rhizome covered in imbricate scales and leaf-base remnants which may have tufts of long hairs in their axils (excessively developed in *A. fulgens*); *cauline leaves* narrow, 3 to 20 times as long as wide, occurring below the middle of the stem, linear to lanceolate or narrowly oblong to oblanceolate, or spathulate, margins entire, denticulate or dentate, sessile to broadly or narrowly-winged petiolate, the petioles mostly shorter than the blade (except in *A. lonchophylla*), 1 to 3 pairs of leaves (occasionally 4 to 5, rarely more), the uppermost sessile and reduced; *periclinium* very conspicuous, moderately to densely lanate-pilose; *involucral bracts* biseriate, lanceolate to oblanceolate; *capitula* large, solitary to 5, rarely more, radiate, broadly hemispheric to campanulate-turbinate; *ray and disc florets* yellow to orange; *anthers* yellow; *pappus* white, barbellate.

KEY TO THE SPECIES OF SUBGENUS *ARCTICA*

1. Basal leaves broad, 1.5 to 7 times as long as wide; achenes glabrous below, sparsely hirsute above or glabrous throughout, occasionally densely glandular; capitula 1 (rarely 3); periclinium yellow to white.

    2. Leaves conspicuously short-stipitate glandular; involucral bracts sparingly pilose otherwise glabrous, uniformly short-stipitate glandular; capitula nodding in anthesis; achenes glandular towards summit .... *A. louiseana*

    2. Leaves sparsely or not at all glandular; involucral bracts scarcely glandular; capitula erect or nodding in anthesis; achenes rarely glandular .... *A. frigida*

1. Basal leaves narrow, 3 to 20 times as long as wide; achenes densely hirsute throughout, rarely glandular; capitula 1 to 5 (rarely 8), erect; periclinium white.

    3. Lower cauline leaves sessile or very short and broad-winged, entire or remotely toothed; ligules entire or denticulate, the teeth less than 0.5 mm long; stems usually caespitose .... *A. rydbergii*

    3. Lower cauline leaves distinctly petiolate; ligules obviously 3-dentate, the teeth 0.1 to 7.0 mm; stems solitary or few.

4. Basal leaves entire or sometimes irregularly dentate; petiole narrow- or broad-winged and shorter than the blade; capitula 1 to 3 (rarely 5), hemispheric.

5. Plants of prairies and grasslands or mountains; leaves mostly entire, oblanceolate to narrowly oblong, obtuse; capitula broadly hemispheric; ligulate and disc florets yellowish-orange.

6. Base of stem with dense tufts of brown woolly hair in axils of old leaf bases; disc corollas with spreading stipitate-glandular and glandless hairs; capitula 1 (rarely 3) .... *A. fulgens*

6. Base of stem lacking axillary tufts of brown hair, occasionally with few whitish hairs; disc corollas stipitate-glandular, with few or no spreading septate-glandless hairs; capitula 1 to 3 *A. sororia*

5. Plants of arctic, subarctic or alpine habitats; leaves acute or acuminate; capitula hemispheric; ligulate and disc florets yellow .... *A. angustifolia*

4. Basal leaves regularly dentate or denticulate, long-petiolate, the petiole length approximately equalling the blade; capitula 3 to 7, rarely less or more, campanulate-turbinate .... *A. lonchophylla*

TREATMENT OF INDIVIDUAL TAXA

The following species are arranged in the sequence in which their names appear in the key.

1. **Arnica louiseana** Farr, Ottawa Nat. 20:109. 1906. *A. louiseana* subsp. *genuina* Maguire, Brittonia 4:419. 1943. TYPE: "Lake Louise, Canadian Rocky Mts. Rockslide on Fairview Mt. Alt. about 6000 ft. Aug. 18, 1905. *E.M. Farr 1067*". (HOLOTYPE PH!, ISOTYPE GH). Figure 14. Generalized illustration Figure 16c.

Plants 4-20 cm high; *stems* solitary from a short branched rhizome, simple, glandular-puberulent, leaves to middle of stem or rarely all basal; *cauline leaves* 1-3 pairs or none, sessile or narrowed to a short-winged petiole; *basal leaves* 4-20 mm broad, 13-75 mm long; *leaves* elliptic to oblong to ovate-lanceolate, apex obtuse or occasionally acute or acuminate, margins entire to saliently denticulate to slightly undulate, uniformly short-stipitate glandular; *periclinium* scantily to moderately yellowish-gold pilose, short-stipitate glandular; *involucral bracts* 8-12 mm long, 1.5-3.0 mm broad, narrowly lanceolate, acuminate, sparingly pilose otherwise glabrous, uniformly short-stipitate glandular; *ligulate florets* 7 to 10, 12-20 mm long, 2.5-4.6 mm broad, the lobes 0.2-1.5 mm long; *achenes* 3.2-5.0 mm long, glabrate below, short-hirsute and glandular towards the summit or occasionally uniformly pubescent; *capitulum* nodding in anthesis, solitary, campanulate-turbinate, 9-20 mm high, 8-17 mm broad; *chromosome number* 2n=76 and 95.

DISTRIBUTION AND HABITAT: Infrequent and localized on exposed alpine tundra slopes and mature calcareous rock slides at 1800-2100 metres in the Canadian Rocky Mountains of Alberta in the vicinities of Waterton, Jasper and Banff National Parks (Figure 15). Although it can be reasonably expected to find *A. louiseana* in the Rocky Mountains of British Columbia, I have yet to see specimen from this province.

REPRESENTATIVE SPECIMENS: **CANADA, Alberta:** Top of Mt. Bourgeau *Scotter 10062* (DAO); Flanc N. du N. Saskatchewan *Boivin 5093* (DAO); Mt. Wilson *Breitung, Porsild &*

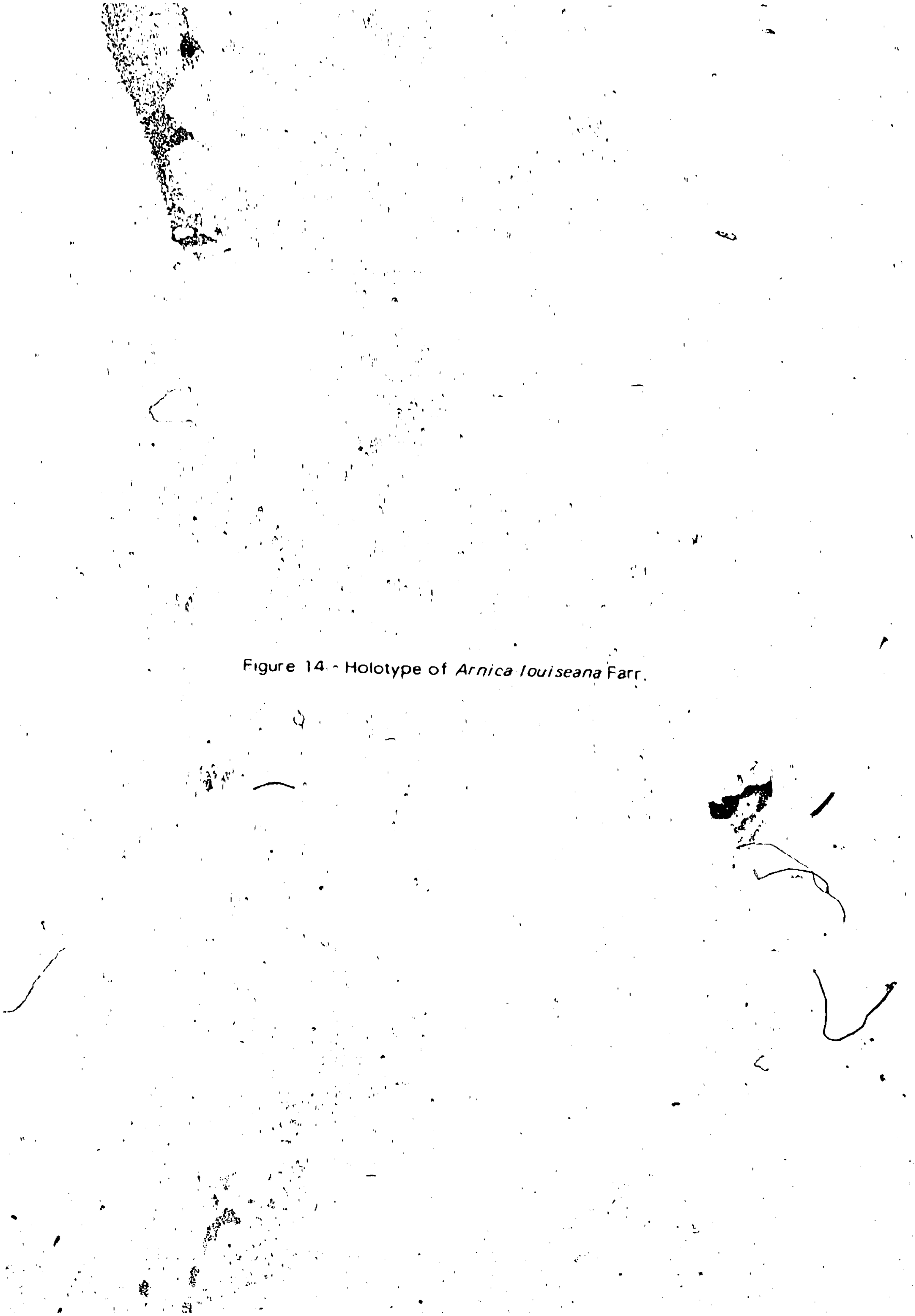


Figure 14. - Holotype of *Arnica louiseana* Farr.

TYPE COLLECTION

TYPE

Arnica Louiseana Farr, Ottawa
Naturalist 20: 109. 1906.
Louis C. Wheeler 1942

Herbarium, University of Pennsylvania
Collection of Edith M. Farr

[illegible]

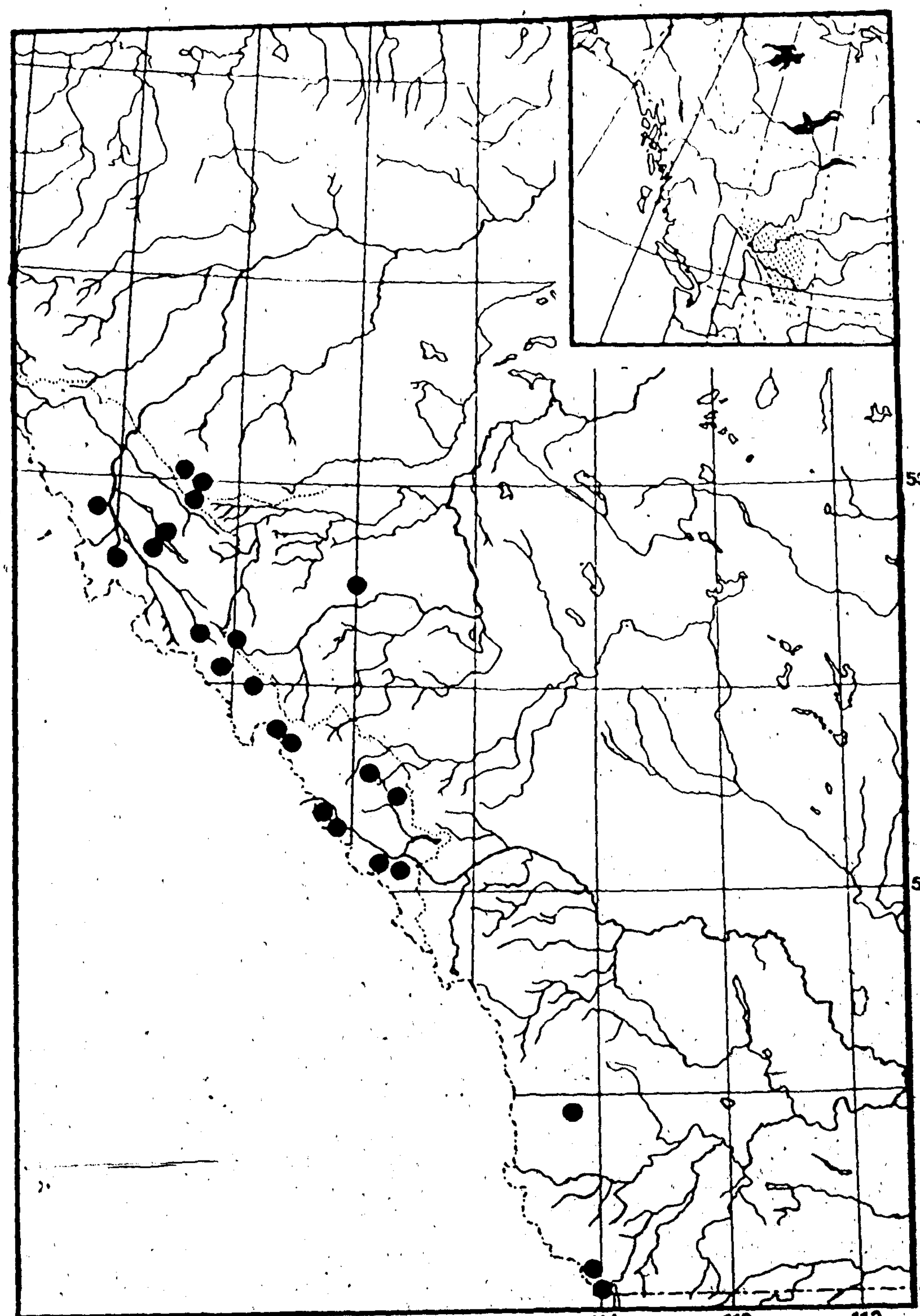


Figure 15 - Distribution of *Arnica louiseana.*

Boivin 2938 (DAO); W. Hailstone Butte, Livingstone R. *Norris 72* (DAO); Mt. Edith Cavell *Calder 37189* (DAO); Mt. Anderson *Breitung, Porsild & Boivin s.n.* (DAO); Maligne Lake *Scotter 9797* (DAO); Moraine Lake *Straley 1607* (DAO); Mt. Paget *Macoun 65519* (CAN,GH,NY,US); S. Peyto Lake *Weber 2446* (GH,NY,UC); Mt. Patterson *Porsild & Breitung 16164* (CAN); Snow Creek Pass *Porsild 22666* (CAN); Clearwater Forest Reserve, N. Nordegg *Porsild 20718* (CAN); Panther Mtn. *Porsild & Breitung 16280* (CAN); Bow River Pass *Porsild & Breitung 14927* (CAN); Mt. Saskatchewan *Porsild & Breitung 16067* (CAN); Columbia Icefields *Scoggan 16440* (CAN); Sulphur Mtn. *Sanson 309* (CAN); Whistler Mtn. *Laing s.n.* (CAN); Lake Louise *Macoun 65520* (CAN,NY); Mt. Richards *Breitung 17454* (NY); Mt. Richards *Breitung 17457* (ALTA); Lake Louise *Farr s.n.* (PH); Whitehorse Creek *Dumais & Andrewchow 5239* (ALTA); 3 mi. S. Cadomin *Dumais 6274C* (ALTA); Bald Hills *Kuchar s.n.* (ALTA); Prospect Mtn. *Mortimer 438* (ALTA); Anderson Peak *Kuchar 2901* (ALTA); Whitegoat Wilderness *Lee s.n.* (ALTA); Lake Louise *Brown 665* (GH,NY,PH).

Arnica louiseana is very restricted in its distribution, occurring at high elevations in the Canadian Rocky mountains. It was originally described by Miss Edith Farr in 1906 from the vicinity of Lake Louise, Banff National Park, Alberta, and can be separated from all other arnicas by its evident glandularity, its small size, and the nodding tendency of its peduncle. The search for *A. louiseana* in Banff and Jasper National Parks proved to be somewhat disappointing. This species was found to consist of solitary individuals intermittently scattered on alpine tundra slopes or nestled amongst calcareous rocks at lower elevations. The inaccessibility of many alpine areas precluded an accurate census of these plants in Alberta.

2. **Arnica frigida** Meyer ex Iljin, Trav. Musc. Bot. Acad. Sci. URSS. 19:112. 1926.

Stems solitary or several from a short branched rhizome, rarely branching, glabrate to hispidulous-puberulent below, becoming sparsely to densely hispidulous-pilose near the periclinium, leaves to middle of stem, rarely above; *cauline leaves* sessile or narrowed to a short-winged petiole; *basal leaves* with slender petiole as long as the blade, margins inconspicuously denticulate or dentate to slightly undulate, rarely entire, glabrate to sparingly hispidulous-puberulent and sparsely or not at all glandular; *periclinium* and *involucral bracts* rarely short-stipitate-glandular; *achenes* usually glabrous below and sparsely hispid at the summit, or seldom uniformly sparsely hispid, rarely glandular; *capitulum* nodding or erect in anthesis, solitary, hemispheric to occasionally turbinate.

Arnica frigida is extremely variable in pubescence and leaf form. The species is, however, characterized by its obtuse or abruptly pointed, elliptic to oblanceolate leaves; achenes which are glabrous below and sparsely hispid at the summit, and a single capitulum. The two subspecies delimited in *A. frigida* can be separated by the suite of characters listed in the key below. In addition, these two taxa can be distinguished on their geographical distribution, habitat specificity, and chromosome number. Generalized illustrations Figs. 16a and 16b.

KEY TO SUBSPECIES OF *ARNICA FRIGIDA*

Periclinium sparsely to densely yellow lanate-pilose; involucral bracts 1.8 to 4.9 mm broad, pilose at base becoming glabrate or remaining densely pilose above, plants 0.6 to 4.0 dm high .... subsp. *frigida*

Periclinium moderately white pilose; involucral bracts 2.5 to 4.6 mm broad, pilose at base becoming glabrate above, plants 0.5 to 2.5 dm high .... subsp. *griscomii*

2a. **Arnica frigida** Meyer ex Iljin subsp. **frigida**, Trav. Musc. Bot. Acad. Sci. URSS. 19:112. 1926. *A. louiseana* subsp. *frigida* (Meyer ex Iljin) Maguire, Madrono 6:153. 1942. *A. louiseana* var. *genuina* Maguire, Madrono 6:153. 1942. *A. louiseana* var. *frigida* (Meyer ex Iljin) Welsh, Great Basin Nat. 28:149. 1968. TYPE: "St. Laurence Bay (and Eschscholtz Bay), 1815-1818. *Eschscholtz s.n.*". (HOLOTYPE LE, PHOTO CAN!, UC!, ISOTYPE LE, PHOTO UC!). Figure 17.

A. nutans Rydb., N. Am. Fl. 34:328. 1927. TYPE: "Alaska, Vicinity of Port Clarence. Hillsides along Tuksuk Channel, near Port Clarence. July 30, 1901. *F.A. Walpole 1618*".

Figure 16 - Generalized illustrations of *Arnica frigida* and *A. louiseana*. (A) *A. frigida* subsp. *frigida* (based on *Downie 476*; (B) *A. frigida* subsp. *griscomii* (based on *Fernald, Long & Fogg 2140*); (C) *A. louiseana* (based on *Straley 1607*).

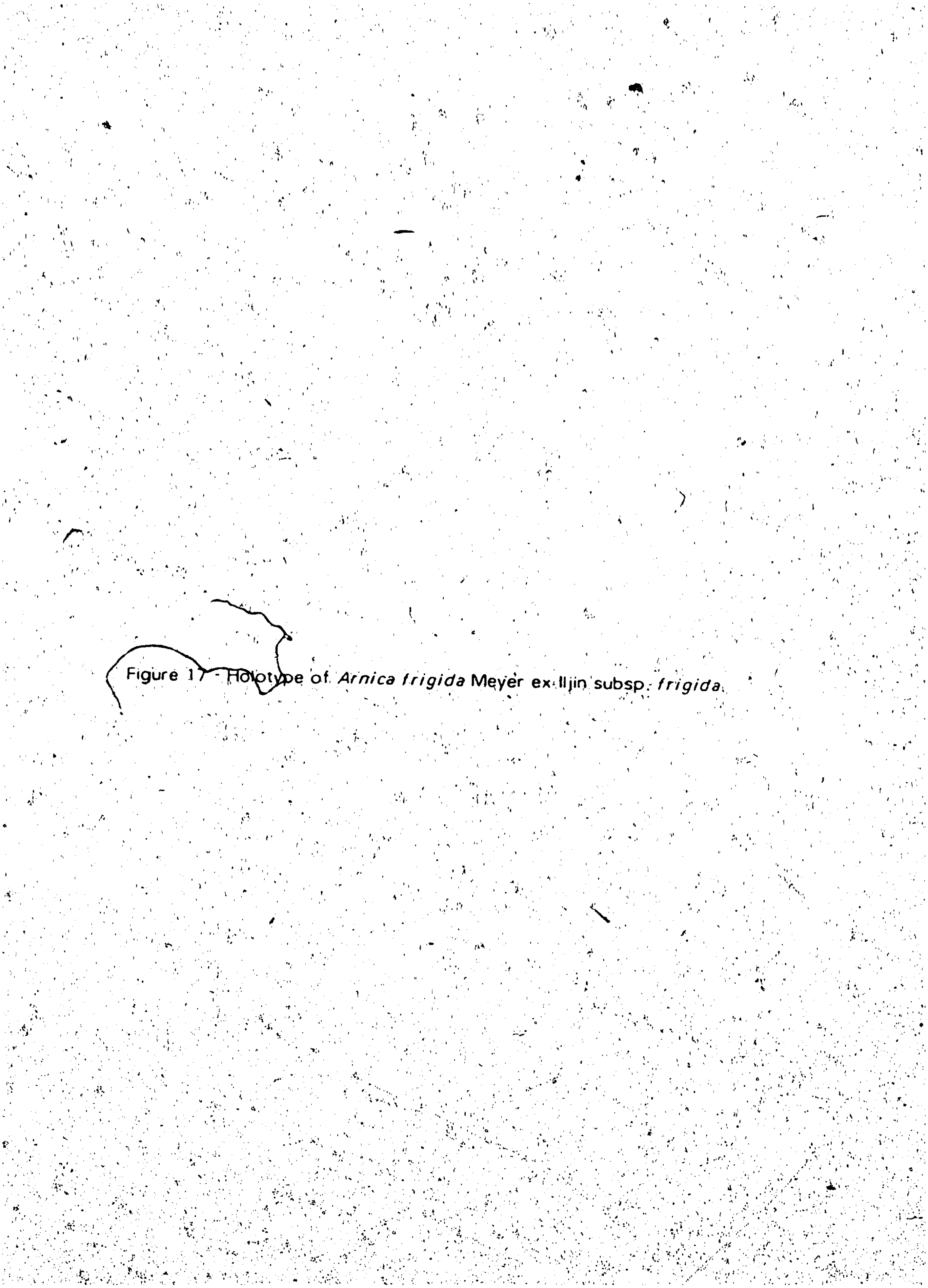
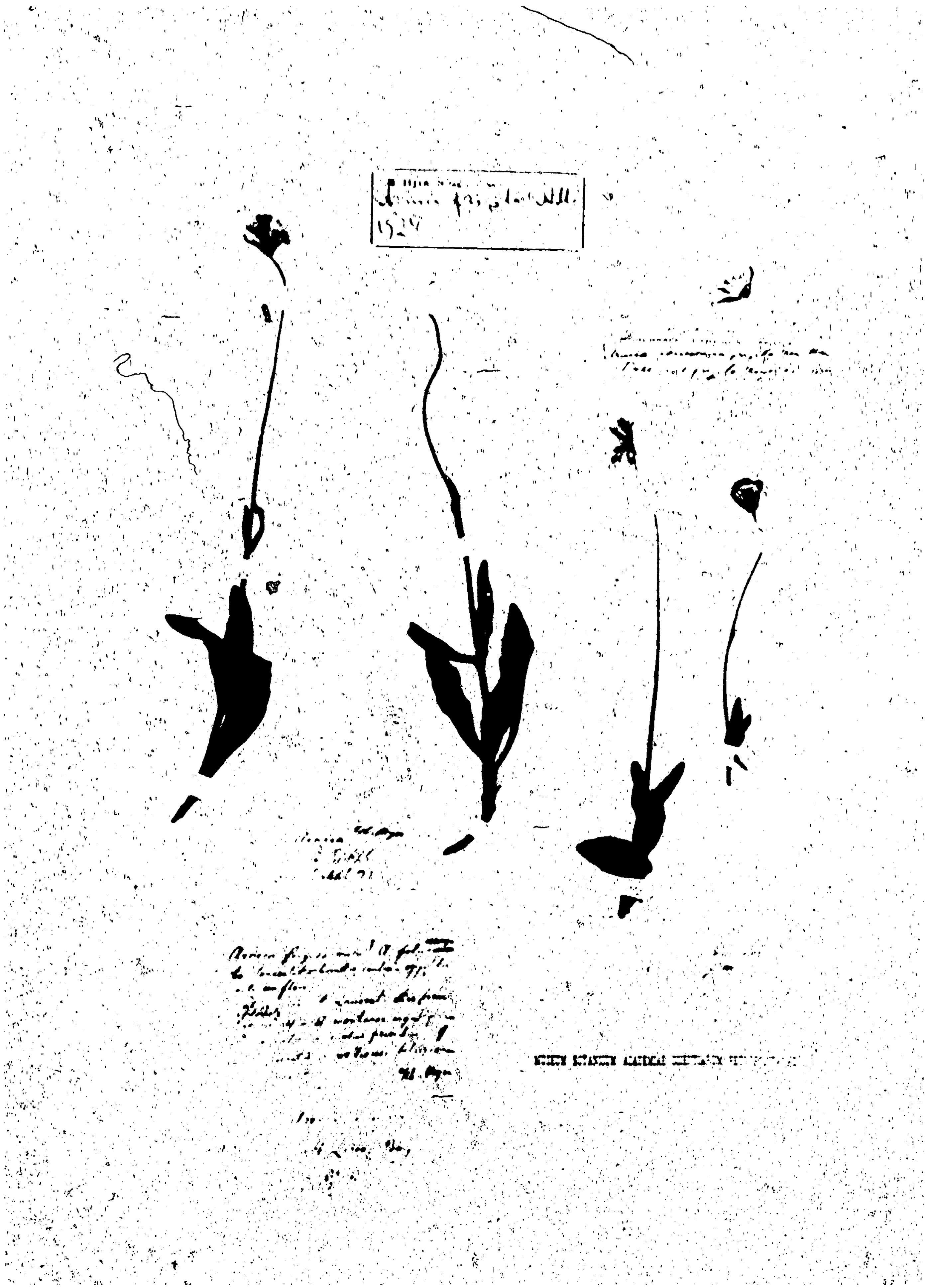


Figure 17 - Holotype of *Arnica frigida* Meyer ex Iljin subsp. *frigida*.



(HOLOTYPE NY!, PHOTO CAN!, UC!, ISOTYPE US, PHOTO UC!)

A. sancti-laurentii Rydb., N. Am. Fl. 34:328. 1927. TYPE: "Sinu St. Laurentii. *Chamisso s.n.*". (HOLOTYPE GH, PHOTO CAN!, UC!)

A. brevifolia Rydb., N. Am. Fl. 34:329. 1927. *A. louiseana* var. *brevifolia* (Rydb.) Maguire, Madrono 6:153. 1942. TYPE: "Alaska. Copper River Region. Near Camp 6/ 15-19, in lateral moraine of Chitislene Glacier. June 19, 1902. *W.L. Poto 46*". (HOLOTYPE US!, PHOTO CAN!, UC!, DRAWING NY!)

A. mendenhallii Rydb., N. Am. Fl. 34:329. 1927. *A. louiseana* var. *mendenhallii* (Rydb.) Maguire, Madrono 6:153. 1942. TYPE: "Alaska. Fort Hamlin, Yukon River to Bergman, Koyukuk River. Found on Old Man Creek, a branch of the Koyukuk River. July 8, 1901. *W.C. Mendenhall s.n.*". (HOLOTYPE US!, PHOTO CAN!, UC!, DRAWING NY!)

A. illiamnae Rydb., N. Am. Fl. 34:331. 1927. *A. louiseana* var. *illiamnae* (Rydb.) Maguire, Madrono 6:153. 1942. TYPE: "Alaska. Lake Iliamna region. Open tundra along Nogheling Trail. July 20, 1902. *M.W. Gorman 163*". (HOLOTYPE US!, PHOTO CAN!, UC!)

A. louiseana var. *pilosa* Maguire, Madrono 6:154. 1942. TYPE: "Alaska. Igloo Creek, McKinley National Park. July 13, 1932. *J. Dixon 29*". (HOLOTYPE UC!, ISOTYPE US)

A. snyderi Raup, Sargentia 6:250. 1947. TYPE: "Alpine crevices and slide rock. Vicinity of Brintnell Lake. App. Lat. 62° 5' N., Long. 127° 35' W, north slope of Colonel Mt., S.W. Mackenzie. July 5, 1939. *H.M. Raup & J.H. Soper 9383*". (HOLOTYPE RM!, ISOTYPE CAN!)

A. frigida var. *glandulosa* Boivin, Rhodora 55:56. 1953. TYPE: "Yukon Territory, Canada. Steep rocky slope by Klondike River. About 20 miles east of Dawson on road to McQuesten. July 17, 1949. *J.A. Calder & L.G. Billard 3767*". (HOLOTYPE DAO!)

Plants 0.6 to 4.0 dm high; *cauline leaves* 2 to 4 pairs, 5.0 to 35.0 mm broad, 12.0 to 100.0 mm long, leaves of small plants crowded at base, lanceolate, elliptic to elliptic-lanceolate, spathulate or rarely oblanceolate, apex acute or rarely obtuse, rarely abundant glandular; *periclinium* sparsely to densely yellow lanate-pilose; *involucral bracts* 7.5 to 14.5 mm long, 1.8 to 4.9 mm broad, lanceolate, acuminate, rarely obtuse, pilose at base becoming glabrate or remaining densely pilose above; *ligulate florets* 7 to 17, 10.0 to 39.0 mm long, 2.3 to 8.0 mm wide, the lobes 1.0 to 5.0 mm long; *achenes* 3.2 to 6.0 mm long; *capitula* rarely 3 or more, 11.0 to 30.0 mm high, 8.0 to 20.0 mm broad; *chromosome number* 2n=38, 57, 76 and 95.

DISTRIBUTION AND HABITAT: Abundant in alpine meadows, tundras and calcareous rocky outcrops from the Kolyma River, USSR, east to the islands of the Bering Strait, Alaska, Yukon Territory to the Mackenzie River, Northwest Territories (Figure 18). Scattered populations found north of the Arctic Circle and east to the Coppermine River in NWT, and infrequent to rare in alpine areas of northern British Columbia (Buttrick 1977).

REPRESENTATIVE SPECIMENS: **CANADA. British Columbia:** Mile 83 Haines Rd. *Taylor, Szczawinski & Bell 916* (CAN,DAO,UBC); Mile 60 Haines Rd. *Taylor, Szczawinski & Bell 1103* (CAN,DAO); Summit Pass *Raup & Correll 10507* (GH,CAN,DAO,UBC); Mile 85 Haines Rd. *Clarke 443* (CAN); Storehouse Creek *Beamish, Krause & Luitjens 681811* (CAN,UBC); Teresa Island, Atlin Lake *Buttrick 838* (UBC); Summit Lake *Rose 78430* (UBC); Spatsizi Plateau *Krajina s.n.* (UBC).
Northwest Territories: Mount Cody *Cody & Spicer 11798* (DAO,NY,UBC); 5 mi. S.E. Inuvik *Cain 12* (DAO); Coppermine *Findlay 129* (DAO); Dodo Canyon *Cody & Gutteridge 7694* (DAO); Canada Tungsten Mine *Spicer 1615A* (DAO); Richardson Mts. *Krajina 63071211* (DAO,UBC); Inuvik *Lambert s.n.* (DAO); Caribou Hills *Cody & Ferguson 10057* (DAO); Mackenzie Mts. *Johnson & Munro 13* (DAO); Canoe Lake *Cody & Johansson 12878* (DAO); Canoe Lake *Cody & Johansson 12956* (DAO); Mackenzie Mts. *Rowlands 3* (DAO); 5 mi. S. Horne Lake *Calder 33964* (DAO); Richardson Mts. *Calder 34252* (DAO); Clinton Point *Parmelee 3185* (DAO,UBC); Mackenzie Mts. *Cody 17263* (DAO); Mackenzie Mts. *Cody & Brigham 20938* (DAO); Mackenzie Mts. *Cody & Brigham 21009* (DAO); Mackenzie Mts. *Cody & Scotter 19800* (DAO); Mackenzie Mts. *Cody & Scotter 19197* (DAO); Mackenzie Mts. *Cody & Scotter 19497* (DAO); Mackenzie Mts. *Cody & Scotter 19193* (DAO); Mackenzie Mts. *Cody & Gibbon s.n.* (DAO); Nahanni National Park *Talbot T6148-3* (DAO); Nahanni National Park *Talbot T5024* (DAO); Nahanni National Park *Talbot T6206-21* (DAO); Hornaday River region *Scotter & Zoltai 25732* (DAO); Hornaday River region *Scotter & Zoltai 25751* (DAO); Mackenzie Mts. *Cody & Spicer 17721* (DAO); Mackenzie Mts. *Scotter 12353* (DAO); Mackenzie Mts. *Scotter 12808C* (DAO); Mackenzie Mts. *Scotter 22746* (DAO); Mackenzie River Delta *Porsild 6968* (GH); Coppermine *Dutilly 170* (GH); Liard Range, S.W. Mackenzie Mts. *Jeffrey 337* (CAN); Britnell Lake *Raup & Soper 9492* (CAN); Tree River *Miller 316* (CAN); 37 mi. N.W. McPherson *Youngman & Tessier 17* (CAN); 37 mi. N.W. McPherson *Youngman & Tessier 83* (CAN); S. Richards Island *Porsild 7080* (CAN); Lone Mt. *Wynne-Edwards 8526* (CAN); Richardson Mts. *Porsild 6867* (CAN); Coppermine *Wood s.n.* (CAN); W. Cache Creek *Welsh & Rigby*

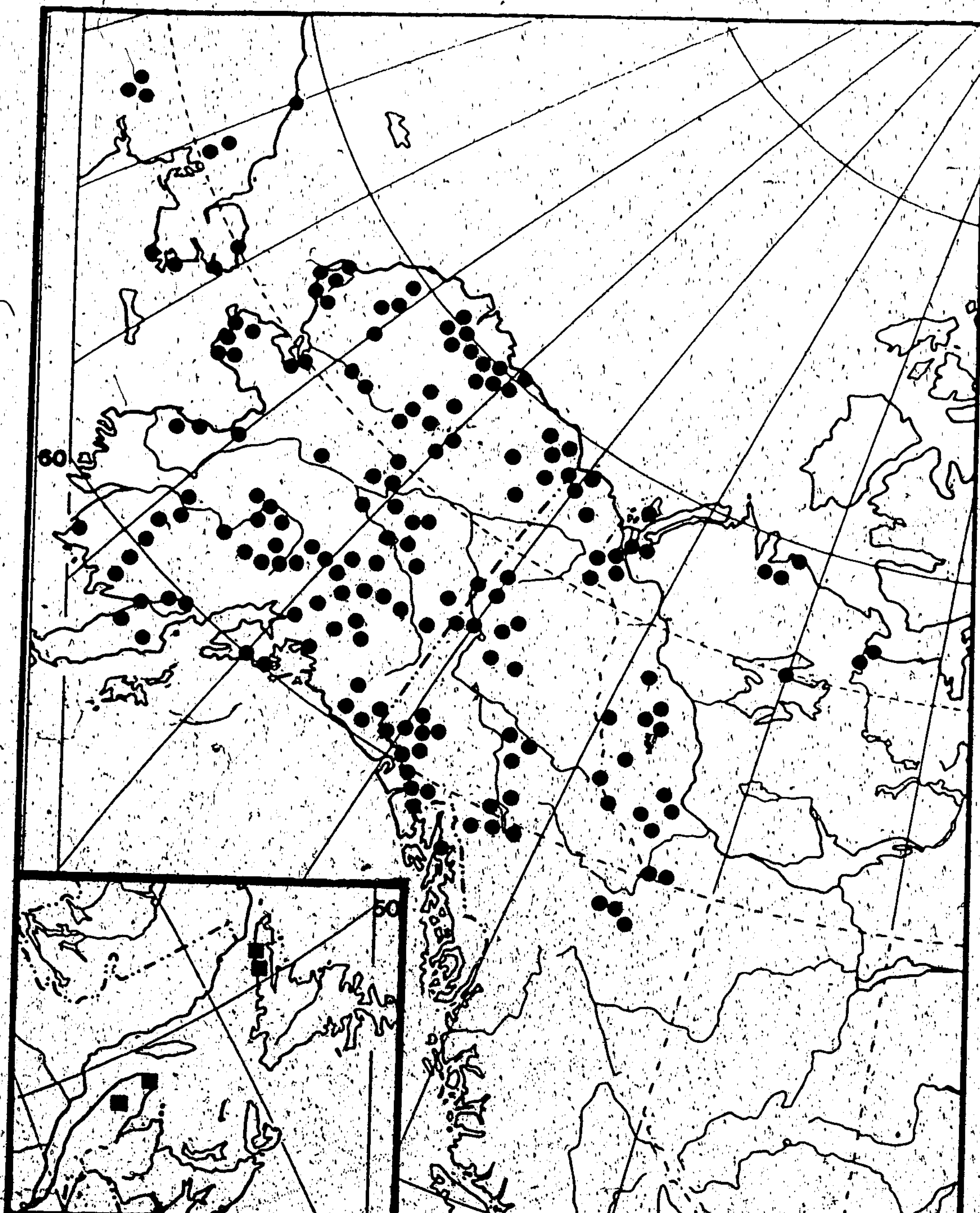


Figure 18 - Distribution of *Arnica frigida* subsp. *frigida* (●) and *A. frigida* subsp. *griscomii* (inset).

12060A (CAN,NY); Mtn. W. Bolstead Creek *Wynne-Edwards 8391* (CAN); Lone Mt. *Porsild 16647* (CAN); Cape McDonnel, Great Bear Lake *A.E. & R.T. Porsild 5162* (CAN). **Yukon:** 20 mi. E. Dawson *Boivin 3767* (DAO); Quill Creek area *Freedman s.n.* (DAO); British Mountains *Lambert s.n.* (DAO); Mt. Peters *Scotter 20775* (DAO); Mt. Maxwell, *Scotter 21169A* (DAO); Burwash Creek Rd. *G.W. & G.C. Douglas 5815* (DAO); Profile Mtn. *Douglas 6345* (DAO); Ogilvie Mts, *Porsild 198* (GH,CAN); N.E. Red Tail Lake *Raup, Drury & Raup 13485* (GH,UBC); Burwash *Raup, Drury & Raup 13322* (GH,CAN,UBC); 7 mi. E. Little Atlin Lake *Raup & Correll 11214* (GH,CAN,UBC); N.E. Red Tail Lake *Raup, Drury & Raup 13465* (GH,CAN); 4 mi. S.E. Ptarmigan Heart *Raup, Drury & Raup 13590* (GH,CAN,UBC); N.E. shoulder Mt. Sheldon *Porsild & Breitung 11102* (GH,CAN,UC,US); Mile 132 Canol Rd. *Porsild & Breitung 9635* (GH,CAN); N.E. Ptarmigan Heart *Raup, Drury & Raup 13760A* (GH,UBC); N.E. Ptarmigan Heart *Raup, Drury & Raup 13760* (GH,CAN); E. Slim's R., Kluane Lake *H.M. & L.G. Raup 12476* (GH,CAN,UBC); E. Slim's R., Kluane Lake *H.M. & L.G. Raup 12514* (GH,CAN,UBC); S.W. Ptarmigan Heart *Raup, Drury & Raup 13520* (GH,CAN); Mtn. S. Haines Rd. Jnctn. *Harris 12068* (GH); S. Kluane Lake *H.M. & L.C. Raup 12158* (GH); 7 mi. E. Little Atlin Lake *Raup & Correll 11307* (GH); Mile 132 Canol Rd. *Porsild & Breitung 10047* (GH,CAN); Mile 132 Canol Rd. *Porsild & Breitung 9755* (GH,CAN,NY,UC,US); Mile 95 Canol Rd. *Porsild & Breitung 10467* (GH,CAN,US); 63 deg. 50 min., 141 deg. 00 min. *Cairnes 93348* (CAN,NY); Burwash Landing *Clarke 292* (GH,CAN); Vicinity of Rusty Glacier *Murray 1776* (CAN); Keno Hill *Porsild 729* (CAN); E. Dempster Hwy. Pass *Beamish, Krause & Luitjens 681725* (CAN,NY,UBC); Lower Firth R. *McNeish s.n.* (CAN); McQuesten area *Campbell 469* (CAN); Pass between Teslin & Nisutlin *Porsild & Breitung 11054* (CAN); Ross-Lapie R. Pass, Canol Rd. *Porsild & Breitung 10080* (CAN); Mile 132 Canol Rd. *Porsild & Breitung 9948* (ALTA,CAN); Mile 132 Canol Rd. *Porsild & Breitung 9972* (CAN); Mile 100 Haines Hwy. *Schofield & Crum 8271* (CAN); Firth R. *McEwen 208* (CAN); 13 mi. N.E. Lapierre House *Youngman & Tessier 600* (CAN); 12 mi. S.W. Haines Jnctn. *Pearson 142* (CAN); Grizzley Creek *Lambert 7660* (CAN); E. Herschel Island *Cooper 33C* (NY); N.W. Dawson City *Greene 225* (ALTA); Mile 41 Dempster Hwy. *Greene 453* (ALTA); S. Mt. Klotz *Greene 421* (ALTA); Mile 58 Dempster Hwy. *Greene 529* (ALTA); Mile 58 Dempster Hwy. *Greene 528* (ALTA); N.W. Dawson City *Greene 229* (ALTA); Sunblood Mtn., Virginia Falls *Carbyn 30* (DAO); Firth R., 23 mi. from coast *Cashman 40* (DAO); Kluane Game Sanctuary *Freedman 291* (CAN); Mt. Decoeli *Brink s.n.* (UBC); Sheet Mt. *Krajina & Hoefs s.n.* (UBC); Whitehorse *Beamish, Krause & Luitjens 681463* (UBC); Marble Creek Plateau, Kluane Park *Neily 62* (KLUANE); N. Hoge, Burwash Uplands, Kluane Park *Neily 166* (KLUANE); Onion Lake, Kluane Park *G.W. & G.G. Douglas 9081* (KLUANE); Duke River, 45 km S. Burwash Landing, Kluane Park *Freese 108* (KLUANE).

U.S.A., Alaska: Donnelly Dome *Harms 2804* (ALA,CAN,DAO,GH); Eagle Summit *Harms 6262* (ALA,DAO,GH); Mt. McKinley National Park *York 213* (DAO); Upper Kurupa River Valley *Hodgdon & Riedenans 8607* (DAO); Lower Kurupa River Valley *Hodgdon 8848* (DAO); Kanayut Lake *Spetzman 2086* (CAN,DAO); Ogotoruk Creek *Packer 2283* (ALTA,DAO); Endicott Mtn. *Cooper CV-685* (DAO); Mile 12 Paxton-Cantwell Hwy. *Webster 188* (DAO); Curry *Schofield 1850* (DAO); Mile 12 Paxton-Cantwell Hwy. *Webster 224* (DAO); Mile 250 Richardson Hwy. *Cody & Webster 5036* (DAO); King Salmon *Schofield 2129* (DAO,GH,NY); King Salmon *Schofield 2021* (DAO); Mt. Marathon *Calder 5621* (DAO,NY,US); Eagle Summit *Scamman 484* (GH); Umiat *Hulten s.n.* (ALA,GH,NY,US); Chandler Lake *Wiggins 13692* (GH,US); Chandler Lake *Wiggins 13813* (GH,US); Eagle Summit *Harms 2954* (ALA,GH); W. Canoe Mtn. *Drury 1786* (ALA,GH); S.E. Farewell *Drury 3004* (GH); Head of Big River *Drury 4085* (ALA,CAN,GH); Head of Big River *Drury 4252* (ALA,GH); 3-4 mi. downstream from Georgetown *Drury 1903* (ALA,GH); Kuskokwim River Drainage Basin *Drury 3209* (ALA,CAN,GH); 59 mi. above Big Rapids *Drury 2146* (ALA,GH); Along Ganes and Yankee Rd. *Drury 3449* (ALA,GH); Head of Big River *Drury 4050* (ALA,GH); Moose Pass *A. & R. Nelson 3492* (ALA,GH,NY,UC,US); Mt. Fairplay *Scamman 6265* (GH); Mt. McKinley National Park *Scamman 680* (GH); Wiseman *Scamman 2302* (GH); Eagle Summit *Scamman 2162B* (GH); Miller House *Scamman 850A* (GH); Manley Hot Springs *Scamman 3770* (GH); Miller House *Scamman 2164* (GH); Miller House *Scamman 3620* (GH); Takotna *Anderson & Gasser 7390* (ALA,GH); Eagle Summit *Scamman 3621* (GH); Miller House *Scamman 5156* (GH); Eagle Summit *Scamman 850* (ALA,GH); Mt. McKinley National Park *Scamman 679* (GH); Yankee Creek *Scamman 1911A* (GH); Yankee Creek *Scamman 1911B* (GH); Cantwell *A.E. & R.T. Porsild 95* (CAN,GH); Mastodon Dome *Scamman 4866* (GH); Eagle Summit *Scamman 4786* (GH); Miller House

Scamman 4669 (GH,US); Harrison Divide *Scamman 4727* (GH); Mt. McKinley National Park *Scamman 5108* (GH); Norton Sound *A.E. & R.T. Porsild 930* (GH); Kokrines Mtn. *A.E. & R.T. Porsild 807* (ALA,CAN,GH,US); Farewell Mtn. *Drury 2624* (ALA,CAN,GH); Along Kuskokwim R. from Russian Mission to Napaimute *Drury 1768* (ALA,CAN,GH); Livengood *Scamman 1766* (GH,US); Anvil Hill, Nome *Scamman 3942* (GH); Mt. N.E. Of Blocks *Drury 4104* (GH); Farewell Lake *Drury 2343* (ALA,GH); Near Farewell Lake *Drury 2529* (ALA,GH); Farewell Mtn. *Drury 2638* (GH); Near Farewell *Drury 2893* (ALA,CAN,GH); 12 mi. N.W. Kurupa Lake *Hodgdon, Glazier & Piedeman 8371* (GH); Two Lakes *Hulten s.n.* (GH,NY,US); Cape Beaufort *Hulten s.n.* (ALA,GH,NY); 2 mi. N.W. Umiat Village *Hodgdon 8985* (GH); Teller *Scamman 5646* (GH); Teller *Scamman 5645* (GH); Fairbanks *Scamman 1674* (GH); Eagle Summit *Scamman 2162* (GH); 13 mi. W. Paxson *Harms 4167* (ALA,GH); 2 mi. N. Igiugig *Harms 4317* (ALA,GH); E. Oumalik *Ward 1478* (CAN,GH,UC,US); Near College *A.E. & R.T. Porsild 243* (ALA,CAN,GH); Goldstream Creek and Pedro Dome *A.E. & R.T. Porsild 150* (CAN,GH); Sadlerochit River *Spetzman 835* (CAN,US); Maybe Creek *Spetzman 2616* (CAN); Grayling Lake *Hettinger 51* (CAN); Kongakut River Hill *Hettinger 367* (CAN); Anaktuvuk Pass *Spetzman 1891* (CAN,US); Sheep Mtn. *Spetzman 4262* (CAN); Norton Sound *A.E. & R.T. Porsild 932A* (CAN); Mt. Ve-ten-azin-ja *Jordal 3624* (CAN,US); Bristol Bay *Jones 9318* (CAN,NY); 3 km S.S.E. Cape Sabine *Shetler & Stone 3162* (CAN); Naknek *Norberg s.n.* (CAN,GH,UC,US); N. side Naknek River *Raup 66* (CAN); Naknek *Lepage 24162* (CAN); White Mts. *Gjaerevoll 19* (CAN); S. Tapana River valley *H.M. & L.G. Raup 12659* (CAN); 2 mi. N. Aniak *Drury 1501* (ALA,CAN); Guerin Glacier terminus *Murray 2015* (ALA,CAN); Mt. Veta *Spetzman 5466* (CAN); Norton Sound *A.E. & R.T. Porsild 1166* (CAN); Head Chitina River *Liang 203* (CAN); Head Chitina River *Liang 203A* (CAN); Buckland River *A.E. & R.T. Porsild 1629* (CAN); Mile 49 Richardson Hwy. *McBeth 360* (NY); Lake Peters *R.D. & M. Wood 459* (CAN); Healy *Anderson 5724* (CAN,NY); Healy *Anderson 1969* (NY); Cantwell *A.E. & R.T. Porsild 96* (CAN); Thompson Pass *J. & C. Taylor 19113* (NY); Canon of Earl River *Shainwald s.n.* (NY); 7 mi. N. Palmer *Welsh 4217* (NY); Mile 39 Elliott Hwy. *Welsh 4434* (ALA,NY); Polychrome Pass *McBeth 223* (NY); Mt. McKinley National Park *A.N. & R.A. Nelson 3747* (ALA,NY); Franklin Bluffs *Koranda & Shanks 22939* (NY); Summit Lake *Grinnell 194* (NY); Mendenhall, near Juneau *Anderson 2A375* (PH); Port Clarcua *Sharp s.n.* (PH); Onion Portage *C. & B. Schweger 56-116* (ALTA); Mt. Umiat *McPherson 72-379* (ALTA); Kigluaik Mts. *Harris 1366* (ALTA); Anvil Mtn., Seward Peninsula *Harris 1302* (ALTA); 56 km E. Chitina *Harris 1192* (ALTA); Summit Lake, 10 km N. Paxson *Harris 1208* (ALTA); Ogotoruk Creek *Packer 2654* (ALTA); 138 mi. N.N.E. Arctic Village *Hettinger 367* (ALTA,CAN); Middle Kurupa River valley *Hodgdon & Piedeman 878A* (US); Upper Kurupa River valley *Hodgdon 8306* (US); Mt. Katolinat *Muller 1219* (US); Kogglung *Muller 1040* (US); Utakok R. below Driftwood Creek *Ward 1269A* (US); Middle fork of Koyokuk River *Marshall s.n.* (US); Dumpling Mtn. *Hagelbarger 258* (US); Sheenjek Valley *Mertie s.n.* (US); Headwaters of Mulchatna River *Sargent & Smith 51* (US); Along 141st Meridian *Eaton 19* (US); Near Wiseman *Jordal 1916* (US); Road from Martel to Post *Muller 697* (US); Johnston Hill *Muller 1104* (US); Stu-yak-lor River *Harrington 81* (US); Tikchik and Wood R. Lakes *Mertie 122* (US); N.E. Wonder Lake *A. & R.A. Nelson 3937* (ALA,US); Kokrinus *Palmer 1563* (US); Bessey Rd., Nome *Miller 108C* (ALA,US); Rampart *Rader 11* (US); Little Creek, Nome *Thornton 185* (US); Valley of Chandaler River *Mertie 43* (US); 12 mi. S. Napamuta *Miller 289C* (ALA,US); Mt. McKinley National Park *Mackis 4* (US); Katmai Region *Hagelbarger 56* (US); Katmai Region *Hagelbarger 71* (US); Ansktoobak River *Schrader s.n.* (US); Bitter Granite Mtn. *Miller s.n.* (US); Little Wart Mtn. *Miller s.n.* (US); Yukon R. between Rampart and Tanana *Palmer 55* (ALA,US); John River *Schrader s.n.* (US); Gold Bay *Piper 4248* (US); Talstoi *Harrington 35* (US); Lake Schrader *Scholander & Flagg S-529* (US); Chandler Lake *Wiggins 13694* (US); S.W. Takotna Mtn. *Layden 165* (US); Above Wiseman *Jordal 2116* (US); At camp *Schrader s.n.* (US); Mt. McKinley National Park *A. & R.A. Nelson 3663* (ALA,US); Downstream from Okpilak River *Cantlon & Malcolm 58-0023* (US); Pitmegea River *Cantlon & Gillis 57-452* (ALA,US); E. Okpilak Lake *Cantlon & Gillis 57-2118* (US); W. Mest Mtn. *Ward 1269* (US); Between Yukon R., Nation R. and Boundary *Mertie 113* (US); Between Yukon R., Nation R. and Boundary *Mertie 112* (US); Camp 11 *Schrader s.n.* (US); Richardson Glacier *Rausch s.n.* (US); Mt. McKinley National Park *Warren W-2231* (US); Nome *Hill 34* (US); Teller Reindeer Station *Walpole 1833* (US); Above Fannie Quigley's place *A. & R.A. Nelson 3901* (ALA,US); Mt. McKinley National Park *A. & R.A. Nelson 3902* (ALA,US); Meade River *Hulten s.n.* (US); Region of Tikchik and Wood R. Lakes *Mertie 122A* (US); W. side Jago River *Cantlon & Gillis 57-732* (US); Mt. McKinley National Park *A. & R.A. Nelson 3578* (US); Mt. McKinley National Park *A. & R.A. Nelson*

3747 (US); W. side Jago River *Cantlon & Gillis 57-641* (US); Mt. McKinley National Park *A. & R.A. Nelson 3678* (ALA,US); Lake Peters *Hultén s.n.* (US); Anaktvuk Pass *Hultén s.n.* (US); Dark Creek Valley *Cantlon & Malcolm 58-0143* (US); Iliamna Bay *Gorman s.n.* (US); White River Valley *Eaton s.n.* (US); Mt. McKinley National Park *Dixon 36* (UC,US); White Mtn. *Collier s.n.* (US); Mt. McKinley National Park *A. & R.A. Nelson s.n.* (ALA,US); Wild Lake, N. Bettles *Jordal 2463* (US); Wahoo Lake *Chapman 51* (ALA); Tikchuk Lakes *Densmore 253B* (ALA); Tikchuk Lakes *Densmore 78* (ALA); Marsh Mtn., near Aleknagik *Roberson 184* (ALA); Killeak Lake *Racine 99* (ALA); Rainbow Mtn. *Parker RM-75* (ALA); Lava Lake *Racine 167* (ALA); Finger Mtn. *Murray & Johnson 6067* (ALA); Mile 40 Council Rd. *Parker 235* (ALA); Rainbow Mtn. *Smith 2610* (ALA); Mile 103 Steese Hwy. *T.P. & J.T. O' Farrell 49* (ALA); Onion Portage *Schweger 6* (ALA); Onion Portage *Schweger 56* (ALA); Onion Portage *Schweger 116* (ALA); Ray Mts. *Kassler 61* (ALA); Anvil Mtn. *Kelso 82-48* (ALA); Noluck Lake *Parker 196* (ALA); Mt. Eielson *Viereck s.n.* (ALA); Philip Smith Mts. *Murray & Johnson 6101* (ALA); Wrangell Mts. *Alf et al. 432* (ALA); Gobbler's Knob *Murray & Johnson 5095* (ALA); Lake Peters *Batten 496* (ALA); Carnivore Creek *Batten 283* (ALA); N. Ambresvajun Lake *A.R. & C.G. Batten 75-185* (ALA); N. Ambresvajun Lake *A.R. & C.G. Batten 75-132* (ALA); Ambresvajun Lake *A.R. & C.G. Batten 75-401* (ALA); Ambresvajun Lake *A.R. & C.G. Batten 75-369* (ALA); 12 km S.E. Cape Sabine *Shetler & Stone 3247* (ALA); Mile 40 Council Rd. *Parker 274* (ALA); Mile 77-78 Dalton Hwy. *Khokhryakov, Yurtsev & Murray 6673* (ALA); Skiland *Yokal 41* (ALA); South Hill *Trent JNT-87-1965* (ALA); Meade River *Geist s.n.* (ALA); Selawik Hills *Lipkin 80-135* (ALA); Guerin glacier terminus *Murray 2081* (ALA); Mile 33 Taylor Hwy. *Nava 38* (ALA); Rainbow Mtn. *Parker RM-5* (ALA); Nome *Williams 2643* (ALA); E. fork of Kuskokwim River *Viereck 5009* (ALA); Rainbow Mtn. *Harms 4154* (ALA); Mt. Hayes *Anderson 549* (ALA); Cantwell *Frohne 54-444* (ALA); Near Atkasook *Komarkova et al. 379* (ALA); Cantwell *Palmer 1915* (ALA); Cantwell *Palmer 1923* (ALA); Mile 141.5 Taylor Hwy. *Harms 4920* (ALA); Miller Creek *Hatler 22* (ALA); Mile 72 Mt. McKinley National Park *Richey s.n.* (ALA); Mt. McKinley National Park *Frohne 54-238* (ALA); Ballaine Lake *Hatler 5* (ALA); University of Alaska *Alt 5* (ALA); Big Delta Quad. *Johnson 35* (ALA); Sheenjek River *Kessel S-166* (ALA); Sheenjek River *Kessel S-153* (ALA); Stony Creek *Schene s.n.* (ALA); Kantishna *Frohne 54-314* (ALA); Easter Creek *Staender 31* (ALA); Ukinyik Creek *Viereck & Bucknell 4491* (ALA); Mile 6 Cantwell Rd. *Frohne 54-352* (ALA); Anvil Mtn. *Heller 959* (ALA); E. fork Kuskokwim River *Viereck 6024* (ALA); Jumbo Dome *Brophy et al. SB8146* (ALA); Ogotoruk Creek *Johnson et al. 266* (ALA); Oumalik *Ebersole & Bowman 244* (ALA); Atigun River *Ward & Rothe 45* (ALA); Seward *Helmstetter 80-208* (ALA); Lost River *Lenarz 80* (ALA); Cape Dyer *Viereck & Bucknell 4156* (ALA); Ogotoruk Creek *Johnson & Neiland 168* (ALA); Wells Mtn. *Helmstetter 123-79* (ALA); Lake Peters *Batten 887* (ALA); Fish Creek *Murray & Johnson 6687* (ALA); Sadlerochit River *Hendrick 78-100* (ALA); Kipmik Lake *Young 4874* (ALA); Ogotoruk Creek *Johnson RJ-82* (ALA); Donnelly Dome *Yokel 30* (ALA); Mile 64.5 Mt. McKinley National Park *Richey s.n.* (ALA); Wiseman *Brockman s.n.* (ALA); Ikpikpuk River *Geist s.n.* (ALA); Kokrines *Miller 1563* (ALA); Kokrines *Miller 1640* (ALA); Serpentine Hot Springs *Springer s.n.* (ALA); Cape Beaufort *Stone 915* (ALA); Unalakleet *Becker 23* (ALA); Mancha Creek *Mouton s.n.* (ALA); Takahula Lake *Jorgensen T191* (ALA); Jago River *Murray 6946* (ALA); Alaska *Anderson 1005* (ALA); Cape Thompson *Johnson, Viereck & Melchior 527* (ALA); Ogotoruk Creek *Johnson & Neiland 87* (ALA); E. fork Kuskokwim River *Viereck 5229* (ALA); Eagle Summit *Kessel s.n.* (ALA); Dexter Rd. *Heller 986* (ALA); Cape Thompson *Belson s.n.* (ALA); Mt. Eielson *Viereck 1217* (ALA); Eagle Summit *Moore 17* (ALA); Mile 15.5 Teller Rd. *Walker s.n.* (ALA); Lake Iliamna *Donaldson 184A* (ALA); 85 mi. N.E. Fairbanks *Seim s.n.* (ALA); Kilo Hot Springs *Kassler 270* (ALA); Between Castner and Fels glaciers *Shaughnessy 72-114* (ALA); Dry Creek *Viereck & Jones 5666* (ALA); N. Grayling Lake *Murray 6713* (ALA); Canning River *Spetzman 375* (ALA); Independent Ridge *Spetzman 100* (ALA); Wickersham Dome *Batten 76-152* (ALA); Kalubik River *Mason 76-423* (ALA); Goodnews Bay *Williams 3593* (ALA); Mt. McKinley National Park *Palmer 406* (ALA); Newhalen *Thomas N-11-52* (ALA); Fielding Lake *Spooner RSS-P-98* (ALA); Mile 45 Mt. McKinley National Park Rd. *Frohne 54-105* (ALA); Arrigetch Creek *Cooper CV-685* (ALA); Feather River *Pegau 273* (ALA); N.E. Loon Lake *G. & V. Staender 27* (ALA); Mile 67.8 Mt. McKinley National Park Rd. *Richey s.n.* (ALA); Mt. McKinley National Park *Gornall 273* (UBC); Mile 250.2 Richardson Hwy. *Gornall 282* (UBC); Eagle Summit *Finch 365* (UBC); Marshall *Harrington 148* (US); Mt. McKinley National Park *Frohne 54-277* (ALA); Mile 66 Mt. McKinley National Park Rd. *Richey s.n.* (ALA). Carlo Creek Forest above Carlo Creek *Carwile 79-161* (ALA); Mount McKinley National Park *Dixon 56* (UC); Norton Sound *Rhodes, Newhall &*

Giacomini s.n. (UC); Norton Sound *MacGregor s.n.* (UC); Near Nome *Powers 73* (UC); Mt. Eielson, McKinley Natl. Park *Langenheim 4166* (UC); On summit between American Creek and King Salmon Creek along Taylor Hwy. to Eagle from Liberty *Langenheim 4144* (UC); McKinley Natl. Park, head of Savage River *Mexia 2049* (UC); Wonder Lake, Photograph Hill *Mexia 2225* (UC); Kuskokwim River to Horn Mtns. *Stewart 600* (UC); Sheep Creek *Winters 203* (ALA); Mile 29 Elliott Hwy. *Harms 3841* (ALA); Feniak Lake, Makpik Creek *Young 4355* (ALA); SE Farewell *Drury 2830* (ALA); Mt.McKinley Natl. Park, between mile 70 and 80 *Viereck 1107* (ALA); 3 mile radius of Camp Denali *Bucknell 30* (ALA); Eagle Summit *Shetler 257-AF* (ALA); Thompson Pass, Richardson Hwy. *Frohne 53-161* (ALA); Farewell Mtn. *Parker 747* (ALA); Angel Creek and Chena River *Keller 1055* (ALA); Mt. Osborn, Central Kigluaik Mtns. *Kelso 84352* (ALA); Post Lake and Post River *Parker 475* (ALA); Mile 42 Council Road *Kelso 83-21* (ALA); V.A.B.M. Koganak *Meyers & Hayden 81-168* (ALA); Mile 20 Teller Road *Kelso 83-53* (ALA); Sager's Camp, Mt. McGinnis *Murray 3061* (ALA); Post Lake *Parker 868* (ALA); Tin Creek *Parker 606,649* (ALA); Tributary of Big Salmon Fork *Parker 725* (ALA).

U.S.S.R.: Arakamtchetchene Island *Wright s.n.* (NY); Arakamtchetchene Island *Anonymous* (NY); Plover Bay *Dall s.n.* (US); E. Chukotsky, Km 159 Route Egvekinot-Iultin *Petrovsky s.n.* (ALTA); Chukotsky Peninsula, Lake Yoni *Nechayer, Plieva & Yurtsev s.n.* (ALTA); Chukotsky Peninsula, Chegitun River *Sekretareva, Sytin & Yurtsev s.n.* (ALTA); Chukotsky Peninsula, Chegitun River *Sekretareva, Sytin & Yurtsev s.n.* (ALTA); Chukotsky National Area, Mt. Pevek *Shamurin & Yurtsev s.n.* (ALTA); Chukotsky Peninsula, Lavrentiya *Korobkov s.n.* (ALTA); Chukotsky Peninsula, Matuchan River *Karenin et al. s.n.* (ALTA); Chukotsky National Area, Anadyr Hills *Karenin & Petrovsky s.n.* (ALTA); Chukotsky Peninsula, Lavrentiya *Korobkov s.n.* (ALTA); Chukotsky National Area, Anadyr Hills *Korobkov s.n.* (ALTA); Chukotsky National Area, Anadyr Hills *Korobkov s.n.* (ALTA); Chukotsky Peninsula, Leningrad *Yurtsev s.n.* (ALTA); Chukotsky Peninsula, Urelik and Provideniya *Afonina et al. s.n.* (ALTA); Chukotsky Peninsula, Iultin *Zimarskaya, Korobkov & Yurtsev s.n.* (ALTA); Chukotsky Peninsula, Yoniveem River *Nechayev, Plieva & Yurtsev s.n.* (ALTA).

Arnica frigida subsp. *frigida* was first described (as *A. alpina* L.) in 1831 by C.F. Lessing in his report on the Synanthereae from plant material gathered during the Romanzoffiana Expedition (1815-1818). In the earliest revision of North American *Arnica*, Torrey and Gray (1843) placed the first described *A. alpina* L. into the much confounded *A. angustifolia* Vahl complex. Within this complex were also placed *A. fulgens* Pursh, *A. plantaginea* Pursh and members of the *A. angustifolia* aggregrate. Herder (1867) was able to give a much better interpretation of *Arnica* after viewing many collections brought to him from throughout the U.S.S.R. and Alaska (which at that time was owned by the U.S.S.R.) and retained *A. alpina sensu* Lessing.

Although the actual type specimen of *A. frigida* ssp. *frigida* was not seen, a photograph was provided by UC. The specimen was collected by Eschscholtz as *A. alpina* Less. and appears identical to *A. frigida*. In 1926 Iljin proposed *A. frigida* Meyer *ex* Iljin.

The following year, Rydberg (1927) proposed five names for the polymorphic *A. frigida* subsp. *frigida* with the typical species being described as *A. nutans*. Rydberg had probably not been aware of the work of Iljin. The variable size of *A. frigida* subsp. *frigida* had led Rydberg to give the name *A. mendenhallii* to large specimens and *A. brevifolia* to the smallest specimens. With the exception of size, these plants are identical with those of *A. frigida* subsp. *frigida*. The type specimen of *A. sancti-laurentii* was collected at St. Laurence Bay by A. C. Chamisso at the same time as Eschscholtz selected the type of *A. frigida*. Maguire (1943) has observed that these two plants are identical. Chamisso accompanied Eschscholtz on the collecting expedition.

A. illiamnae is represented by a specimen which has a distinct glandularity on the herbage and a branching habit. This branching habit is very rarely seen within this species and represents no more than an abnormality in growth form. The glandularity is more prominent than normally found but otherwise these plants are identical to *A. frigida* subsp. *frigida* and do not warrant taxonomic consideration.

Arnica louiseana var. *pilosa*, a taxon thought to be a hybrid between *A. frigida* and *A. angustifolia* subsp. *tomentosa* because of its erect capitula and dense periclinium and involucral bract pubescence (Maguire 1943), is typical *A. frigida*. The degree of periclinium and bract pubescence is environmentally induced, for when plants are observed after tissue turnover in the greenhouse, periclinium and bract vestiture is reduced considerably. Similarly, the great variation in periclinium pubescence found within natural populations of *A. frigida* influenced Boivin (1953) to propose *A. frigida* var. *glandulosa* for plants lacking a pilose involucre and periclinium. These two taxa are therefore treated as synonyms.

Arnica snyderi Raup was proposed for plants resembling *A. louiseana* Farr, but distinguished by being more scapose; and having nearly to quite entire, and glabrous to sparingly glandular leaves. In leaf shape these plants have been reported to resemble *A. frigida* subsp. *griscomii* (Raup 1947). However, the yellowish-brown peduncle and periclinium seem to suggest a closer affinity to *A. louiseana*. In the present investigation, these plants, common to the Brintnell Lake area in the Northwest Territories, were found to be identical in habit, and leaf shape and pubescence to triploid *A. frigida* in northern Yukon. Periclinium colour was also found to be an environmentally induced character. *Arnica snyderi* is therefore a synonym of *A. frigida* subsp. *frigida*.

2b. **Arnica frigida** subsp. **griscomii** (Fern.) S.R. Downie, Can. J. Bot. 64:1369. 1986. *A. griscomii* Fernald, Rhodora 26:105. 1924. *A. louiseana* subsp. *griscomii* (Fern.) Maguire, Brittonia 4:419. 1943. *A. louiseana* var. *griscomii* (Fern.) Boivin, Phytologia 23:95. 1972. TYPE: "Québec, Matane County. Cold chimneys in the schist at about 900-1000m altitude, south of Fernald Pass, Mt. Mattaouisse. Aug. 20, 1923. *M.L. Fernald & L.B. Smith 26084*". (HOLOTYPE GH!, PHOTO CAN!, ISOTYPES CAN!, MT!, UC!, PHOTO UC!). Figure 19.

Plants 0.5 to 2.5 dm high; *cauline leaves* 1 to 2 pairs, 6.0 to 25.0 mm broad, 15.0 to 80.0 mm long, leaves spathulate to ovate or lanceolate-oblong, apex acute or obtuse; *periclinium* moderately white-pilose; *involucral bracts* 9.0 to 13.5 mm long, 2.5 to 4.6 mm broad, broadly lanceolate to oblanceolate, apex acuminate to obtuse, pilose at base becoming glabrate above; *ligulate florets* 6 to 11, 15.0 to 22.0 mm long, 3.0 to 6.0 mm broad, the lobes 0.4 to 1.8 mm long; *achenes 2.5 to 4.5 mm long; capitula* 12.0 to 23.0 mm high, 11.0 to 20.0 mm broad; *chromosome number* 2n=76.

DISTRIBUTION AND HABITAT: Rare on exposed hornblende-schists and dry schistose talus in the alpine areas (850-1070 m) of Mts. Logan, Mattaouisse and Saint-Alban of the Gaspé Peninsula in Québec; and infrequent in the turfy talus of limestone sea-cliffs and gravelly ~~limestone barrens~~ in the areas of Ingornachoix Bay, St. John Bay, St. Barbe Bay and the Doctor Hill Range of northwestern Newfoundland (Figure 18).

REPRESENTATIVE SPECIMENS: **CANADA, Newfoundland:** St. John Bay *Fernald, Long & Fogg 2141* (DAO,GH,MT,NY,PH,US); St. John Bay *Fernald, Long & Fogg 2139* (DAO,GH,MT,NY,PH,US); St. John Bay, S.W. Port Au Choix *Fernald, Long & Fogg 2142* (GH,MT,NY,PH,US); Region between St. John Bay and Ingornachoix Bay *Fernald, Long & Fogg 2143* (GH,MT,PH); St. John Bay *Fernald, Long & Fogg 2140* (GH,MT,NY,PH,US); St. John Island *Fernald et al. 29216* (GH,PH); St. Barbe S. District, Port Au Choix *Hay & Bouchard 74031* (CAN); Doctor's Hill, St. Barbe *Tuomikoski 343* (CAN,MT). **Québec:** Mt. Saint. Alban *Marie-Victorin, Rolland-Germain & Dominique 49028* (DAO,MT); Matane Co., Mt. Mattaouisse *Fernald, Griscom, Mackenzie, Pease & Smith*

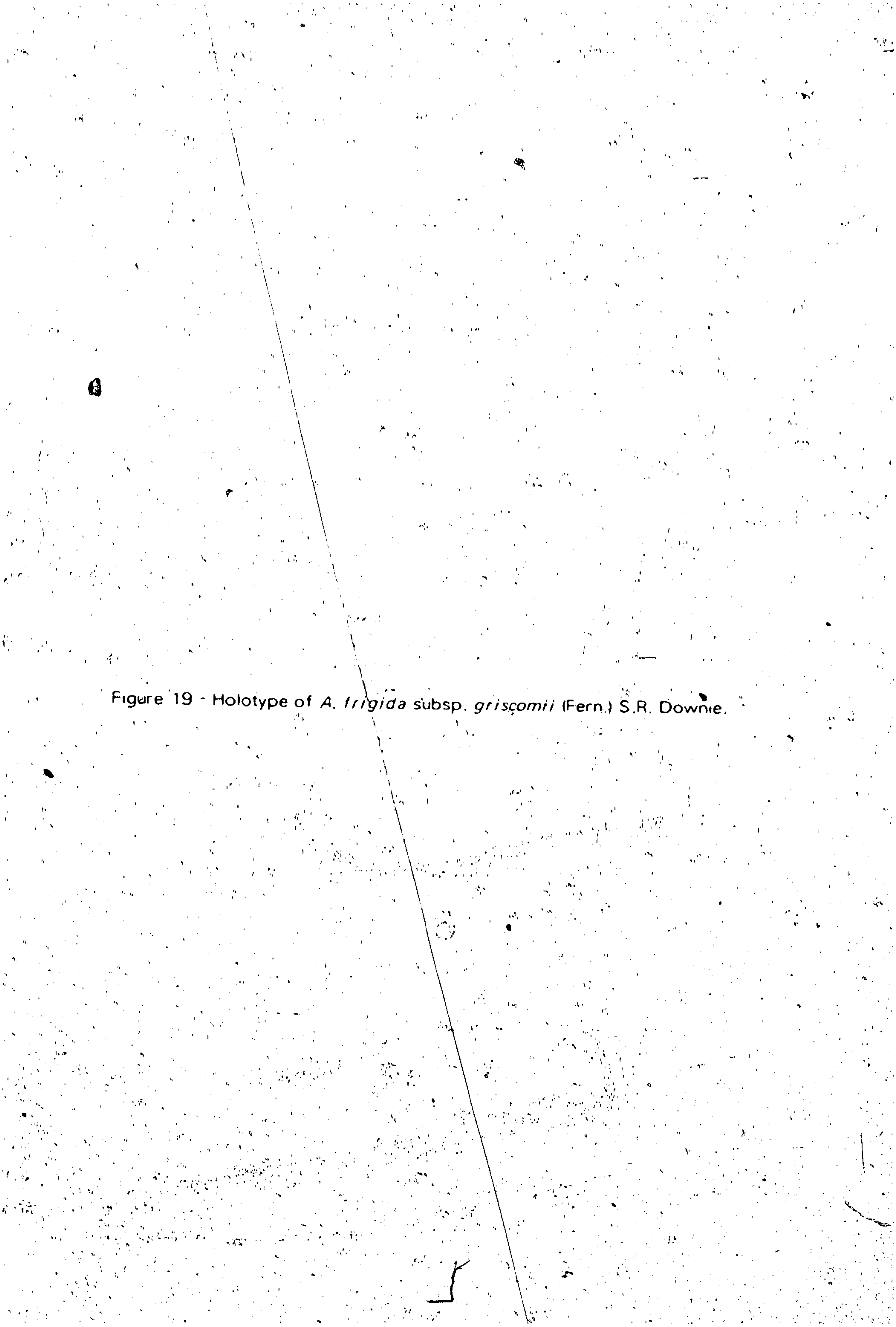


Figure 19 - Holotype of *A. frigida* subsp. *griscomii* (Fern.) S.R. Downie.

GRAY HERBARIUM
HARVARD
UNIVERSITY
FLORA OF QUEBEC
MATANE COUNTY
26154
ANNOTATION LABEL
MONOGRAPH OF THE GENUS ARNICA

26082 (MT,NY,US); Matane Co., Mt. Logan *Pease & Smith 26083* (MT,NY); Matane Co., Mt. Mattaouisse *Fernald & Smith 26085* (NY,US).

While studying specimens of *A. louiseana* and observing no morphological differences between this taxon and *A. frigida* subsp. *griscomii*, Fernald (1933) combined his previously proposed *A. griscomii* (Fernald 1924) to the earlier proposed name of *A. louiseana*. However, the apparent differences led Maguire (1943) to propose *A. louiseana* subsp. *griscomii*.

Arnica frigida subsp. *griscomii* exists in less than a half-dozen localities in the Gaspé Peninsula and is a rare plant of Québec's flora (Bouchard *et al.* 1983). The only collection obtained from Québec in this study was found to be precariously situated on the limestone precipices of Mt. Saint-Alban. This almost inaccessible population was abundant in this locality. Collecting trips to Mt. Logan and Mt. Mattaouisse (see Collins and Fernald (1925) for location of the latter) were to no avail. This taxon has been reported to form extensive vegetative carpets along the limestone barrens of northwestern Newfoundland (Fernald 1933). After extensive searching throughout the Port Au Choix area, only two small populations were found. It is feared that *A. frigida* subsp. *griscomii* is not as abundant as it once was and that there is a definite probability of total extirpation.

3. **Arnica rydbergii** Greene, Pittonia,4:37. 1899. TYPE: "Flora of Central Montana. Little Belt Mts., near the Pass. Aug. 10, 1896. *J.H. Flodman 891*". (HOLOTYPE ND!, ISOTYPES NY! (2 specimens), US!, PHOTO CAN!). Figure 20. Generalized illustration Figure 21.

A. caespitosa A. Nels., Bot. Gaz. 30:203. 1900. TYPE: "Yellowstone National Park, on high stony ridges, Druid Peak, Wyoming. July 12, 1899. *A. & E. Nelson 5785*". (HOLOTYPE RM!, ISOTYPES RM!)

A. tenuis Rydb., Bull. Torrey Club 28:20. 1901. TYPE: "Big Horn Mountains, Sheridan Co., Northwestern Wyoming. Aug. 1899. *F. Tweedy 2094*" (HOLOTYPE NY, PHOTO

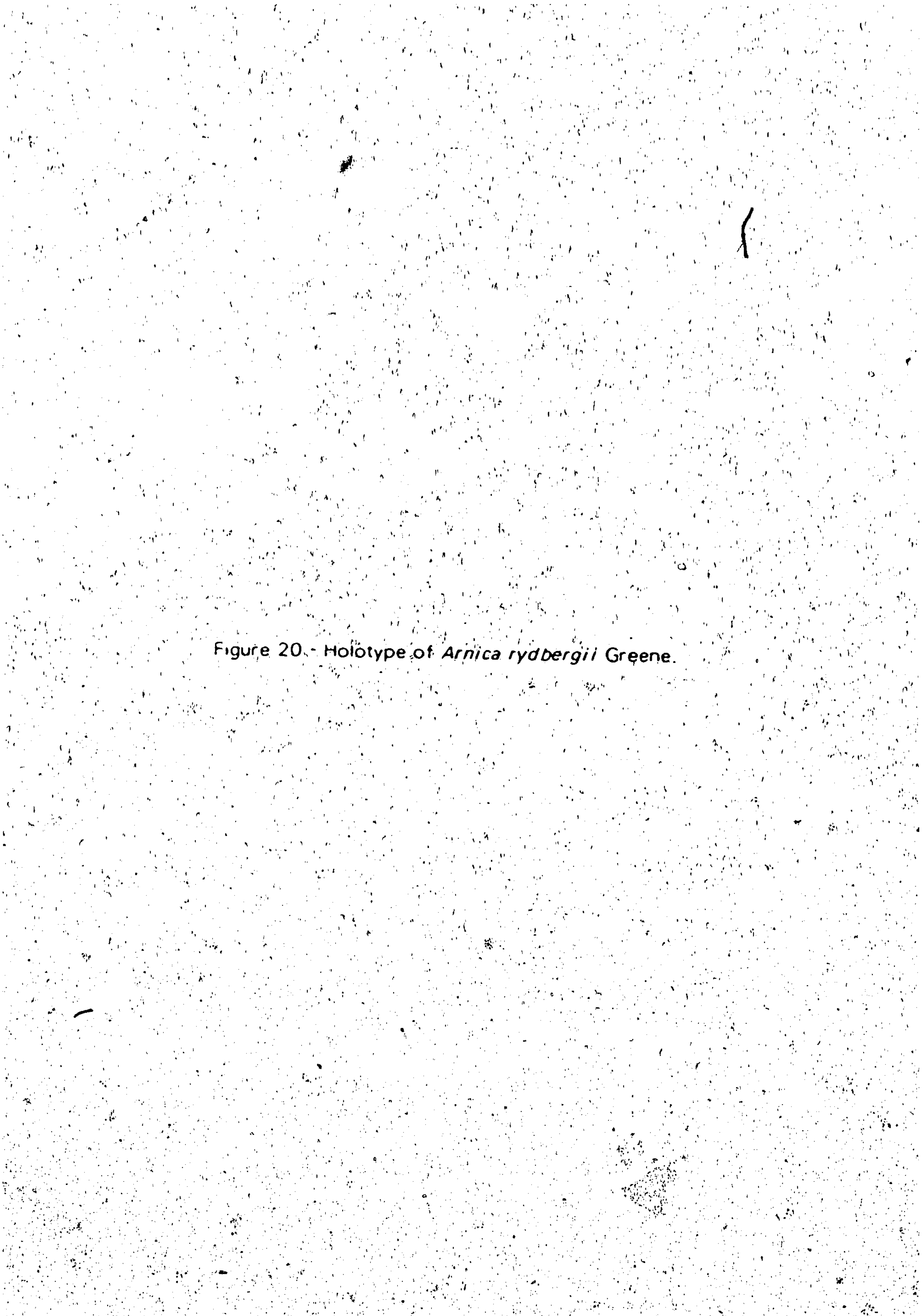


Figure 20.- Holotype of *Arnica rydbergii* Greene.


HERBARIUM
45923
GREENEANUM
FLORA OF CENTRAL MONTANA

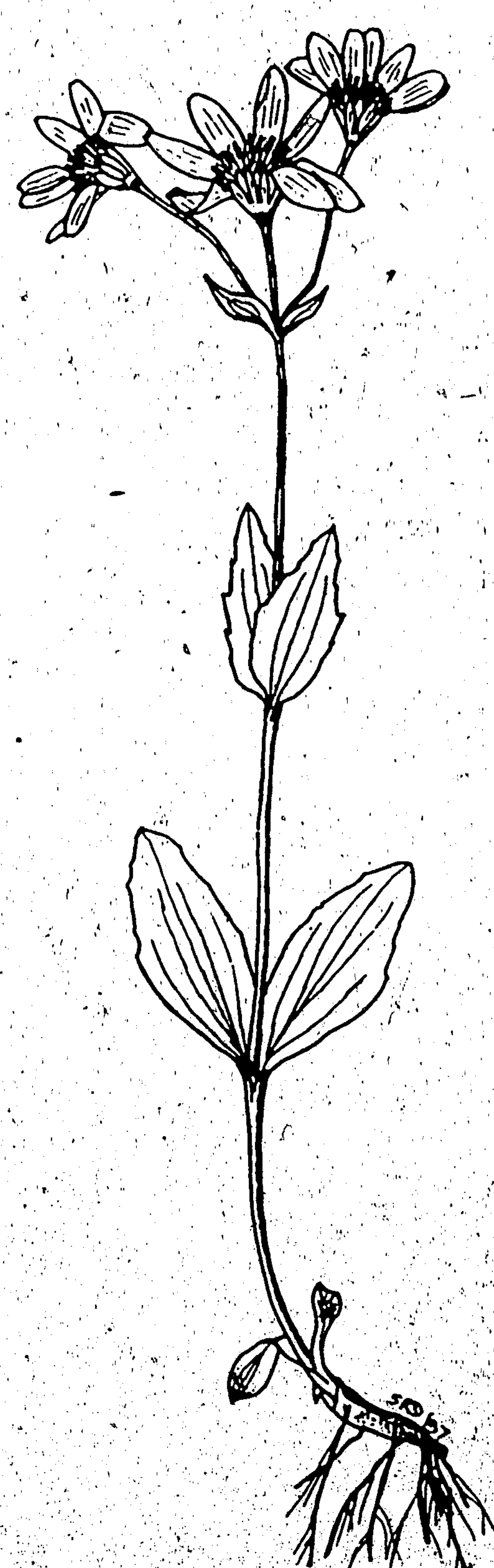


Figure 21 - Generalized illustration of *Arnica rydbergii* (based on *Maguire 2886* [ALTA]).

CAN!)

A. aurantiaca Greene, Torreya 1:42. 1901. TYPE: "Eastern Oregon Plants. Head of Keystone Creek, Wallowa Mtns. Aug. 2, 1900. *Wm. C. Cusick 2451*". (ISOTYPE RM!, US)

A. lasiosperma Greene, Leaflets 2:48. 1910. TYPE: Estes Park, base of Long's Peak, Colorado, 26 Aug. 1895. *Osterhout s.n. fide* Maguire (1943)

A. cascadensis St. John, Rep. Prov. Mus. Nat. Hist. B.C. 1926:10. 1927. TYPE: "Mt. McLean, British Columbia, July 11, 1926. *W.B. Anderson 8003*". (HOLOTYPE Washington State College, PHOTO CAN!)

A. sulcata Rydb., N. Am. Fl. 34:344. 1927. TYPE: "Scott Mountain, Siskiyou County, California. Aug. 22, 1896. *E.L. Greene 1005*". (HOLOTYPE GH, DRAWING NY!)

A. ovalis Rydb., N. Am. Fl. 34:338. 1927. TYPE: "Crow Nest Pass, Rocky Mtns. July 31, 1897. *J.M. Macoun 72719*". (HOLOTYPE CAN!, PHOTO CAN!)

Plants 0.8 to 3.5 dm high; *stems* sparsely puberulent becoming moderately pubescent upwards, stipitate-glandular; *cauline leaves* 2 to 4 pairs; *upper cauline leaves* sessile, lanceolate to broadly lanceolate; *lower cauline leaves* 2.0 to 7.0 cm long, 0.5 to 2.5 cm broad, apex acute to occasionally obtuse, oblanceolate to spathulate, the petioles sessile or very short and broad-winged, margins entire to occasionally denticulate to sometimes predominantly dentate, glabrous to sparsely pilose, stipitate-glandular, 3 to 5 nerved; *capitula* erect, 1 to 3 occasionally 5, campanulate-turbinate, 9.0 to 15.0 mm broad, 7.0 to 22.0 mm high; *periclinium* moderately white pilose, short-stipitate-glandular; *involucral bracts* 9 to 15, 7.3 to 14.5 mm long, 1.3 to 3.1 mm broad, linear-oblong to narrowly lanceolate, apex acute, glabrous to sparingly pilose, stipitate-glandular; *ligulate florets* 6 to 10, yellow, 13.5 to 29.0 mm long, 4.0 to 8.5 mm broad, minutely 3-toothed or entire, if toothed the lobes 0.1 to 0.5 mm long; *disc florets* 6.1 to 9.1 mm long, tubular, stipitate-glandular, densely pilose, the tube 2.3 to 3.7 mm long; *achenes* 3.8 to 7.1 mm long, densely hirsute throughout, not glandular; *chromosome number* 2n=38 and 76.

DISTRIBUTION AND HABITAT: Dry to mesic, exposed, rocky alpine slopes and ridges or alpine meadows in the Rocky Mountains of Alberta and British Columbia, south in the Cascade Mountains to Washington and Oregon, the Uinta Mountains of Utah and the Rocky Mountains of Wyoming and Colorado (Figure 22). Also known from Vancouver Island.

REPRESENTATIVE SPECIMENS: **CANADA, Alberta:** Citadel Mtn., vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 15970* (CAN); Vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13364* (CAN); Bow River Pass, Banff Park *Porsild & Breitung 14934* (CAN); Mt. Bourgeau and Mt. Brett *Porsild & Breitung 13761* (CAN); Vicinity of Mt. Temple Ski Lodge, Banff Park *Porsild & Breitung 12786* (CAN); Cirque Mtn., Bow Pass, Banff Park *Porsild & Breitung 16209* (CAN); Sawback Range, Banff Park *Porsild & Breitung 15517* (CAN); Mt. Eisenhower, Banff Park *Porsild & Breitung 15839* (CAN); Maligne River, Jasper Park *Turner 6903* (CAN); Mt. Norquay, Banff Park *Pellvet 92152* (CAN); Yellow Head Pass, Jasper Park *Spreadborough 19641* (CAN); Yellow Head Pass, Jasper Park *Spreadborough 19642* (CAN); Belly River *Dawson 14749* (CAN); Shovel Pass, Jasper Park *Macoun 96032* (CAN,NY); Lake Louise, Banff Park *Macoun 65522* (CAN,NY); Lake Louise, Banff Park *Macoun 65524* (CAN); Crow's Nest Pass *Macoun 22817* (CAN,NY); Mt. Louis, Banff Park *Lewis 92154* (CAN); Mt. Edith, Banff Park *Lewis 92155* (CAN); Sheep Mtn., Waterton Lakes Park *Macoun 11609* (CAN,NY); Lake Louise, Banff Park *Macoun 14706* (CAN); Lake O'Hara, Banff Park *Macoun 65521* (CAN,NY); Quartz Ridge, vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Lid 19515* (CAN); Snow Creek Pass, Banff Park *Porsild 21436* (CAN); Snow Creek Pass, Banff Park *Porsild 21437* (CAN); Snow Creek Pass, ~~Banff Park~~ *Porsild 22626* (CAN); Mt. Patterson, Banff Park *Porsild & Breitung 16161* (CAN); Mt. Coleman, along trail to Sunset Pass *Porsild & Breitung 16128* (CAN); Mt. Wilson, Banff Park *Porsild & Breitung 16117* (CAN); Mt. Patterson, Banff Park *Porsild & Breitung 16162* (CAN); Vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13211* (CAN); Fatigue Pass, vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13936* (CAN); Vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13448* (CAN); Citadel Peak, vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 14246* (CAN); Citadel Mtn., vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 15973* (CAN); Burstall Valley *Kondla 1781* (ALTA); Forget-me-not Mtn. *Lee s.n.* (ALTA); Eagle's Nest Creek area, Wilderness Park *Pegg 1719* (ALTA); Bald Hills, 3.5 km south Lookout *Kuchar 516* (ALTA); Bald Hills, 1 km south Lookout *Kuchar 515* (ALTA); Mile 92 Highwood Pass, 5 miles northwest Mt. Head, Kananaskis Forestry Rd. *Packer 4246* (ALTA); Sofa Mtn., Waterton Lakes Park *Kuchar 2714* (ALTA); Mile 85 Kananaskis Forestry Road, between Pyriform Mtn. and Mt. Head *Packer 473* (ALTA); Bald Hills, 3 km southsouthwest Lookout *Kuchar 517* (ALTA); Blakiston Mtn., Waterton Lakes Park *Packer 2894* (ALTA); Hat Mtn. *Ringius 1165* (ALTA); White Goat Campground *Krajina s.n.* (UBC); Larch Valley, Banff Park *Vrugtman 620050* (UBC); Mt. Glendown, Waterton Lakes Park *Breitung 16063* (NY); Mt. Rowe, Waterton Lakes Park *Breitung 17514* (NY); Carthew Pass, Waterton Lakes Park *Breitung 16674* (NY); Carthew Pass, Waterton Lakes Park *Breitung 16677* (NY); Crow's Nest Pass *Macoun 72719* (NY); Upper Twin Lake, Waterton Lakes Park *Blais 1928* (NY); Mt. Lineham, Waterton Lakes Park *Breitung 14027* (ALTA); Hat Mtn. *Ringius 1148* (ALTA); Prairie Bluff, 10 miles northwest Twin Butte *Shaw 2250* (BYU); Devil's Head Lake, Banff Park *Macoun s.n.* (C); Mt. Fairview, Banff Natl. Park *Dudynsky 7840* (ALTA). **British Columbia:** Near Cranbrook *Scoggan 16167* (CAN); Near Rossland *Anderson & Hall s.n.* (CAN); Goat Creek Mtn., 27 miles north Natal *Weber 2284* (UBC,CAN,NY); Mtn. at Kicking Horse Lake *Macoun 14705* (CAN); Old Glory Mtn., near Rossland *Macoun 64988* (CAN,NY); North Chilliwack Lake *Macoun 26934* (CAN); Cascade Range, near McGillivray Creek *Macoun 96033* (CAN,NY); Mt. McLean, near Lillooet *Macoun 96035*

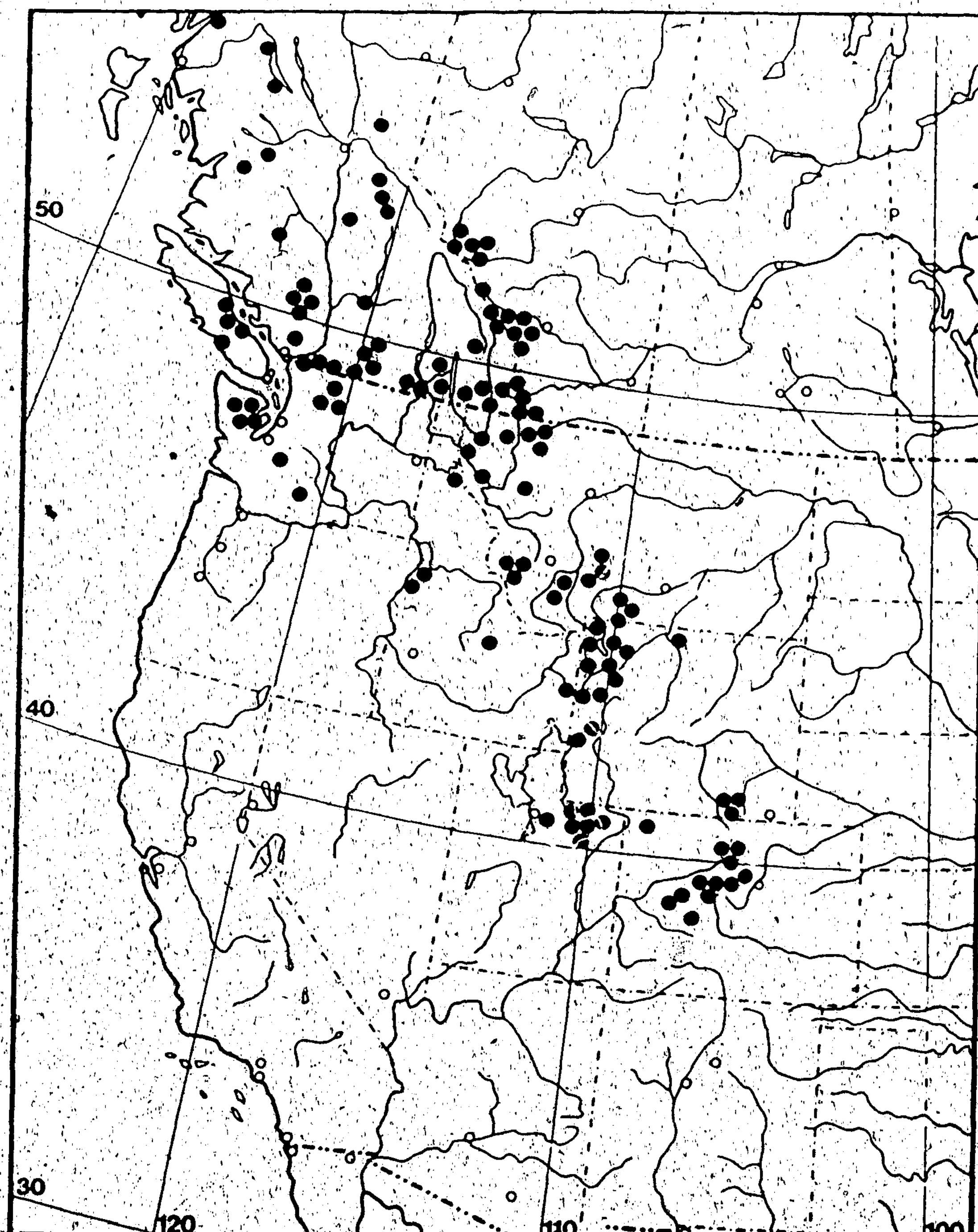


Figure 22 - Distribution of *Arnica rydbergii*.

(CAN,NY); Near head of McGillivray Creek *Macoun 96036* (CAN,NY); Lake House, Skagit River *Macoun 60334* (CAN); Mt. Assiniboine *Porsild 78377* (CAN); Cayoosh Creek, near Lillooet *McCalla 2886* (ALTA); Garibaldi *Perry s.n.* (UBC); Boss Mtn., Takomkane Mtn. *Williams & Luitjens 4* (UBC); Bridge Rd., Cranbrook *Krause 682020* (UBC); Mt. Apex; Penticton *Eastham s.n.* (UBC); Eagle Mtn., Fording River *Morrison s.n.* (UBC); D.O.T. Signal Station, Marysville *Fodor 512* (UBC); Flathead *Bell & Davidson 241* (UBC); Paddy Lake Rd., Manning Park *Beamish & Vrugtman 60702* (UBC); Bowron Lakes Park *Verbeek 95* (UBC); Blackwell Peak, north Ranger Station on Hope-Princeton Hwy., Manning Park *Calder & Savile 10527* (UBC); Apex Mtn. near Summerland *Stoner s.n.* (UBC); West Elizabeth Mine, near Lillooet *Beamish & Vrugtman 610601* (UBC); Fording River, Mt. Turnbull *Morrison s.n.* (UBC); Mt. Idaho *Beamish et al. 750092* (UBC); Tod Mtn., Kamloops *Taylor & Szczawinski 774* (UBC); Manning Park, Skyline Trail *Allen s.n.* (UBC); Big White Mtn., east Kelowna *Straley 1660* (UBC); Yahk Mtn., southeast Moyie *Straley 1574* (UBC); Ridge southeast Fossil Pass, Pemberton Meadows *Davidson s.n.* (UBC); Moore Peak *Johns 554* (UBC); Miller Creek, Pemberton Meadows *Chaney 3* (UBC); North Relay Creek cabin *Selby 96744* (UBC); Chipuin Mt., Marble Mtns. *J.W. & E.M. Thompson 590* (NY); Bluster Mt., Marble Mtns. *J.W. & E.M. Thompson 406* (NY); Lake Bootahnie, Marble Mtns. *J.W. & E.M. Thompson 146* (NY); Itcha Mtns., 26 miles northeast Anahim Lake *Calder, Parmelee & Taylor 20201* (NY); Mt. McLean, near Lillooet *Macoun 96034* (NY); Cathedral Park, Glacier Lake *Hainault 7696B* (ALTA).

U.S.A., Colorado: CHAFFEE CO.: Monarch Pass, between Gunnison and Salida along Hwy. 50 *Neese 15903* (BRY); CLEAR CREEK CO.: Silver Plume Mtns. *Shear 4970* (NY,RM); Silver Plume *Shear 4603* (NY); Gray's Peak, Clear Creek *Patterson 77* (NY); GILPIN CO.: Eldora to Baltimore *Tweedy 5824* (NY,RM); GRAND CO.: Mt. Howard *Clokey 4383* (NY,RM); LAKE CO.: 1 mile east Independence Pass, Leadville-Glenwood Springs *Rollins 1351* (NY); Mt. Elbert *Clokey 3628* (RM); LARIMER CO.: Lulu Pass *Osterhout 271* (NY,RM); Summit North Park Range *Goodding 1838* (BRY,NY,RM); Mt. Cameron *Osterhout 3811* (RENO,RM); Head of Windy Gulch, Mtns. of Estes Park *Osterhout 3107* (RM); Chambers Lake *Osterhout 3717* (RM); Rocky Mtn. Natl. Park *McNeal 271* (RM); PARK CO.: 1.2 miles west Hoosier Pass *Nelson 541* (BRY); ROUTT CO.: Hahn's Peak *Goodding 1698* (NY,RM); SUMMIT CO.: Mt. Helen near Breckenridge *Mackenzie 310* (NY); Jnctn. Hwy. 9 and Blue Lakes Rd., 5.5 miles south Brackenridge *Nelson 703* (RM).
Idaho: BONNEVILLE CO.: Caribou Mtn. *Payson & Armstrong 3555* (RM); CUSTER CO.: Head Rock Creek; 0.5 mile west Mt. Borah *Hitchcock & Muhlick 10934* (MONT,NY,RM); IDAHO CO.: Sheep Creek Lake No. 2, Seven Devil's Mtns. *Christ 2616* (NY); Seven Devils Lake, Seven Devils Mtns. *Christ 13991* (NY); Heavens Gate, Seven Devils Mtns. *Christ 12552* (NY); LEMHI CO.: Liberty Mtn., west Gilmore *Christ & Ward 14865* (NY); SHOSHONE CO.: Coeur d'alene Mtns., near Stevens Peak *Leiberg 1466* (NY,RM).
Montana: BEAVERHEAD CO.: East Pintlar Peak, Anaconda Range *Hitchcock & Muhlick 12867* (MONT,NY,RM); CARBON CO.: Spread Creek, East Rosebud River *Hawkins s.n.* (MONT); DEERLODGE CO.: Upper east slope Goat Flats, where trail to Upper Seymour Lake starts, Anaconda-Pintlar Range *Lackschewitz 4591* (NY); FLATHEAD CO.: Bob Marshall Wilderness, mtn. south Salk Lake *Lackschewitz 9098* (NY); GALLATIN CO.: Bridger Mtns. *Rydberg & Bessey 5228* (NY); East slope Bridger Mtns., 0.5 mile south Bridger Bowl skiing installations *Lackschewitz 5208* (NY); Bozeman, above Ferry Lake *Cotner s.n.* (MONT,RM); Bangtail Meadows above Olson Creek, Bridger Canyon *Dale 91* (MONT); Bridger Mtns., south Sacajawea area *Forcella s.n.* (MONT); Mt. Baldy in Bridger Range *Forcella s.n.* (MONT); GLACIER CO.: Midvale *Umbach 393* (NY); Blackfeet Indian Reservation *Gilman-Thompson s.n.* (NY); Ptarmigan Lake, Glacier Park *Hitchcock 2038* (MONT,RM); Piegan Pass *Maguire 1089* (RM); Cracker Lake *Maguire 1088* (RM); LINCOLN CO.: Mt. McDonald *Elrod s.n.* (NY); North Leigh Lake, Cabinet Mtns. *Woodland 686* (MONT); MADISON CO.: Old Hollowtop, near Pony *Rydberg & Bessey 5232* (NY); Divide to east Brandon Lakes, Tobacco Root Mtns. *Hitchcock 17038* (NY); Black Butte *Hitchcock 16326* (NY); MINERAL CO.: 5 miles northeast Big Prairie Ranger Station, Flathead Natl. Forest *Hitchcock 18606* (NY); PARK CO.: Between Clark's Fork, Yellowstone River and Beartooth Lake *Hitchcock 16688* (NY); 1 mile east Silver Pass, 9 miles west Four Mile Ranger Station, Boulder River Canyon *Hitchcock 16380* (NY); POWELL CO.: 5 miles northeast Big Prairie Ranger Station, Flathead Natl. Forest *Hitchcock 18594* (NY,RM), *18606* (RM); Mt. Powell *Task 258* (MONT).
Utah: DUCHENSE CO.: La Motte Peak *E.B. & L.B. Payson 5082* (NY,RM); Uinta Mtns., near Mirror Lake, 20.5 miles from Kamas *Goodrich 14771* (BRY,NY); Northeast 1/4 of

Section 32, Lower Chain Lake *Welsh, Neese & Atwood 18908* (BRY); South Pine Island Lake *Snow s.n.* (BRY); Ashley Natl. Forest, on Burnt Ridge *Goodrich 2665* (BRY); Chain Lakes Basin, 4th Chain Lake *Welsh, Neese & Atwood 18956A* (BRY); Head Pole Canyon near Lake Chepeta *Ostler 469* (BRY); Ashley Natl. Firest, head Squaw Basin below Brown Duck Mtn., 19.5 miles north Tabiona *Goodrich & Atwood 16184* (BRY); Trail below Jordan Lake, Uinta Mtns. *Albee 5* (BRY); Trail below Jordan Lake, Uinta Mtns. *Albee 1052* (UT); Flat below Jordan Lake, Naturalist Basin *Albee 669* (UT); SUMMIT CO.: Uintah Mtns., divide between East Fork of Bear River and Black's Fork *Goodman & Hitchcock 1538* (NY,RM); 3 miles north Trial Lake Campground, Notch Mtn. *Neese 10860* (BRY); Bald Mtn. *Welsh & Davis 1821* (BRY); Wasatch Natl. Forest; Bald Mtns., between East Fork of Black's Fork and Smiths Fork *Ostler 668* (BRY); Uinta Mtns., Clegg Lake *Albee 5675* (UT); Coney Peak *Goodman & Payson 255* (RM); West Fork Bear River, Uintah Mtns. *E.B. & L.B. Payson 4902* (RM); UINTAH CO.: Ashley Natl. Forest, 1.5 miles east Marsh Peak *Goodrich 17617* (BRY); UTAH CO.: Pike Cirque, Mt. Timpanogos *Allred 1032* (BRY).
Washington: CLALLAM CO.: Along trail to Mt. Angeles from Hurricane Lodge *Straley 1677* (UBC); Olympic Mtns. *Elmer 3417* (NY); Olympic Mtns. *Elmer 2595* (NY); JEFFERSON CO.: Constance Pass *Meyer 1562* (NY,RM); OKANOGAN CO.: Along trail to Slate Lake, Okanogan Natl. Forest, west Twisp *Straley 1496* (UBC); PIERCE CO.: Mt. Rainier, Mt. Rainier Natl. Park *Allen s.n.* (NY); SKAGIT CO.: Goat Mtns., Cascade Mtns. *Allen 229* (NY,US); WHATCOM CO.: Slate Peak, 29 miles northwest Winthrop *G.W. & G.G. Douglas 3990* (ALTA); Slate Peak, 29 miles northwest Winthrop *G.W. & G.G. Douglas 4438* (BRY); YAKIMA CO.: Mt. Aix, Snoqualmie Natl. Forest *Thompson 15035* (ALTA,UBC,NY).
Wyoming: ALBANY CO.: Medicine Bow Mtns., U. of Wyoming Summer Camp *Wann s.n.* (NY); West Lake Marie, Medicine Bow Mtns. *Rollins 998* (NY); No Locality info. *French 120* (UT); South Nash Fork Campground along Hwy. 130 *B.E. & L. Nelson 722* (RM); Medicine Bow Mtns., 12.6 miles west Centennial along Libby Creek *Nelson 870* (RM); Below Sugarloaf in Snowy Range *Bliss 440* (RM); North Snowy Range *Salheim 378* (RM); BIG HORN CO.: Big Horn Mtns., between Five Springs Point and Elk Springs Creek, 21.5 miles east Lovell *Nelson 6219* (RM); FREMONT CO.: Absaroka Mtns., 14 miles northnorthwest Dubois, Burroughs Creek, 1 mile northnortheast Ramshorn Peak *Kirkpatrick 4446* (RM); Absaroka Mtns., Twilight Creek *Kirkpatrick 1727* (RM); LINCOLN CO.: Commissary Ridge, south Fontenelle Mtn. *Smith 1158* (NY,RENO,RM); Sheep Mtn., Ferry Peak, Snake River Range near Alpine *Payson & Armstrong 3473* (RM); PARK CO.: Absaroka Mtns., north fork Shoshone River drainage *Evert 2315* (NY,RM); Beartooth Mtns., around Gardner Lake *Evert 6193* (NY); SUBLETTE CO.: Bridger Natl. Forest, near Seneca Lake, Wind River Mtns. *Lewis 1026* (BRY); Piney Mtn., 25 miles west Big Piney *E.B. & L.B. Payson 2702* (RM); TETON CO.: Buffalo Fork *Tweedy 522* (NY); Grand Teton Natl. Park, Glacier Canyon *Williams 923* (NY); YELLOWSTONE NATIONAL PARK CO.: Mt. Washburn *Condon 5717* (BRY,UT); On divide between Heart and Round Lakes *Shannon & McDonald 605* (UT).

Confined to the cordillera of western North America, *A. rydbergii* is readily distinguished by its small, narrow heads; its minutely denticulate or entire ligule margins; few and narrowly tubular disc florets; clustered stems; and a strong tendency for the lower cauline leaves to be sessile.

During the period 1899 to 1901, four names were proposed for this species, including *A. rydbergii* Greene. As previously suggested by Maguire (1943), and observed in this study, the type specimens of *A. caespitosa*, *A. tenuis* and *A. aurantiaca* all fall within the normal variation of the species and were undoubtedly named before the application of *A. rydbergii* was fully understood. The type of *A. cascadensis*, although not seen in this study, has been described as a glandless *A. rydbergii*, for it maintains all other diagnostic features (Maguire 1943). The presence (or absence) of short-stipitate glandular hairs on the leaves and periclinium is not a critical character. *Arnica lasiosperma* is merely a depauperate specimen of *A. rydbergii* (Maguire 1943).

The short-petiolate and large oval basal leaves of *A. ovalis* led Rydberg to propose this new species in 1927. However, its entire to indistinctly denticulate ligules, the narrow capitulum, and the sessile cauline leaves strongly suggest that this species conforms to *A. rydbergii*. In the same year, Rydberg proposed *A. sulcata* for a single specimen possessing a short-plumose pappus, and a sulcate and copiously glandular stem. Maguire (1943) has observed similarities between this taxon and *A. rydbergii*, and has placed *A. sulcata* under synonymy with the latter. With the presence of this plumose pappus, it is doubtful if this species belongs in *A. rydbergii*. In addition, the range of *A. rydbergii* does not extend as far south as California. However, not having observed this specimen, it is difficult to assign it to any one particular taxon. Until subsequent collections and observation reveal this taxon to be a good species, it should remain a synonym with *A. rydbergii*.

4. **Arnica fulgens** Pursh, Fl. Am. Sept. 527. 1814. *A. montana* var. *fulgens* (Pursh) Nutt., Gen. N. Am. Plts. 2:164. 1818. TYPE: "On the banks of the Missouri" (Pursh 1814). (HOLOTYPE indicated by Maguire (1943) to be in BM was not found by staff. ISOTYPE, without locality, PH!, PHOTO CAN!). Figure 23. Generalized illustration Figure 24A.

A. pedunculata Rydb., Bull. Torrey Club 24:297. 1897. TYPE: "Flora of Central Montana, Spanish Basin, Madison Range. July 11, 1896. *J.H. Flodman 899*" (HOLOTYPE NY!)

A. monocephala Rydb., Mem. N. Y. Bot. Gard. 1:435. 1900. *A. pedunculata* var. *monocephala* (Rydb.) Lunell, Am. Midl. Nat. 5:241. 1918. *A. pedunculata* forma *monocephala* (Rydb.) Cockerell, Torreya 18:183. 1918. TYPE: "Exploration of Montana

Figure 23 - Isotype of *Arnica fulgens* Pursh.


ANNOTATION LABEL
MONOGRAPH OF THE GENUS ARNICA
ISOTYPE OF
Arnica fulgens Pursh
Fl. Am. Sept. 527. 1814.
Stephen R. Downie Oct. 1986.
NORTHERN TRANSCONTINENTAL SURVEY
TYPE COLLECTION
Arnica fulgens Pursh
FLORA OF CALIFORNIA
ANNOTATION LABEL
MONOGRAPH OF THE GENUS ARNICA
ACADEMY OF NATURAL SCIENCES, PHILADELPHIA

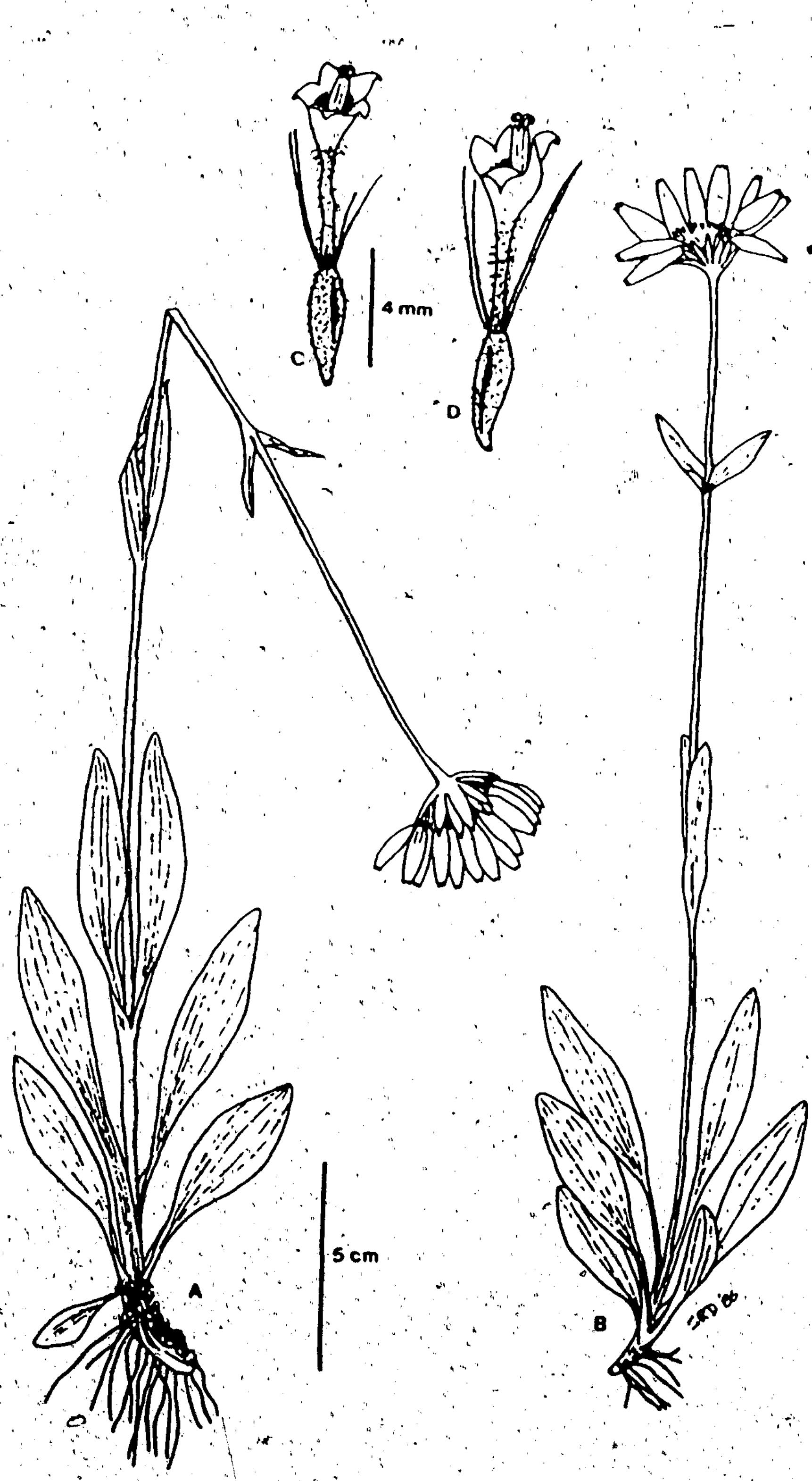


Figure 24 - Generalized illustrations of *Arnica fulgens* and *A. sororia.* (A) Habit of *A. fulgens* (slightly modified from *Downie 554*); (B) habit of *A. sororia* (based on *McCalla 4510*); and (C and D) disc florets (with pappus removed) of *A. fulgens* and *A. sororia*, respectively.

and Yellowstone Park. Bridger Mountains, Mont. 14 June 1897. *P.A. Rydberg and E.A. Bessey 5221*". (HOLOTYPE NY!, ISOTYPE CAN!)

A. pedunculata var. *tubularis* Cockerell, J. Hered. 7:428. 1916. TYPE: "Boulder, Colorado. June 1915. *W.P. Cockerell s.n.*". (HOLOTYPE GH!)

Plants 1.0 to 7.2 dm high; *stems* simple, stout, moderately puberulent becoming increasingly pubescent upwards, stipitate-glandular; *leaves* 3 to 5 pairs; *upper cauline leaves* sessile and reduced; *basal leaves* 4.5 to 20.0 cm long, 0.6 to 2.5 cm broad, apex obtuse, narrowly oblong to oblanceolate, rarely broadly spathulate or oval, the petioles narrow or broad-winged and shorter than the blade, margins entire to rarely remotely denticulate, moderately uniformly pubescent, stipitate-glandular, 3 to 5 nerved; *capitula* erect, solitary to occasionally 3, broadly hemispheric, 14.0 to 30.0 mm broad, 11.0 to 17.0 mm high; *periclinium* moderately to densely white pilose, stipitate-glandular; *involucral bracts* 13 to 21, 10.0 to 15.5 mm long, 1.5 to 4.5 mm broad, narrowly to broadly lanceolate to elliptic-oblong, apex obtuse to occasionally acute, uniformly pilose throughout, the tips pilose within, stipitate-glandular; *ligulate florets* 8 to 16, dark orange-yellow, 16 to 32 mm long, 2.9 to 8.0 mm broad, 3-toothed, the lobes 0.3 to 2.1 mm long; *disc florets* 6.0 to 9.1 mm long, goblet-shaped, stipitate-glandular, densely pilose, the tube 2.5 to 5.0 mm long; *achenes* 3.5 to 7.0 mm long, densely hirsute throughout, occasionally sparingly glandular; *pappus* white, occasionally tawny, barbellate; *rhizomes* short, densely scaly, thick, conspicuous dense tufts of long brown woolly hair in axils of basal leaves and persistent leaf bases; *chromosome number* 2n=38,57.

DISTRIBUTION AND HABITAT: Plants widely distributed throughout interior British Columbia and southern Alberta extending north into the Peace River drainage area, southern Saskatchewan, southwestern Manitoba (White and Johnson 1980), and as far south as northern California, northern Nevada, northern Utah, northern Colorado, and east to western North and South Dakota (Figure 25). Plants of the prairies and grasslands at low elevations in the northern part of the range to montane plants up to 3,000 m in Wyoming and Colorado. Plants commonly found in moist depressed areas, often

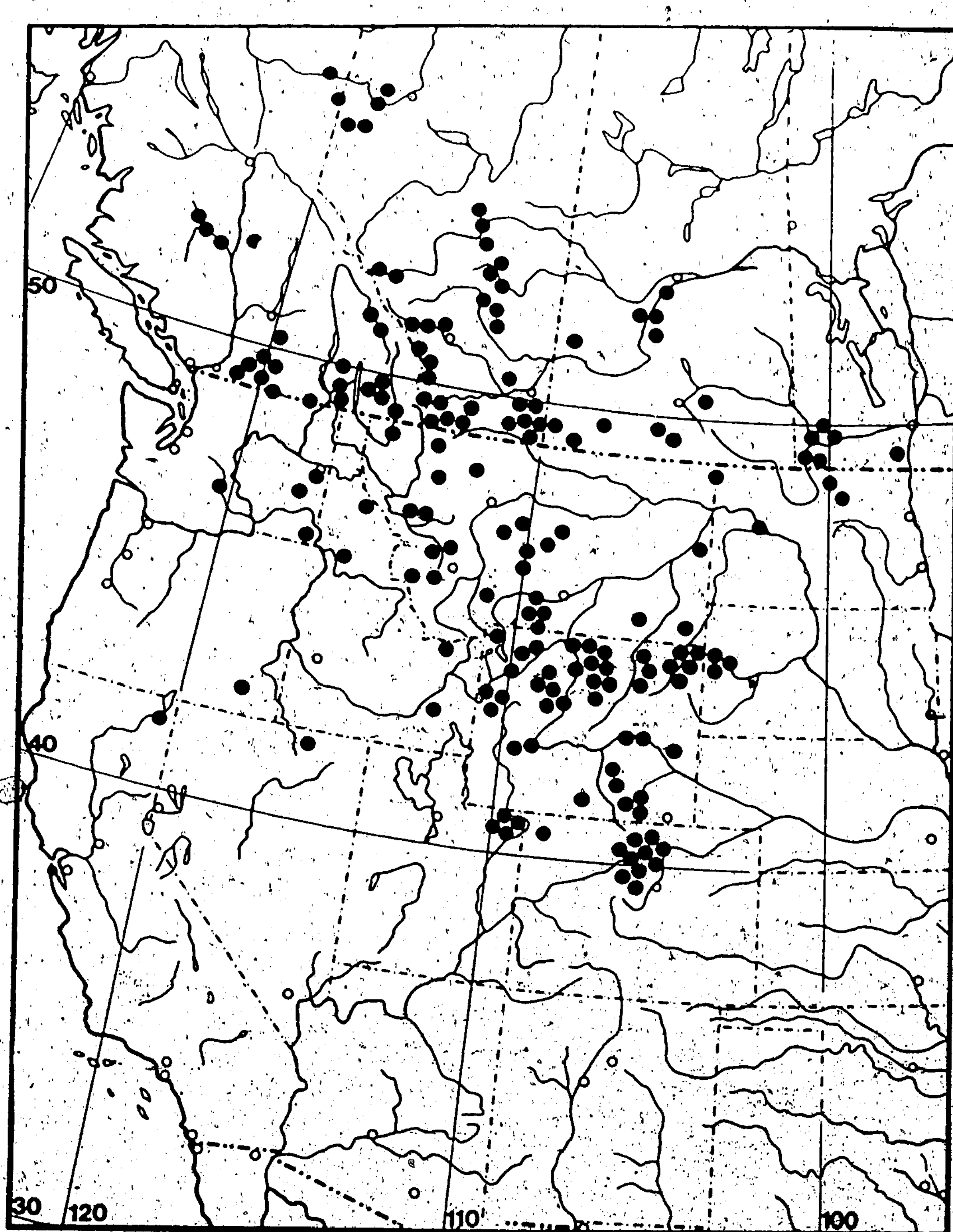


Figure 25 - Distribution of *Arnica fulgens*.

growing in dense clumps.

REPRESENTATIVE SPECIMENS: **CANADA, Alberta:** South of Cypress Hills Prov. Park *Bradley s.n.* (ALTA); Handhills, 8 miles south of Delia *Boivin & Perron 12374* (ALTA); Police Outpost Prov. Park *Shaw 2462* (ALTA,BYU); Northeast of Grand Prairie *Moss 8090* (ALTA); Willow Creek Rd., Cypress Hills Prov. Park *Cormack 175* (ALTA); Old Wive's Lake, N. Peace R. *Macoun 59983* (NY); Spring Creek, Cypress Hills Prov. Park *Cormack 363* (ALTA); Graburn Cairn, Cypress Hills Prov. Park *Scott 1300* (ALTA); 10 miles southeast Medicine Hat *Rusconi s.n.* (ALTA); 3 miles south Elkwater, Cypress Hills Prov. Park *Boivin & Alex 9381* (ALTA); Manyberries Expt. Station *Boivin, Hubbard & Alex 9548* (ALTA); East of Seven Persons *McCalla 11664* (ALTA); 2-3 miles north Millet, Hwy. 2 *Dumais & Young 1552* (ALTA); 5 miles north Hwy. 1, northeast Cochrane *McCalla 11866* (ALTA); East of Seven Persons *McCalla 11663* (ALTA); 10 miles north Elkwater *McCalla 11648* (ALTA); Mt. Glendown, Waterton Lakes Park *Breitung 16047* (ALTA); 10 miles north Elkwater *Moss 9791* (ALTA); Top of Cypress Hills above Elkwater *Moss 3247* (ALTA); Airdrie *Moss 1075* (ALTA); 7 miles west Pincher Creek *Survey 725* (ALTA); Dunvegan *Moss 7533* (ALTA); Battle River north Castor *Brinkman 2068b* (ALTA); West of Seven Persons *Moss 9831* (ALTA); Craigmyle district *Brinkman 1634* (ALTA); Wilson *Sexsmith 239* (ALTA); Kananaskis *Aikenhead s.n.* (ALTA); Meeting Creek *Kvisle s.n.* (ALTA); Donalda, Meeting Creek *Brinkman 2144* (ALTA); Near Edmonton *Moss s.n.* (ALTA); Lily Lake, north Edmonton *Moss 954* (ALTA); Scotfield, southeast Hanna *Brink s.n.* (UBC); Interpretive Building Hill, Waterton Lakes Park *Nagy & Bliss 985* (UBC); Route 1A, 6.5 km east jnctn. Route 1Y, east Banff *Straley 2749* (UBC); 10 miles north Elkwater *McCalla 11648* (UBC); Stettler area, Paintearth *Klar 472* (ALTA); Seven Persons, Moore Farm *Klar 1174* (ALTA); 10 miles northeast Manyberries *Shaw 2787* (BYU); Lee Creek, Poll Haven Community Pasture *Shaw 1510* (BYU); Red Rock Canyon *Walsh 264* (UT); 3 miles northeast Waterton Lakes Park townsite *G.W. & G.G. Douglas 7593* (BYU).
British Columbia: Fort St. John *Moss 8170* (ALTA); Harry Lake, Hat Creek drainage *Johns 530* (UBC).
Manitoba: Oak Lake, 30 miles west Brandon *Scoggan 11040* (ALTA,CAN); Brandon *Macoun 12725* (CAN,MT); Wheatlands, Grand Trunk Pacific Railway line *Macoun & Herriot 72815* (CAN); Assinaboine Rapids *Macoun 14703* (CAN); Broomhill, 10 mi. N.W. Melita *Scoggan 11055* (CAN); Near bank of Souris River, 10 miles S Melita *Dore & Lindsay 11016* (RM).
Saskatchewan: Saskatoon *Tripp s.n.* (ALTA); Cypress Hills Prov. Park *Breitung 4312* (ALTA,RM); Southfork, Maple Creek district *Boivin & Perron 12088* (ALTA,SASK); 3 miles west Big Muddy, Wood Mountain district *Boivin & Perron 11917* (ALTA,UBC,SASK); 5 miles SE Climax *Boivin & Perron 12127* (RM,SASK); 12 miles S Cadillac, Cypress Bench near headwaters of Frenchman Creek *Argus & Best 4833* (RM,SASK); Dundurn *Campbell s.n.* (SASK); Saskatoon *Frazer s.n.* (SASK); 2 miles W Saskatoon *Conpland 72* (SASK); Saskatoon, 8th Street *Frazer 101* (SASK); Murraydale, on bench of Cypress Hills *Zilke 160* (SASK); Rush Lake *Bolten 140* (SASK); Cypress Hills *Bolten 139* (SASK); Cypress Hills *Newsome 47-62* (SASK); Kernen's Prairie, Sutherland *Baines s.n.* (SASK); Kindersley, 2 miles N *Hood 116* (SASK); Leney *Hudson 3327* (SASK); Antelope Park *Thorpe 28* (SASK); 8 miles S Bengough *Ledingham 850* (SASK); Rosthern *Stevenson s.n.* (SASK); Saskatoon *Tripp 78* (SASK); Regina *Willing 134-128* (SASK); Assiniboia *Frazer s.n.* (SASK).

U.S.A., California: MODOC CO.: Patterson Mill Road, 1/4 mile to Silver Creek *Alexander & Kellogg 4748* (RENO).
Colorado: BOULDER CO.: 2 miles south Boulder *Ramaley 15976* (PH,RM); Boulder *Bethel & Clokey 4382* (PH,RM); National Center for Atmospheric Research property *Grant 261* (BYU); Boulder *Ramaley 9591* (RM); Boulder *Robbins 1631* (RM); S. Boulder *Crandall 2672* (RM); 2 miles S Boulder *Ramaley s.n.* (RM); GILPIN CO.: Tolland *Clokey 3959* (PH,RM); Tolland *Robbins 6553,6768* (RM); GRAND CO.: Berthoud Pass *Tweedy 5816,5818* (RM); Fraser *Osterhout 3302* (RM); JACKSON CO.: Kings Canon *E.B. & L.B. Payson 4276* (RM); LARIMER CO.: Pinkham Creek *Goodding 1492* (BYU,PH,RM,SASK); Hwy. north Virginia Dale *Straley 1463* (UBC); Rist Canon, 15 miles west Fort Collins *Crandall s.n.* (RM,US); Eagle Rock, 6 miles NE Estes Park *A. & R. Nelson 5757* (RM); Estes Park *Osterhout 1372* (RM); Moraine Park *Osterhout 2811* (RM); Estes Park *Cooper*

66,68 (RM); Horsetooth Mtn. *Osterhout 5248* (RM); Chamber's Lake *Osterhout 3707* (RM); Horsetooth Gulch *Crandall 2679* (RM); MOFFAT CO.: Swede Spring on Cold Springs Mtn. *Peterson & Kennedy P3-366* (BYU); Spitzie Spring, Cold Springs Mtn. *Parks & Cocciolo 518* (BYU); Whisky Springs Ranch, 4 miles above Greystone on Zenobia Peak Rd. *Weber & Salamun 12572* (SASK).

Idaho: BANNOCK CO.: Vicinity of Pocatello *Soth 25* (C); CLARK CO.: Camas meadows, 1 mile northwest Kilgore *Maguire 17163* (PH); IDAHO CO.: White Bird summit *Constance 1939* (PH); SHOSHONE CO.: Coeur d'Alene Mtns., Santianne Creek *Leiberg 1048* (RM).

Montana: CARBON CO.: Red Lodge, opposite Grignon Ranch on Cook City Hwy., opposite Piny Dell Cabins *Cash s.n.* (MONT); No Locality *Hawkins s.n.* (MONT); Custer Natl. Forest, 2.5 miles northnorthwest Shriver *Stickney 2665* (MONT); CARTER CO.: Region 6, T35, R56E *Skunk & Schmautz s.n.* (MONT); FERGUS CO.: 28 miles south Lewistown, 6 miles north Halfmoon Canyon *Hitchcock 16043* (UC); Judith Mtns. *Mussehl & Zapatka s.n.* (MONT); GALLATIN CO.: Bozeman *Macoun 12725* (MT); Bozeman *Blankinship s.n.* (MONT); Camp Creek *Jones s.n.* (RM); GLACIER CO.: 4.5 miles east Glacier Park *Wright & Anderson s.n.* (MONT); GRANITE CO.: Near Phillipsburg *Kirkwood 1794* (MONT); JUDITH BASIN CO.: Stanford *Moran 1423-M* (BYU); LEWIS AND CLARK CO.: Lewis and Clark Forest *Moran s.n.* (BYU); LINCOLN CO.: Rexford *Metcalf & Wright s.n.* (MONT); MEAGHER CO.: Harley Park, 6 miles west Neihart *Hitchcock & Muhlick 12307* (PH,RM); MISSOULA CO.: Pattee Canyon Picnic area, N. Missoula *Straley 1497* (UBC); Butler Creek, 1.5 miles above jnctn. LaValle Creek Rd., 6 miles northnorthwest Missoula *Stickney 1646* (MONT); PONDERA CO.: Conrad *Robbins s.n.* (MONT); POWDER RIVER CO.: 3.3 miles southeast Ashland, 15 Mile Creek *Anderson & Scharff s.n.* (MONT); POWELL CO.: Rock Creek Lake Rd., 8 miles west Deer Lodge *Trask 308* (MONT); RAVALLI CO.: Sula, south Darby *Hitchcock & Muhlick 9083* (MONT); SHERIDAN CO.: Westby *Larsen 13* (PH); SILVER BOW CO.: 0.3 mile north Mud Lake, 9.5 miles northnortheast Wise River *Stickney 2789* (MONT); STILLWATER CO.: Absarokee *Hawkins s.n.* (MONT); Reed Point *Hawkins s.n.* (MONT); Beehive *Hawkins s.n.* (MONT); SWEET GRASS CO.: 3 miles south Melville *Anderson & Scharff s.n.* (MONT); WHEATLAND CO.: Haymaker Game Range *Kirsch 124* (MONT); WIBAUX CO.: Hodges, road southwest of Webo *Elliott s.n.* (UT); YELLOWSTONE CO.: Beaver Lakes *Harrison 1294* (BYU).

Nevada: ELKO CO.: Jarbidge, Jack Creek Divide *Nelson & Macbride 2019* (RM).

North Dakota: BENSON CO.: York *Follman 462* (RM); DUNN CO.: Fort Berthould Indian Reserve, Blue Butte *Redmann s.n.* (SASK); ROLETTE CO.: Dunsieth *Lunell s.n.* (PH,RM).

Oregon: HARNEY CO.: Steens Mtns., 17 miles east and 10 miles south Frenchglen *Hansen 744* (NY).

South Dakota: LAWRENCE CO.: Boulder Creek Park, 6 miles E. Deadwood *Hayward 997* (RM); North Whitewood *McIntosh 14* (RM); Sturgis-Bear Butte *McIntosh 267* (RM).

Utah: DAGGETT CO.: Diamond Mtn. plateau *Neese 13969* (BYU); Greendale Canyon, 2 miles southwest Flaming Gorge Dam *Neese 13802* (BYU); Ashley Forest, west Allen creek *Garrett 105* (BYU); UINTAH CO.: Diamond Mtn. plateau, 2 1/2 miles south Matt Warner Res. *Neese, Nelson et al. 14075* (BYU); Summit of pass between Vernal and Manila *Cottam 6069* (UT).

Washington: ASOTIN CO.: Big Butte Ranger Station, above Anatone *Downen 109* (ALTA); KITTITAS CO.: Ellensburg, Rattlesnake Hills *Thompson 8344* (PH); SPOKANE CO.: Ft. Wright *Turesson s.n.* (RM); STEVENS CO.: No Locality *Moran s.n.* (BYU); WHITMAN CO.: Rock Lake *Beattie & Lawrencee 2334* (PH); Rock Lake *Sandberg & Leiberg 103* (C,PH).

Wyoming: ALBANY CO.: Hwy. 26, 10 miles east Bosler Junction *Porter 4892* (PH,RM); Chug Creek *Nelson 7303* (RENO,RM); 1 mile northnortheast of Duck Creek on Pemount or Albany County Rd. 231, northwest of Twin Mtns. *B.E. & L. Nelson 1348* (BYU,RM); Laramie Range, W Eagle Rock *Holliday 75* (RM); Laramie Range, W Eagle Rock *Aslamy 69* (RM); E. Vedawoo on Rd. to Happy Jack *Asplund 72-9* (RM); E. Univ. of Wyoming Science Camp, Medicine Bow Mtns. *Solheim 222* (RM); University Camp *A. & R.A. Nelson 861* (RM); Cooper Lake *Goodding 14* (RM); Fish Creek *Nelson 1783* (RM); Pole Mtn. *Porter 3218* (RM); BIG HORN CO.: No Locality *Moran s.n.* (BYU); Big Horn Mtns., Duncum Mtn., 17 miles NW Burgess Jnctn. *Nelson 6193* (RM); Big Horn Mtns., SE Hunt Mtn., 33.5 miles ESE Lovell *Nelson 6353* (RM); Big Horn Mtns., 1.8 miles SSW Snowshoe Pass on Black Mtn. Rd., 13 miles ESE Shell *Nelson 6610* (RM); Big Horn Mtns., 27 miles E. Greybull, Ranger Creek below Snowshoe Pass *Nelson 3306* (RM); Big Horn Mtns., 17 miles NNE Hyattville along S. Trapper Creek *Nelson 3343* (RM); 10-15 miles E. Kane *L.O. & R. Williams 3024* (RM); 10-15 miles E. Kane *L.O. & R. Williams*

3024 (C); CAMPBELL CO.: 8 1/4 miles northeast of Recluse *B.E. & L. Nelson 1247* (BYU); 2 3/4 miles E. Savageton *Dueholm & Hartman 1611* (SASK); 26.5 miles SSW Gillette on Hwy. 50 *B.E. & L. Nelson 1289* (RM); 8 1/4 miles NE Recluse, 2.5 miles E. Recluse-Olmstead Creek Rd. *B.E. & L. Nelson 1247* (RM); CARBON CO.: Sage Creek *Holmes 234* (RM); Pathfinder Mine, 34 miles SSE Casper *Current 307* (RM); Sullivan's Ranch *Goodding 91* (RM); Shirley Mtns., SE Leo *C.L. & M.W. Porter 7788* (RM); CROOK CO.: 7 miles south Stroner *Dueholm & Hartman 1309* (BYU); West of Sundance, along Rt. 14, ca. 12 miles west Jnctn. Interstate 90 *Straley 1841* (UBC); 7 miles W. Hulett, Rocky Point Rd. *C.L. & M.W. Porter 9268* (RM,SASK); Hulett *Ownbey 619* (RM); Cement Ridge *Gilley, Parmelee, Wilson & Coleman 772* (RM); Cement Ridge, 7.5 miles NE Moskee, 15 miles ESE Sundance *Marriott & Nelson 1411* (RM); Snider Ranch, 14 miles W. Sundance *Marriott 2395* (RM); The Brakes, 2.8 miles SSE Aladdin *Marriott 2427* (RM); Bear Lodge Mtns., Oak Creek, 5 miles N. Aladdin *Marriott 2871* (RM); Oak Creek, 4.4 miles W. Sundance *Marriott 2752* (RM); Bear Lodge Mtns., 5.2 miles NNE Alva *Marriott 2965* (RM); Goldie Divide, 5 miles NW Hulett *Marriott 3191* (RM); Bear Lodge Mtns., Taylor Divide and headwaters of Ogden Creek, 4.8 miles NNW Sundance *Marriott 3243,3261* (RM); Cabin Creek, SSW Cedar Hill, WSW Devil's Tower *Marriott 6524* (RM); Inyan Kara Creek Drainage off Norris Divide, 14 miles SW Sundance *Marriott 6573,6626* (RM); Hain Spring (off Lost Canyon), 9.5 miles NNE Four Corners *Marriott 6678* (RM); Black Buttes, E. Iron Mtn., 9.5 miles SE Sundance *Marriott 6951* (RM); Bear Lake, on divide between Idol and Surprise Gulches *Marriott 7029* (RM); FREMONT CO.: Lake Draw, 14.5 miles NE Dubois *Gerhart, Rizor & Jones 134* (RM); Green Mtns., Wild Horse Overlook *Hartman 8412* (RM); Green Mtns., 1.3 miles W. Wild Horse Overlook *Hartman 8434* (RM); Owl Creek Range, E. Wind River Canyon, Bird's Eye Pass *C.L. & M.W. Porter 8611* (RM); Between Atlantic City & Lander *Porter 4564* (RM); Wind River Range, 25 miles W. Lander *Fisser 676* (RM); 15 miles NW Dubois, Waynes Creek *Kirkpatrick 1049* (RM); 14 miles ENE Dubois, Indian Ridge N. to Telephone Draw *Kirkpatrick 4211* (RM); 13 miles NNW Dubois, 2 miles SW Ramshorn Peak *Kirkpatrick 4320* (RM); White Pass, 6 miles S. Ramshorn Peak *Nelson 10897* (RM); HOT SPRINGS CO.: Absaroka Mtns. *Martin & York 1300* (RM); 1/2 mile N. headwaters Grass Creek, S. Twin Lakes *Kirkpatrick 3023* (RM); Between Twin Buttes & Little Grass Creek *Kirkpatrick 3073* (RM); 21 miles SSW Meeteetse, 3 miles NW Cottonwood Peak *Kirkpatrick 4775* (RM); The Holy City, 1 mile S. Squaw Teat Butte *Nelson 11125* (RM); Castle Rocks, N. fork and Creek Drainage *Nelson 11168* (RM); Negro Creek near jnctn. Cottonwood Creek *Nelson 11237* (RM); JOHNSON CO.: U.S. Hwy. 16, 8 miles WSW Buffalo *Nelson 5884* (RM); U.S. Hwy. 16 between Powder River Pass and Munkres Pass, 23 miles SW Buffalo *Nelson 5982* (RM); Above Powder River Pass, 23 miles SW Buffalo *Nelson 6047* (RM); Doyle Creek on Hazelton Rd., 1.7 miles SE Hazelton Pyramid *Nelson 6758* (RM); 1 mile W. Dullknife Reservoir Spillway *Hartman 9580* (RM); Snow Cave Ridge, 8 miles WNW Mayoworth *Hartman 9769* (RM); 23 miles SW Buffalo, Middle fork Crazy Woman Creek *Nelson 3590* (RM); 3 miles Hazelton Rd. along Billy Creek Access Rd. *Hoffman 410* (RM); NATRONA CO.: Casper Mtn. area, Garden Creek Falls *Jozwik 67* (RM,SASK); Casper Mtn. *Tresler 356* (RM); NIOBRARA CO.: 20.5 miles WNW Lusk *Nelson 1568* (RM); PARK CO.: 15 miles northwest of Meeteetse *Williams & Hugie s.n.* (BYU); Absaroka Mtns., 20 miles northwest of Cody *Evert 3176* (BYU); Absaroka Mtns., Pat O'Hara Peak, 20 miles NW Cody *Evert 3176* (RM); Absaroka Mtns., 1-2 miles S. Trough Spring, NW Rattlesnake Mtn. *Evert 1899* (RM); Francs Fork, 4 miles SW Greybull River *Kirkpatrick 61* (RM); 43 miles SW Cody, S. Fork Shoshone River *Kirkpatrick 445* (RM); 19 miles SW Meeteetse, S. Fork Dick Creek *Kirkpatrick 734* (RM); Jack Creek Cabin, 24 miles WSW Meeteetse *Kirkpatrick 1114* (RM); 1 3/4 miles SW jnctn. Greybull River and Anderson Creek *Kirkpatrick 1220* (RM); 29 miles W. Meeteetse, E. fork Warhouse Creek *Kirkpatrick 1431* (RM); Meadow Creek, 27 miles SW Meeteetse *Kirkpatrick 2081* (RM); 19 miles SSW Cody, 1 mile S. Meeteetse Creek *Kirkpatrick 2531* (RM); 16 miles SW Meeteetse, N. fork Dick Creek *Kirkpatrick 3160* (RM); 21 miles W., Meeteetse Ridge, between Pickett Creek & Little Rose Creek *Kirkpatrick 5207* (RM); Clay Butte, near Beartooth Butte *Porter & Rollins 5857* (RM); SHERIDAN CO.: Big Horn Mtns., 20 miles west Dayton *Williams 2363* (UC); 11.5 miles SE Burgess Jnctn., 1.5 miles W. Sawmill Pass *Nelson 4423* (RM); Duncum Mtn., 16 miles NW Burgess Jnctn. *Nelson 6159* (RM); SE Hunt Mtn., 19 miles WSW Burgess Jnctn. *Nelson 6343* (RM); 5.5 miles N. Burgess Jnctn. *Dueholm 8146* (RM); 0.3 miles NW Freeze Out Point *Hartman 10323* (RM); NE Freese Out Peak *Dueholm 8207* (RM); 7 miles N. Burgess Jnctn., SE Dry Fork Ridge *Nelson & Dueholm 3733* (RM); WASHAKIE CO.:

SE High Park, Leigh Creek, 15 miles NE Ten Sleep *Nelson 5905* (RM); 31 miles SE Ten Sleep *Nelson 3499* (RM); 31 miles SE Ten Sleep *Nelson 3087* (RM); 9.5 miles ESE Big Trails, Hazelton Rd. *Nelson 3118* (RM); 14.5 miles SSE Big Trails along Cherry Creek *Nelson 3453* (RM); 12 miles SE Big Trails *Nelson 3524* (RM); WESTON CO.: W. Hwy. 116, 4 miles NNE Upton *Marriott 6303* (RM); S. Elk Mtn. *Marriott 7253* (RM); YELLOWSTONE NATIONAL PARK: Mammoth, Beaver Lakes *Harrison 1294* (BYU).

Arnica fulgens is a densely rhizomatous species occupying montane to grassland habitats throughout northern United States and adjacent southwestern Canada. It is distinguished by having a large hemispheric capitulum, entire leaves, dense axillary tufts of brown woolly hairs at the base of the stem, and glandless hairs on the disc corollas. *A. fulgens* was first described by Pursh (1814) in his *Flora Americae Septentrionalis*. In 1818, Nuttall reduced *A. fulgens* Pursh to *A. montana* var. *fulgens* and later, recognizing its affinity with *A. angustifolia* Vahl, transferred it to the latter in 1841. *A. fulgens* was maintained under *A. angustifolia* in the North American floras of Torrey and Gray (1843) and Gray (1884). It would not regain its specific status until Rydberg's *North American Flora*.

A. pedunculata Rydb. was proposed in 1897 for those plants similar to *A. angustifolia* but with axillary tufts of brown hair, a long-peduncled solitary head and fine pubescence (Rydberg 1897). Three years later, Rydberg (1900) proposed the name *A. monocephala* Rydb. for a plant resembling *A. pedunculata* but much smaller and with broader leaves. The type specimens of both *A. pedunculata* and *A. monocephala* are typical *A. fulgens*.

In his *Flora of the Rocky Mountains*, Rydberg (1917) included *A. monocephala* in *A. pedunculata* and treated *A. sororia* Greene as *A. fulgens*. In 1927, however, Rydberg properly interpreted the plants with the dense axillary tufts as *A. fulgens* and placed both *A. pedunculata* and *A. monocephala* in synonymy. *A. sororia* was recognized as its true form. The close similarity between *A. pedunculata* and *A. monocephala* must have been apparent to others for in 1918 both Cockerell and Lunell treated *A. monocephala* as a forma and variety of *A. pedunculata* respectively. It is presumed that they had not yet seen the work of Rydberg (1917).

The type and only specimen of *A. pedunculata* var. *tubularis*, consisting of only peduncle and capitulum, is an aberration of *A. fulgens* in which the ligulate florets are tubular.

5. **Arnica sororia** Greene, Ottawa Nat. 23:213. 1910. *A. fulgens* var. *sororia* (Greene) G.W. Dougl. ~~and G. Ruyle-Dougl.~~ in Taylor and MacBryde, Can. J. Bot. 56:185. 1978. TYPE: "Near International Boundary between Kettle and Columbia rivers. Cascade, B.C. June 30, 1902. *J.M. Macoun [Geol. Surv. Can. No. 64987]*" (HOLOTYPE ND!, ISOTYPES CAN!, GH!, PHOTOS CAN!, UC!). Figure 26. Generalized illustration Figure 24B.

A. stricta Greene non *A. stricta* A. Nels., Ottawa Nat. 23:214. 1910. *A. trinervata* Rydb., N. Am. Fl. 34:344. 1927. TYPE: "Near International Boundary between Kettle and Columbia Rivers. June 30, 1902. *J.M. Macoun [Geol. Surv. Can. No. 64979]* On Isotypes: "W. of Cascade, B.C." (HOLOTYPE ND!, ISOTYPES CAN!, NY, PHOTOS CAN!, UC!).

Plants 1.5 to 5.0 dm high; *stems* simple to branched, slender, moderately puberulent below becoming increasingly pubescent upwards, stipitate-glandular; *leaves* 3 to 6 pairs; *upper cauline leaves* sessile and reduced; *basal leaves* 3.5 to 14.5 cm long; 0.6 to 2.4 cm broad (usually narrower than in *A. fulgens*), apex obtuse, narrowly oblong to oblanceolate, the petioles narrow-winged and shorter than the blade, margins entire to rarely remotely denticulate, moderately uniformly pubescent, short-stipitate glandular, 3 to 5 nerved; *capitula* erect, 1 to 5 (rarely more), broadly hemispheric, 11.0 to 27.0 mm broad, 9.0 to 17.0 mm high; *periclinium* moderately to densely white pilose, stipitate-glandular; *involucral bracts* 13 to 20, 9.5 to 14.2 mm long, 1.2 to 3.1 mm broad, narrowly to occasionally broadly lanceolate, apex acute, uniformly pilose throughout, tips not at all pilose within, glandular; *ligulate florets* 9 to 17, dark orange-yellow, 15.0 to 31.0 mm long, 2.5 to 7.5 mm broad, 3-toothed, the lobes 0.2 to 1.8 mm long; *disc florets* 6.9 to 10.0 mm long, goblet-shaped, uniformly stipitate-glandular, not at all pubescent, the tube 3.0 to 5.5 mm long; *achenes* 3.0 to 5.5 mm long, densely hirsute throughout, occasionally sparingly glandular; *pappus* white or nearly so, barbellate; *rhizomes* short, less scaly than in *A. fulgens*, slender, hair tufts in

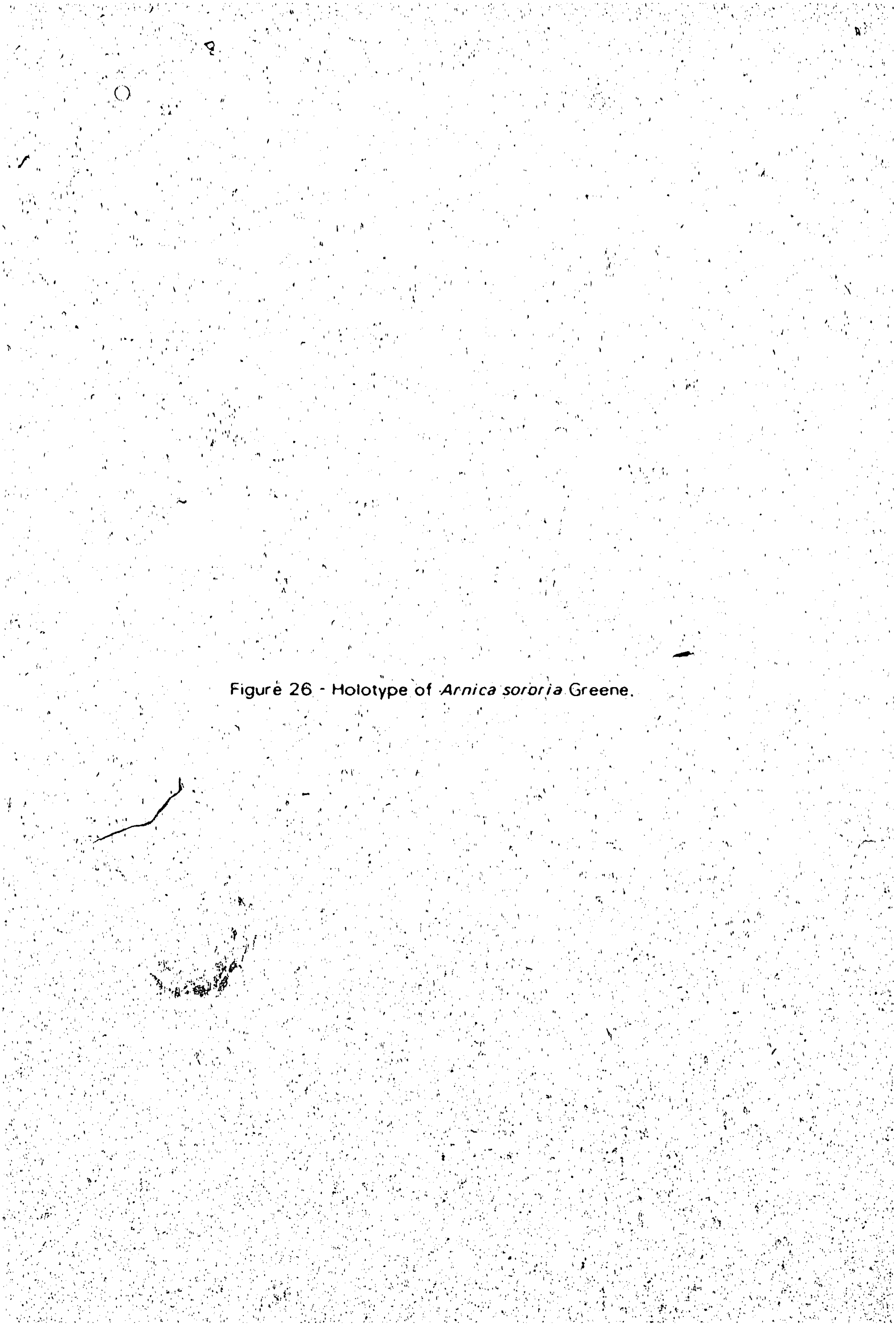


Figure 26 - Holotype of *Arnica sororia* Greene.

Arnica [illegible], Greene No. 64,997

Ex Herb. Geological Survey of Canada.

INTERNATIONAL BOUNDARY COMMISSION COLLECTION.

Arnica pedunculata, Rydb.

Near International Boundary between Kettle and Columbia rivers.

Collected by J. M. Macoun, June 30th, 1902. Alt. ... ft.

Cascade, B.C.

axils of old basal leaves sparse and white, or absent; *chromosome number* 2n=38.

DISTRIBUTION AND HABITAT: Widely distributed throughout the interior of southern British Columbia, southern Alberta, and as far south as northern California, northern Nevada, northern Utah and east to north and western Wyoming and eastern Montana (Figure 27). Plants of the prairies and grasslands at low elevations particularly in very dry areas. Plants in less dense populations, in drier habitats and at lower elevations than *A. fulgens*.

REPRESENTATIVE SPECIMENS: **CANADA, Alberta:** Squaw Mtn., vicinity of Banff *McCalla 2012* (ALTA,US); Craigmyle district *Brinkman 960* (ALTA,US); Kananaskis Forestry Reserve *Porsild & Breitung 16395* (CAN); Devil's Head Lake, Banff Park *Sanson s.n.* (CAN); Cascade Mtn., Banff Park *Lewis 92153* (CAN); Frank *Scoggan 16720* (CAN,SASK); 4 miles north of jnctn. of Hwys. 41 and 41A near Medicine Hat to Dunmore *Scott 1268* (ALTA); Little Sandhill Creek Coulee, Dinosaur Park area *Klar 1210* (ALTA); Whisky Gap *Survey 918* (ALTA); Big Valley, Stettler district *Brinkman 2280* (ALTA); West Medicine Lodge coulee, Cypress Hills Prov. Park *Bradley s.n.* (ALTA); 4 miles west Coleman *Hermann 12800* (ALTA); Hwy. 5, 3.5 km north Blakiston Creek bridge, Waterton Lakes Park *Kuchar 2537* (ALTA); Suffield *Moss 1172* (ALTA); Waterton Lakes National Park *Stringer s.n.* (ALTA); Nose Hill, north Calgary *McCalla 8748* (ALTA); Southeast of Medicine Hat *McCalla 3693* (ALTA); Mt. Cascade, Banff Park *No coll. info.* (ALTA); Craigmyle district *Brinkman 5413* (ALTA); Red Rock Canyon, Waterton Lakes Park *McCalla 6714* (ALTA); Near Calgary *Willing s.n.* (ALTA); West of Hanna on way to Cereal *L. & G. Goulden s.n.* (ALTA); Waterton Lakes National Park *Breitung 15768* (ALTA); Castle River region *Cormack s.n.* (ALTA); Butte Tete-de-Boeuf, Medicine Hat district *Boivin & Alex 9672* (ALTA); Milk River Ridge, 40 miles south Lethbridge *Dore & Breitung 11702* (ALTA); Red Rock Canyon *Walsh 244* (UT); St. Mary River, 1 mile west Woolford *Shaw 723* (BYU); Cook's Ranch, St. Mary's River *Shaw 778* (BYU) 7 miles north Magrath, St. Mary's River *Shaw 1323* (BYU); Jenkin's Ranch, 1 mile northeast Waterton Lakes Park *Shaw 1414* (BYU); Cardwell Ranch, St. Mary River, southeast of Cardston *Shaw 2433* (BYU); Yarrow Creek, north Waterton Lakes Park *Shaw 3027* (BYU); Calgary *Willing s.n.* (SASK).
British Columbia: Kamloops *Henry s.n.* (US); Hwy. between Kaleden and north Skaha Lake *Calder & Savile 8037* (UC); 3 miles north Marguerite on road from Williams Lake to Quesnel *Calder, Parmelee & Taylor 18153* (UC); 7 miles north Marguerite on Fraser R. between Soda Creek and Quesnel *McCabe 1301* (UC); 2 miles north Paul Lake, 14 miles north Kamloops *McCabe 2337* (UC); west side Columbia Lake *McCabe 6392* (UC); Wasa *McCabe 6247* (UC); Deer Park, Lower Arrow Lakes *Macoun 14710* (CAN); Nicola Valley *Dawson 14711* (CAN); Kamloops *Macoun 14713* (CAN); Yacko Lake, south Kamloops *McEvay s.n.* (CAN); Near Spences Bridge *Macoun 14712* (CAN); Flying U Ranch, Cariboo *Eastham s.n.* (CAN); Mt. Kobau, south Okanagon *Vrugtman & Campbell 610402* (CAN); 4 miles east Cranbrook *McCalla 9519* (ALTA); Hwy. 4 Columbia Valley, south Canol Flats *McCalla 9552* (ALTA); Hwy. 4, 35 miles north Cranbrook *McCalla 8157* (ALTA); Lac la Hache *Hardy 15009* (UBC); Swanson's Mtn., Okanagon *Wilson 195 1/2* (UBC); Spotted Lake, Osoyoos *Rose 7926* (UBC); Chilcotin R., Bull Canyon, 4 1/2 miles west Alexis Creek *Calder, Parmelee & Taylor 17345* (UBC); 18 miles north Newgate *G.W. & G.G. Douglas 7481* (BYU); Tranquille Range, Kamloops *Brink s.n.* (RM); Nicola Lake near Merritt *Calder, Parmelee & Taylor 17534* (RM); East Rock Creek on Osoyoos-Grand Forks Hwy. *Calder & Savile 9574* (RM).

U.S.A., California: LASSEN CO.: Madeline Plains *Applegate 866* (US); 2 miles north Madeline *Babcock & Stebbins 1788* (UC); Dixey Mtns. *Baker & Nutting s.n.* (UC); MODOC CO.: Cedar Creek Canyon, 3 miles west Cedarville *Babcock & Stebbins 1822* (UC);

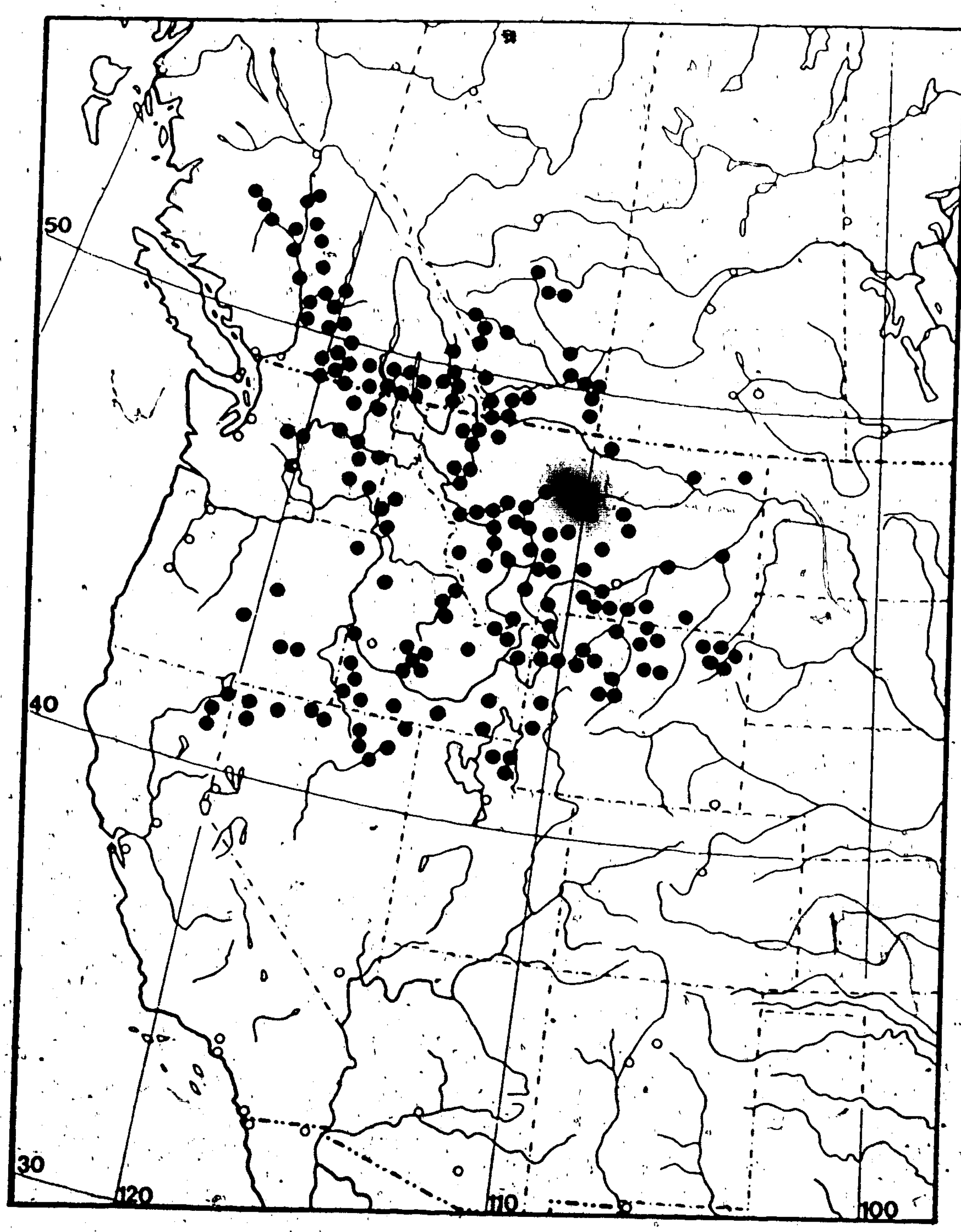


Figure 27 · Distribution of *Arnica sororia*.

PLUMAS CO.: No locality info. *Austin s.n.* (US); Parker Creek below Modoc Natl. Forest Boundary *Ferris & Duthie 143* (RM).
Colorado: PARK CO.: 1 mile north Jefferson *Blake 2077* (RM).
Idaho: ADAMS CO.: 5 miles southwest New Meadows *Hitchcock & Muhlick 13927* (UC,RM); BANNOCK CO.: Soda Springs *E.B. & L.B. Payson 1707* (RM); BLAINE CO.: Ketchum *Nelson & Macbride 1256* (RM,UC,US); 1 mile south jnctn. 20/75 along Hwy. 75 *Atwood 10107* (BYU); Moran Creek, Sawtooth Natl. Forest *Schlatterer 111* (BYU); 10 miles east Carey *Harrison 13442* (BYU); BUTTE CO.: Craters *Davis 438* (UC); CANYON CO.: Squaw Butte *Macbride 140,965* (RM); CASSIA CO.: Cache Peak Range, Silent City of Rocks, 13 miles southeast Oakley *N.H. & P.K. Holmgren 5908* (BYU); CLARK CO.: 25 miles northwest Dubois *Williams, Hugie & Passey s.n.* (UT); U.S. Sheep Expt. Stn. near Dubois *Calvert 152* (BYU); U.S. Sheep Expt. Stn., Dubois *Swenson s.n.* (BYU); Usses Forest, Paddock 7 *No coll. info.* (UT); Monida Pass *McCalla 4765* (ALTA); LATAH CO.: Moscow *Henderson 2784* (RM,US); Moscow *Abrams 717* (UC); LEMHI CO.: Birch Creek summit *Davis 3787* (UC); Head of Birch Creek *Davis 1151* (UC); Salmon *E.B. & L.B. Payson 1830* (RM); JEROME CO.: Snake Plains, Shoshone Falls *Palmer 103* (US); Shoshone Falls *Bennitt 112* (RM); MADISON CO.: Off Hwy. 33 east Newdale on road to Green Canyon Hot Springs *Hreha I-8* (BYU); LZ Ranch, 4 miles southeast White Owl Butte *Lindsay s.n.* (BYU,RM); NEZ PERCES CO.: Lake Waha *A.A. & E.G. Heller 3293* (UC,US); Clearwater River *Sandberg, MacDougal & Heller 325* (C); ONEIDA CO.: 2.5 miles northwest Woodruff *Foster 6365* (BYU); OWYHEE CO.: Deer Creek *Nelson & MacBride 1841* (RM,US); 7 miles southwest Mud Flat on Juniper Mtn. Rd. *Maguire & Holmgren 26325* (UC); Silver City Range, between Silver City and War Eagle Mtn. *Maguire & Holmgren 26659* (UC); East Juniper Mtn. *A.H. Holmgren & D. Holmgren 7963* (UC); TWIN FALLS CO.: Northeast Jarbidge Mtns., 2.2 miles south Rogerson-Murphy Hot Springs Rd., 10.5 miles westsouthwest Rogerson *N.H. & P.K. Holmgren 5787* (UT).
Montana: BEAVERHEAD CO.: 7 miles south Wise River *Hitchcock & Muhlick 14988* (UC); Red Rock Lakes Refuge *Dorn 44[illegible]* (MONT); BIGHORN CO.: 5 miles southeast Crow Agency *York s.n.* (MONT); Grapevine Mtn., north Big Horn Canyon *Wright & Anderson s.n.* (MONT); 6 miles south Pryor *Charff s.n.* (MONT); 23 miles north Decker *Anderson-Wright s.n.* (MONT); BROADWATER CO.: Slim Sam Creek, Radersburg *Kett s.n.* (MONT); CARBON CO.: 25 miles south Red Lodge *Booth 54497* (MONT); Bearcreek *Homes s.n.* (UT); CASCADE CO.: Great Falls *Williams 79* (MONT,US); Great Falls *Williams 334* (MONT); CUSTER CO.: 10 miles north Miles City *Booth s.n.* (MONT); FERGUS CO.: Wolf Creek at Denton *Spragg s.n.* (MONT); FLATHEAD CO.: Columbia Falls *Kennedy 332* (MONT); Columbia Falls *Williams 335* (MONT); Columbia Falls *Williams 79* (US); GALLATIN CO.: University Campus *MacDougal 134* (US); Hyalite Canyon *Booth 28717* (MONT); Bozeman *Tessel 331* (MONT); Bridger Canyon, 8 miles north Bozeman *Swingle s.n.* (MONT); Spanish Basin *Rydberg & Bessey 5223* (MONT,RM); 5 miles northeast Bozeman *Booth 1563* (MONT); No locality info. *Alderson 339* (MONT); Cottonwood Beach, Crazy Mtns., Bozeman *Cotner 280-667* (MONT,RM); Bozeman *Moore s.n.* (UC); Bozeman *Blankinship s.n.* (RM); GLACIER CO.: Many Glaciers, Glacier Natl. Park *McCalla 4510* (ALTA); GOLDEN VALLEY CO.: 2 miles northwest Lavina *Booth 55231* (MONT); HILL CO.: 30 miles south Havre *Dolan 48* (MONT); JEFFERSON CO.: 1 mile from Helena in upper Homme Gulch *McKinney s.n.* (MONT); JUDITH BASIN CO.: No locality infl. *Moran s.n.* (BYU); LAKE CO.: 2 miles south Polson *Hitchcock 17768* (UC); 2 miles south Polson, south of Flathead Lake *Wright s.n.* (MONT); National Bison Range *Thomas 11836* (MONT); Polson *Eichmann s.n.* (MONT); 2 miles south Polson *Hitchcock 17768* (RM); LEWIS AND CLARK CO.: 12 miles north Helena *Parker s.n.* (MONT); 7 miles west Lincoln near Hwy. 2 *Hitchcock 17902* (RM,UC); 8 miles northwest Conway along Rock Creek *Hitchcock 17983* (RM,UC); 9 miles south Helena *McCalla 4743* (ALTA); MADISON CO.: West fork of Madison River *Knowlton s.n.* (MONT); St. Joe Creek *Jones 333* (MONT); MEAGHER CO.: 28 miles west Harlowton, Hwy. 6. *Booth 55367* (MONT); 2 miles north Ringling *Hitchcock & Muhlick 12424* (RM); MISSOULA CO.: South Buckhous place *Kirkwood 1338* (MONT); No locality info. *Brome 893* (MONT); Sagebrush Hills, 1 mile west Greenough *Hitchcock & Muhlick 11499* (MONT,RM,UC); Missoula *Kirkwood 1338* (MONT,UC); Rattlesnake Creek *Barkley & Rose 2450* (UC); PARK CO.: Gardiner, 3 miles south *Booth 54226* (MONT); POWELL CO.: Deer Lodge *Kelsey s.n.* (US); 8 miles south Deer Lodge Co. line *Trask 86* (MONT); Burnt Hollow, Deer Lodge *Trask 217* (MONT); PETROLEUM CO.: 2.5 miles south Rt. 20 at Teigen *Sawyer 45* (MONT); 12 miles southwest of Winnett *Cole s.n.* (MONT); RAVALLI CO.: 10 miles east Darby, Sapphire

Mtns. *Wright s.n.* (MONT); SHERIDAN CO.: 3 miles northwest Dagmar *Sampsen 45* (MONT); SILVER BOW CO.: Pigeon Creek Campground, 16 miles from Butte *Meyer M015* (UT); STILLWATER CO.: Absarokee *Hawkins 37266* (MONT); TREASURE CO.: Divide between Big Horn and Hysham, Hwy. 10 *J.C. Wright & E.A. Wright s.n.* (MONT); VALLEY CO.: 25 miles north Glasgow *Dolan 21* (MONT); WHEATLAND CO.: 3 miles northwest Shawmut *Booth 55339* (MONT); YELLOWSTONE CO.: South of Laurel *J.C. Wright & E.A. Wright s.n.* (MONT).

Nevada: ELKO CO.: 18 miles northeast San Jacinto, Galliher pasture *Shipley s.n.* (US); 10 miles northwest of Elko on Mountain City Hwy. *Nichols & Lund 239* (RENO,UC); East Humboldt Mtns., 5 miles east of Angel Lake on road to Wells *Raven & Solbrig 13460* (NY); North Sunflower Flats, on road to Bieroth Spring *Williams & Tiehn 802104* (BYU,RENO); Independence Mtns., Sheep Creek *Tiehm & Birdsey 5240* (BYU); Independence Range, 60 miles northwest of Elko *Nichols & Lund 220* (RENO); HUMBOLDT CO.: 5 miles east Ft. McDermitt Indian Reservation *Brune 240* (RENO); Rock Spring Campground *Tiehm 4479* (RENO); Humboldt Natl. Forest *Price 100* (BYU); Pine Forest Range, Rodeo Flat, southwest Duffer Peak *Tiehm & Tucker 7296* (RM); WASHOE CO.: Granite Range, west Leadville *Tiehm 8029* (BYU); Peavine Mtn., "Perideridia Meadow" on Heinz Ranch *Williams & Howell 51254* (RENO); Bald Mtn., Peterson Canyon *Rogers 1100* (RENO).

Oregon: CROOK CO.: Vicinity of Laidlaw *Whited 3129* (US); GRANT CO.: Maggot Springs, southeast of Dayville *Cronquist 7360* (UC); HARNEY CO.: Steens Mtns., Anderson Valley *Leiberg 2381* (UC); Base of Steens Mtn. *Howell s.n.* (US); Steens Mtn., Anderson Valley *Leiberg 2381* (UC); 8 miles east Frenchglen on way to Fish Lake *Maguire & Holmgren 26430* (UC); WALLOWA CO.: Cottonwood Creek Canon *Sheldon 8064* (RM).

Utah: CACHE CO.: Spring Hollow *Maguire, Garish, Hobson & Noble 13815* (UC); RICH CO.: 6 miles northwest Sage Creek Jnctn. north of Duck Creek *Snyder & Hawkins 588* (BYU,NY); Negro Dan Hollow near Table Mtn. *Thorne, Snyder & Erickson 2642* (BYU).

Washington: DOUGLAS CO.: Badger Mtn. *Thompson 14658* (US); Badger Mtn., 12 miles north Wenatchee *Hitchcock 17412* (RM,UC); FERRY CO.: Along Columbia River, 6 miles below Northport *Rogers 551* (UC); Republic *Beattie & Chapman 2264* (UC); GRANT CO.: Mouth of Payne's Gulch, 10 miles northeast Coulee City *Gaines & Scheffer 550* (UC); LINCOLN CO.: Columbia River Basin, 5 miles east of Davenport *Constance & Beetle 2744* (RM,UC,US); Mouth of Spokane River *Rogers 505* (UC); Near Davenport *McCalla 4461* (ALTA); KITTITAS CO.: Ellensburg *Whited 542* (US); SPOKANE CO.: Near Spokane Bridge *Suksdorf 8759* (UC); WHITMAN CO.: Pampa *St. John & Pickett 6204* (UC,US); No locality info. *Elmer 94* (US); Pullman *Piper 1578* (US); Head of Rock Lake *Beattie & Lawrence 2461* (UC).

Wyoming: BIG HORN CO.: Big Horn Mtns., northeast Little Mtn., 16 miles northeast Lovell *Nelson 5414* (RM); Big Horn Mtns., 9 miles west Tyrrell Ranger Stn. *Hartman & Odasz 9219* (RM); CAMPBELL CO.: 5 miles NNE Spotted Horse *Hartman & Dueholm 6069* (SASK); N. Gillette *Harner 21* (RM); 20 miles N. Gillette *Turner 44* (RM); CROOK CO.: Black Hills, Goldie Divide, 5 miles NW Hulett *Marriott 3159* (RM); Black Hills, Graham Ranch, 13 miles W. Sundance *Marriott 3300* (RM); Black Hills, Bear Lodge Mtns., 8.6 miles ESE Devil's Tower *Marriott 3300* (RM); Black Hills, Calvin Creek off Coal Divide, 6.9 miles WSW Sundance *Marriott 3543* (RM); Black Hills, Inyan Kara Mtn *Marriott 6883* (RM); Black Hills, NE fork Left Creek, 4-5 miles SW Missouri Buttes *Marriott 7618* (RM); Black Hills, Missouri Buttes *Marriott 7786,7830* (RM); Black Hills, S Williams Divide, 9 miles ESE Sundance *Marriott 7847* (RM); Black Hills, between Hwy 16 and Clay Spur, 35 miles NW Osage *Marriott 6224* (RM); FREMONT CO.: SE Thermopolis, E Wind River Canyon, Birdseye Pass *Fisser 239* (RM); HOT SPRINGS CO.: Absaroka Mtns., 21 miles SSW Meeteetse, 3 miles N Cottonwood Peak, SE Twin Lakes *Kirkpatrick 4776* (RM); SE Thermopolis, E Wind River Canyon, Owl Creek Range *Fisser 472* (RM); Jones Creek, Copper Mtn., 9 miles SE Thermopolis *Porter 6296* (RM); JOHNSON CO.: East boundary of Big Horn Natl. Forest, Hwy 16 *Uttal 5069* (PH); 6.3 miles W Buffalo *Hoffman 727* (RM); LINCOLN CO.: Star Valley-Greys River, Strawberry Creek *Harrison 140* (RM); PARK CO.: 15 miles northwest Meeteetse *Williams & Hugle s.n.* (UT); Absaroka Mtns., 18 miles WSW Meeteetse, W Fork Timber Creek *Kirkpatrick 3556,3561* (RM); Absaroka Mtns., 17 miles SSE Cody, Carter Creek *Kirkpatrick 6043* (RM); Absaroka Mtns., 1/4 mile S North Fork Shoshone River *Evert 2013* (RM); SHERIDAN CO.: 7 miles southeast Sheridan *Dueholm 6845* (BYU); Big Horn Mtns., 1 mile NW Freeze Out Point *Hartman 10200* (RM); E Sheridan *Sharp 128* (RM); Sheridan *Pfadt*

128 (RM); Big Horn Mtns., Little Big Horn River Canyon, 17 miles W Parkman *Hartman & Odasz 9329* (RM); Hidden Water Coal Site *Brink & Mayer 1282* (RM); SUBLETTE CO.: Near Cora *E.B. & L.B. Payson 4341* (RM); TETON CO.: Treasure Mtn., Targhee Natl. Forest, 11 miles east Driggs *Anderson 322* (UC); Gros Ventre Mtns., Sheep Creek *Lichvar 316* (RM); Grand Teton Natl. ~~Park near~~ Moose *Sabinske 13C* (RM); YELLOWSTONE NATIONAL PARK: No locality info. *Mearns 1280* (US); Pelican Cove *Tweedy 682* (US).

Arnica sororia was originally proposed by Greene in 1910. It was later interpreted as *A. fulgens sensu* Rydberg (Rydberg 1917) which added considerable confusion to the true identities of these taxa. The rejection and subsequent transfer of *A. stricta* Greene to *A. trinervata* Rydb. by Rydberg (1927) was due to the former being a later homonym of *A. stricta* Nels. (1901), now a synonym of *A. chamissonis* Less. subsp. *foliosa* (Nutt.) Maguire. *A. stricta* Greene was based on a single collection of J.M. Macoun (Geol. Surv. Can. No. 64979) from British Columbia. These tall, coarse, broad-leaved plants with numerous axillary capitula are somewhat anomalous in *A. sororia*. However, as first indicated by Maguire (1943), these specimens appear to be only morphological extremes in a comparatively unvariable species. I am in agreement with Maguire's (1943) inclusion of *A. trinervata* as a synonym of *A. sororia*.

The recognition of *A. sororia* as a variety of *A. fulgens* (Douglas and Ruyle-Douglas 1978) was influenced by the strong morphological similarity between these two taxa, with the only differentiating character being the presence or absence of disc corolla pubescence. The long axillary tufts of dense brown woolly hairs in *A. fulgens* were not observed to comprise a consistent character (Douglas and Ruyle-Douglas 1978). It is presumed that this misunderstanding occurred due to the frequent misidentification of these taxa and the inclusion of many members of *A. sororia* in with *A. fulgens* herbarium specimens. These axillary tufts furnish an excellent character to separate *A. fulgens* from *A. sororia*. Additional differences between these two taxa include shorter and narrower leaves and a smaller habit in *A. sororia*.

6. **Arnica angustifolia** J.M. Vahl, Fl. Dan. 9(26):5. 1816.

Stems herbaceous, single or rarely branched, arising from a short branched rhizome covered in imbricate scales and leaf base remnants which may have tufts of long hairs in their axils, 0.5 to 5.4 dm high, sparsely to densely pilose, short stipitate-glandular, becoming increasingly villous and glandular upwards; *cauline leaves* 1 to 5 pairs, simple, opposite, mostly from below middle of stem; *upper leaves* sessile and reduced; *lower cauline leaves* 3 to 20 times as long as wide, 2.0 to 14.5 cm long, 0.3 to 2.6 cm broad, the blades linear, narrowly to broadly lanceolate to rarely oblanceolate, apex acute or acuminate, margins entire, denticulate or rarely dentate, petioles sessile, short and broad-winged or narrow-winged and shorter than the blade, glabrous to densely villous and stipitate-glandular, 3 to 5 nerved; *capitula* erect, 1 to 3 (rarely 5), large, hemispheric to broadly hemispheric, 12.0 to 30.0 mm broad, 9.0 to 21.0 mm high; *periclinium* very conspicuous, moderately to densely white pilose, stipitate-glands inconspicuous or dense; *involucral bracts* 9 to 22, narrowly to broadly lanceolate to occasionally oblanceolate, apex acute, 6.5 to 17.6 mm long, 1.5 to 4.1 mm broad, densely to sparsely pilose throughout or evidently pilose at base becoming less so upwards, inconspicuously to obviously stipitate-glandular; *ligulate florets* 6 to 16, yellow, 10.0 to 40.0 mm long, 3.0 to 9.5 mm broad, 3-toothed, the lobes 0.2 to 7.0 mm long; *disc florets* yellow, 5.0 to 10.0 mm long, goblet-shaped, moderately to densely pilose, inconspicuously glandular or absent, the tube 1.9 to 4.1 mm long; *achenes* 3.1 to 7.6 mm long, densely hirsute throughout, inconspicuous or not at all glandular; plants of arctic, subarctic or alpine habitats.

Arnica angustifolia, a circumpolar and circumboreal species, is the most widespread *Arnica*. It is also the most polymorphic. This taxon is identified by its long, narrow leaves; densely hirsute achenes; erect capitula, and yellow florets. These are plants of arctic, subarctic and alpine habitats. Maguire (1943) has segregated this species into seven geographical races; however, results of this investigation indicate that this aggregate is best treated as two distinct taxa: *A. angustifolia* subsp. *angustifolia* (a combination of the previously recognized subspecies *angustifolia, attenuata, sornborgeri, intermedia, iljinii, alpina,* and *A. plantaginea*; and *A. angustifolia* subsp.

tomentosa. These two phenetic groups are readily distinguished and identified on several continuous and descriptive characters. *Arnica angustifolia* subsp. *tomentosa* is a relatively small plant possessing one capitulum and densely villous leaves, stems and involucral bracts. The periclinium is densely pilose and conspicuously stipitate-glandular. *Arnica angustifolia* subsp. *angustifolia* is usually a much taller plant bearing three to five capitula per stem. Its leaves, stems and bracts are never densely villous. In many instances, the leaves are glabrous. The periclinium is usually pilose, but never woolly-villous; and stipitate-glands may be inconspicuous or lacking.

KEY TO SUBSPECIES OF *ARNICA ANGUSTIFOLIA*

Leaves glabrous to moderately villous, entire to dentate, linear to lanceolate or oblanceolate; periclinium moderately to densely white lanate-pilose, stipitate glands occasionally lacking or obscured; stems moderately villous; plants 0.5 to 5.4 dm tall; capitula 1 to 3 (rarely 5) .... subsp. *angustifolia*

Leaves densely villous, entire, lanceolate; periclinium densely pilose and conspicuously stipitate-glandular; stems densely villous; plants 0.6 to 2.0 (rarely 3.0) dm tall; capitula solitary (rarely 3) .... subsp. *tomentosa*

6a. **Arnica angustifolia** J.M. Vahl in Hornem subsp. **angustifolia** , Fl. Dan. 9(26):5. 1816. *A. alpina* var. *angustifolia* (Vahl) Fernald, Rhodora 36:96. 1934. *A. alpina* subsp. *angustifolia* (Vahl) Maguire, Madrono 6:153. 1942.
TYPE: "E. Groenlandia. *Gieseke s.n.*". (HOLOTYPE S!, ISOTYPE C!). Figure 28. Generalized illustrations Figure 29.

A. alpina forma *inundata* Porsild, Medd. Groenl. 58:181. 1926.

Figure 28 - Holotype of *Arnica angustifolia* Vahl.

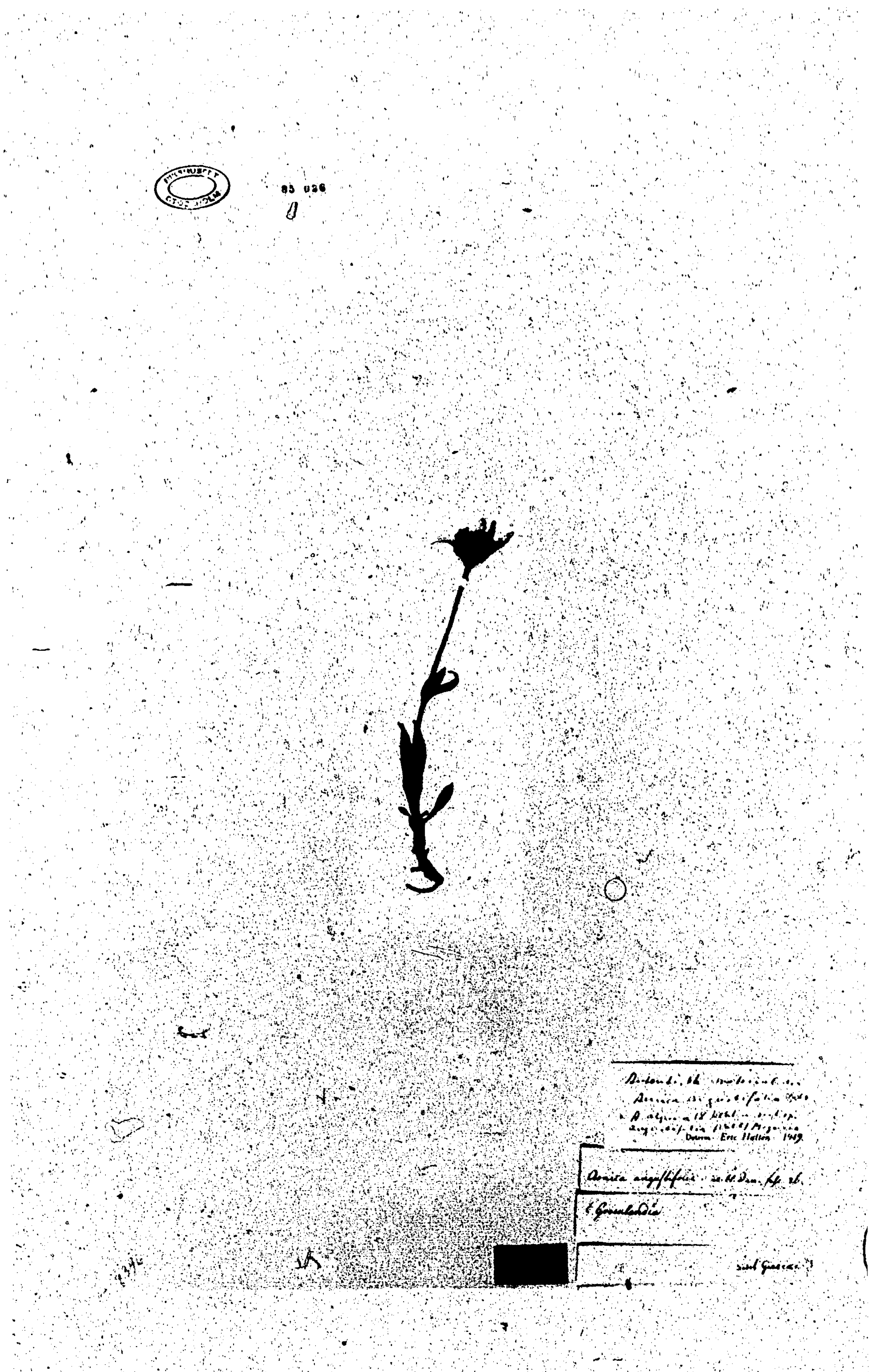

Determ. Eric Hultén 1949

Figure 29 - Generalized illustrations of *Arnica angustifolia* ssp. *angustifolia*. (A) based on *Downie 602-A* [ALTA]; (B) based on *Downie 624* [ALTA].

TYPE: Sargag, Greenland. *Porsild 200 fide* Maguire (1943).

A. alpina var. *vahliana* Boivin, Nat. Can. 75:209. 1948. TYPE: "Baffin Island. 1937. *V.C. Wynne-Edwards 7364" fide* Ediger and Barkley (1978).

Arnica montana var. *alpina* L., Sp. Pl. 884. 1753. *A. alpina* (L.) Olin, Dissert. de Arnica, Upsaliae 11. 1799. *A. alpina* (L.) Olin subsp. *genuina* Maguire, Brittonia 4:408. 1943. *A. angustifolia* subsp. *alpina* (L.) I.K. Ferguson in Heywood, Bot. J. Linn. Soc. 67:282. 1973. TYPE: "Habitat in Alpibus and pratis Europae frigidioris", as described in Linnaeus' *Species Plantarum* (1753) *fide* Maguire (1943)

Arnica attenuata Greene, Pittonia 4:170. 1900. *A. alpina* subsp. *attenuata* (Greene) Maguire, Madrono 6:153. 1942. *A. alpina* var. *attenuata* (Greene) Ediger and Barkl., N. Am. Fl. 10:31. 1978. *A. angustifolia* subsp. *attenuata* (Greene) G.W. Dougl. & G. Ruyle-Dougl., Can. J. Bot. 56:1710. 1978. TYPE: "Open woods and river banks. Lewis River, Yukon Territory. June 13, 1899. *M.W. Gorman 1025*". (ISOTYPE CAN!, US!, PHOTO CAN!)

A. lowii Holm, Repert. Sp. Nov. 3:388. 1907. TYPE: "Severn River (Keewatin) Ont. Aug. 5, 1886. *J. Macoun 14699*" (HOLOTYPE CAN!).

A. alpina subsp. *attenuata* var. *linearis* Hultén, Lunds Univ. Aarrskr. II. Sect. 2, 46:1588. 1950. TYPE: Fort Yukon. *Murie 2204 fide* Ediger and Barkley (1978).

A. alpina subsp. *attenuata* var. *vestita* Hultén, Lunds Univ. Aarrskr. II. Sect. 2, 46:1588. 1950. TYPE: Tonsina Lodge, eastern Pacific Coast district of Alaska. *Anderson 1989 fide* Ediger and Barkley (1978).

Arnica alpina subsp. *iljinii* Maguire, Brittonia 4:411. 1943. *A. iljinii* (Maguire) Iljin, Fl. URSS. 26:658. 1961. *A. angustifolia* subsp. *iljinii* (Maguire) I.K. Ferguson in Heywood, Bot. J. Linn. Soc. 67:282. 1973. TYPE: "Unterlauf des Jenissei, Ust-Jenisseiski Port (69° 39 n. Br.) Aug. 4, 1926. *A. Tolmatchew 199*". (HOLOTYPE L, PHOTO CAN!, ISOTYPES GH!, O!)

Arnica intermedia Turez., Bull. Soc. Nat. Mosc. 34:203. 1851. *A. alpina* subsp. *intermedia* (Turez.) Maguire, Brittonia 4:410. 1943. TYPE: Prope Alach-Jun 1835. *N. Turezaninow 836*. (HOLOTYPE L, PHOTO CAN!)

Arnica sornborgeri Fernald, Rhodora 7:147. 1905. *A. alpina* subsp. *sornborgeri* (Fern.) Maguire, Brittonia 4:414. 1943. TYPE: "Rama, Labrador. Aug. 20-24, 1897. *J.D. Sornborger 157*". (HOLOTYPE GH!, PHOTO CAN!, ISOTYPES NY!, RM!, US!, PHOTO CAN!)

Arnica terrae-novae Fernald, Rhodora 27:90. 1925. TYPE: "Green Gardens, Cape St. George, Newfoundland. July 24, 1922. *K.K. Mackenzie & L. Griscom 11039*" (HOLOTYPE GH, PHOTO CAN!)

Arnica sornborgeri var. *ungavensis* Boivin, Nat. Can. 75:211. 1948. *A. alpina* var. *ungavensis* Boivin, Phytologia 23:94. 1972. TYPE: Québec. Fort Chimo, Baie d'Ungava, berge sablonneuse. Aug. 17, 1945. *Dutilly & Lepage 14768 fide* Ediger and Barkley (1978).

Arnica plantaginea Pursh, Fl. Am. Sept. 527. 1814. *A. alpina* var. *plantaginea* (Pursh) Ediger and Barkley, N. Am. Fl. Ser. II, Pt. 10:32. 1978. TYPE: "Labrador. Herb. Dickson. *Colmaster s.n.*". (HOLOTYPE PHI, PHOTO CAN!, ISOTYPE CAN(?))

Plants 0.5 to 5.4 dm high; *lower cauline leaves* 2.0 to 20.0 cm long, 0.3 to 4.1 cm broad, linear, narrowly to broadly lanceolate to rarely oblanceolate, apex acute or acuminate, margins entire to denticulate or rarely dentate, petioles sessile, short and broad-winged or obviously narrow-winged and shorter than the blade, glabrous to moderately pubescent; *capitula* 1 to 3 (rarely 5); *ligulate florets* 6 to 16, 10.0 to 40.0 mm long, the lobes 0.2 to 7.0 mm long; *periclinium* moderately to densely pilose, stipitate-glands evident or inconspicuous; *achenes* 3.1 to 7.0 mm long; *chromosome number* 2n=38, 57 and 76.

DISTRIBUTION AND HABITAT: A circumpolar taxon, confined primarily between 49° and 83° N. Latitude in North America, and between 60° and 80° N. in the U.S.S.R. Populations also found in northern Scandinavia near the Arctic Circle. [illegible] ica, its range extends from Alaska eastward through the northern regions Manitoba, Ontario and Québec, with isolated populations in northern Newfoundland. Also common from Greenland. Figure 30. In these areas, plants are found in a wide variety of habitats, notably: exposed tundras, gravelly and rocky slopes, roadsides, moist banks and open woodlands. In the southernmost portion of its range it is a plant of alpine slopes and ridges.

REPRESENTATIVE SPECIMENS: CANADA. **Alberta:** Cardinal Divide, 10 miles southwest Cadomin *Dumais 4241* (ALTA); Whistler Mtn., Jasper Park *Packer 3439* (ALTA); Cadomin *Moss 10328a* (ALTA); Eagles Nest Pass, Wilderness Park *Pegg 1714* (ALTA); Prospect Mtn., 10 miles southwest Cadomin *Mortimer 415* (ALTA); Fortymile Creek, west Mt. Louis *Lewis 379* (ALTA); Athabasca Mtn., Jasper Park *Moss 4923* (ALTA); Snow Creek Pass, 40 miles northnortheast Banff *Moss 12682* (ALTA); Bald Hills, Jasper Park *Kuchar 510* (ALTA); Bald Hills, Jasper Park *Kuchar 508* (ALTA); Mt. Norquay *Lewis s.n.* (ALTA); 1-2 miles west Lake Carthew, Waterton Lakes Park *Boivin & Gillett 9005* (ALTA,MT); Shovel Pass *Macoun 96016* (CAN); Angel Glacier, Mt. Edith Cavell *Straley 1618* (UBC).
British Columbia: Natural Bridge, Yoho Park *McCalla 7015* (ALTA,UBC); Mt. Prudence, Liard River *Haddow s.n.* (UBC); Good Hope Lake, 20-25 miles north Cassiar *Beamish, Wade & Pojar 730354* (UBC); Summit Lake *Rose 78464* (UBC); Summit Pass, Alaska Hwy. *Taylor, Szczawinski & Bell 121* (UBC); Birch Mtn., Teresa Island, Atlin Lake *Buttrick 688* (UBC); Good Hope Lake, 20-25 miles north Cassiar *Beamish, Wade & Pojar 730343* (UBC); Mile 81 Haines Rd. *Taylor, Szczawinski & Bell 1366* (UBC); Summit Pass *Raup & Correll 10554* (ALA,C,CAN,RM,US).
Manitoba: Fort Churchill *Ritchie 2133* (CAN,UBC); Gillam, 1 mile north past North Switch *Krivda 6-50* (UBC); Churchill *Porsild 5506* (C,CAN,MT,US); Fort Churchill *Gillett 2462* (MT,RM,US); Churchill, along Hudson Bay *Wolf s.n.* (ALTA); Nelson River, near "Head of Navigation" *Scoggan 6382* (ALTA,CAN,MT); Fort Churchill *Gillett 2011* (MT); Hayes River, 40 miles southwest York Factory *Scoggan 5896* (C,CAN,MT); Hayes River, 100 miles southwest York Factory *Scoggan 5805* (GH); Cape Merry Peninsula, Fort Churchill *Johansen s.n.* (O); Creek at Hudson Bay Railway, 65 miles south Fort Churchill *Johansen s.n.* (O); Churchill *Gardner 437* (GH); Churchill *Macoun 79277* (CAN,MT); Churchill *Birkel-Smith 1005* (C,CAN); Churchill *Macoun 79277* (CAN); Fort Churchill *Irvine 752* (CAN); Fort Churchill *Hyde 119* (CAN); Churchill *Webb C671* (CAN); Churchill *Brown 270* (CAN); Churchill *Schofield & Crum 6521* (CAN); Nelson River, Limestone Rapids *Scoggan 6428* (CAN); Churchill *Dutilly 15 and 141* (CAN); Churchill *Wood 185V* (CAN); Cape Merry, Churchill *Hunt 17* (CAN); Churchill *Gardner 67* (CAN); Fort Churchill *Dore 9998* (CAN); Churchill River, 98° 48' *Cairnes 89721* (CAN); Churchill *Polunin 53* (CAN); Port Churchill *Johansen s.n.* (C); Kettle Rapids, Route of Hudson Bay Railway *Emerton s.n.* (GH).
Newfoundland: Ramah *Sornborger 157* (GH); Flint Island, near Port Manvers *Bryant s.n.* (GH); Port Manvers *Gardner 315* (GH); Torngat Region, head of Nachvak Bay *Woodworth 431 1/2* (GH); Torngat Region, Razorback Mtn., Ryan's Bay *Woodworth 431* (GH); Torngat Region, Rowsell Harbour *Abbe & Odell 569* (CAN,GH); Hamilton Inlet Region, Rodney Mundy Island, Indian Harbour *Abbe & Hogg 568* (GH); Port Manvers *Palmer s.n.* (PH); Nain *Wynne-Edwards 7547* (CAN); Cut-throat Tickle near Okkak *Wynne-Edwards 7502* (CAN); Okkak, Cut-throat Tickle *Wynne-Edwards 7413* (CAN); Cut-throat Harbour south Cape Mugford *Porsild 221* (CAN); Southern Torngats, W. Saglek Fiord *Ives 12* (CAN); Eastern Point, region of St. John Bay *Fernald, Long & Fogg 2124* (GH,MT,NY); South Gargamelle Bay, region of Ingornachoix Bay *Fernald, Long & Fogg 2126* (GH,MT,NY); Labrador, Lat.

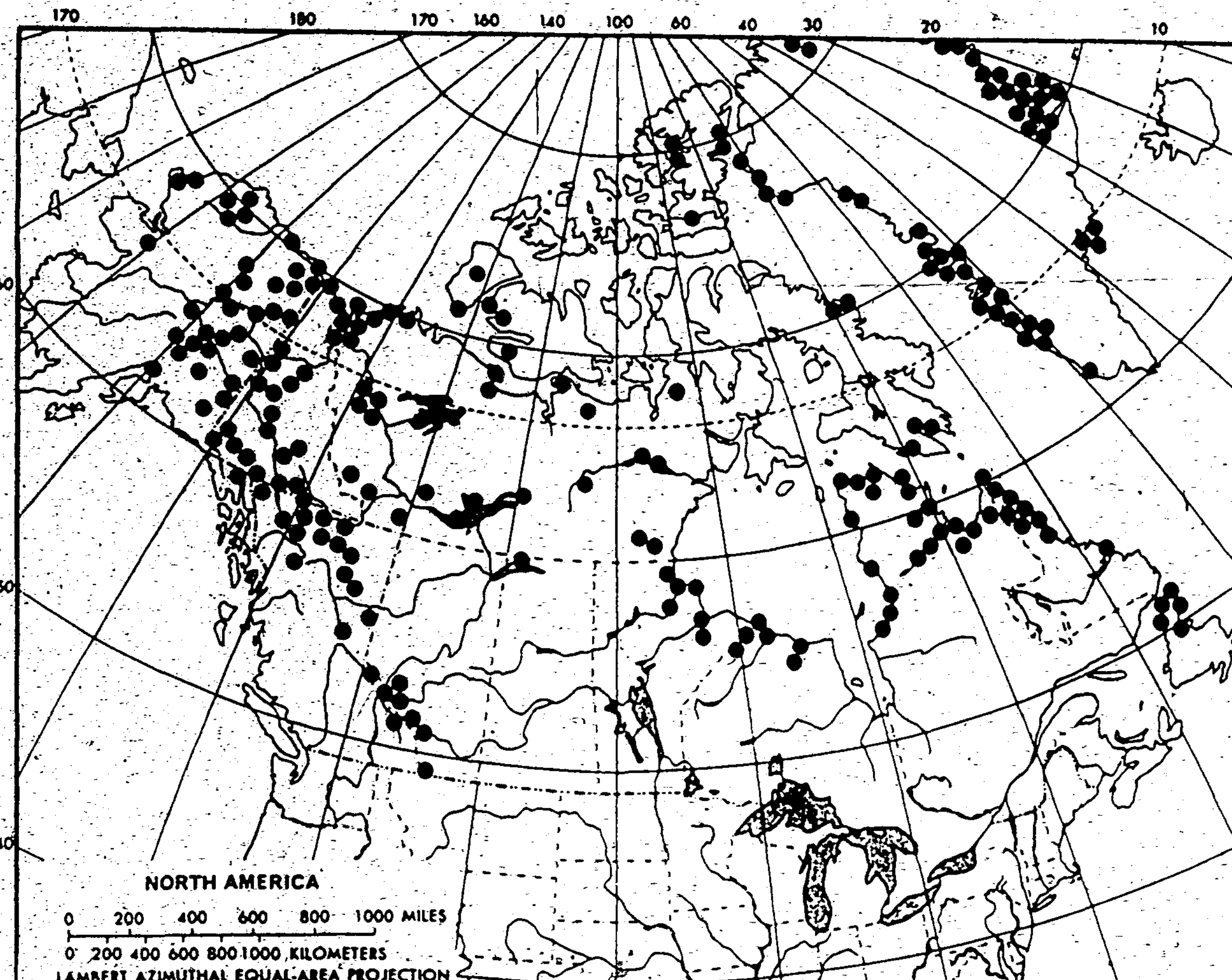


Figure 30 - North American distribution of *Arnica angustifolia* subsp. *angustifolia*.

58 deg. *Anspach s.n.* (NY); Straits of Belle Isle, 1 mile from Savage Cove *Fernald, Pease & Long 29208* (GH); Burnt Cape, Pistolet Bay *Fernald et al. 29029* (GH); Cape Norman, Pistolet Bay *Wiegand, Griscom & Hotchkiss 29213* (GH); Ha-Ha Bay, Ha-Ha Mtn. *Fernald & Long 29215* (GH,PH); Old Port Au Choix, region of St. John Bay *Fernald, Long & Fogg 2123* (GH); Southwest Port Au Choix, region of St. John Bay *Fernald, Long & Fogg 2125* (GH,MT); Straits of Belle Isle, 1 mile from Savage Cove *Fernald & Long 29207* (GH); Cook Point, Pistolet Bay *Fernald & Gilbert 29214* (GH); Burnt Cape, Pistolet Bay *Fernald & Long 29210112* (GH); Labrador, Hebron *Meatzel s.n.* (GH); Labrador, 20 miles north Nachvak *Forbes s.n.* (GH); Labrador, Ekortiarsuk, Cape Chidley *Schmitt 312* (GH); Labrador, Hebron *Forbes s.n.* (GH); Labrador, head Ryan's Bay, Torngat region *Woodworth 430* (GH); Labrador, head Nachvak Bay, Torngat region *Woodworth 429* (GH); Labrador, head of Ryan's Bay, Torngat region *Woodworth 428* (C,GH); Labrador, head of main arm of Ekortiarsuk Bay, Torngat region *Woodworth 432* (GH); Labrador, Kangalaksiorvik Bay *Bryant s.n.* (GH); Labrador, near Island, Seven Islands Bay, Kangalaksiorvik *Abbe 572* (CAN,GH); Rowsell Harbor, Torngat region *Abbe & Odell 570* (GH); Rowsell Harbor, Torngat region *Abbe & Odell 571* (GH); Labrador, Razorback Harbor, Torngat region *Abbe 573* (GH); Labrador, Komaktorvik Fjord *Wynne-Edwards 7136* (CAN); Labrador, Skynner Cove, Nachvak Fjord and Cracker Mtn. *Wynne-Edwards 7111* (CAN); Labrador, Crater Lake vicinity, 52 miles WSW Hebron *Gillet 8661* (US); Old Port Au Choix, St. Barbe district *Penson s.n.* (MT); Labrador, Anchorstok Bay, Cape Mugford *Potter & Brierly 3797* (MT); Labrador, Kangalaksiorvik Bay, Seven Islands Bay *Potter & Brierly 3798* (MT); Labrador, Mt. Brave, Cape Mugford Region *Potter & Brierly 3799* (MT); Labrador, Ryan's Bay *Loken 9* (MT); Cape Norman, White Bay district *Penson s.n.* (MT); Cook's Harbour, Shallow Bay, St. Barbe district *Penson s.n.* (MT); Vicinity Gerin Mtn. *Viereck 639* (ALA,MT); Labrador, Hebron *Landoz(?) s.n.* (NY); Labrador, Seaplang Harbour, Torngat Mtns. *Platt & Boucot 435C* (NY); Labrador, Hebron *Coleman 65* (C).
Northwest Territories: Thelon Game Sanctuary *Perret & Kelsall 10* (UBC); Inuvik *Fodor N63* (UBC); Canoe Creek *Lambert, Krajina & Morrison 65081304* (UBC); Keewatin district, Lake on Tha-anne River *Porsild 5602* (MT,US); Yellowknife, east end Lathan Island *Cody & McCanse 2328* (RM,US); 0.5 mile north Tununuk Point, Richards Island *Hernandez 244* (ALTA); Baker Lake *Wolf s.n.* (ALTA); Fort Reliance, east Great Slave Lake *Wilk 11* (ALTA); Deadman Valley, Nahanni Natl. Park *Kershaw 804* (ALTA); Deadman Valley, Nahanni Natl. Park *Kershaw 803* (ALTA); 6 miles south Tuktoyaktuk *Hernandez 346* (ALTA); 1.5 miles south Imperial Oil Tuktoyaktuk Base *Hernandez 202* (ALTA); Vicinity of Tuktoyaktuk *Younkin 106* (ALTA); Yellowknife, west Kam Lake *Cody & McCanse 2207* (MT); West Cache Creek *Welsh & Rigby 12021* (ALTA); Inuvik, Dolomite Lake *Newton & Swales s.n.* (RM); Richardson Mtns., 1 mile north Loan Lake *Welsh & Rigby 12106* (ALA); Inuvik, Dolomite Lake *Swales 508* (C); Fort Smith *Novic 16311* (UBC); Mackenzie Valley, Donnelly River *Reid 420* (ALTA,SASK); Deadman Valley, Nahanni Natl. Park *Kershaw 798* (ALTA); Parry Bay, Kent Peninsula, Nauyuk Estruary *Taube s.n.* (ALTA); Coppermine *Findlay 40* (ALTA,C,MT,RM); Chick Lake, Chick Ridge *Gubbe 118A* (ALTA); Chick Lake, Chick Ridge *Gubbe 118(43)* (ALTA); Chick Lake *Gubbe 264(78)* (ALTA); Chick Lake *Gubbe 249(65)* (CAN); Liverpool Bay, Nicholson Island *A.E. & R.T. Porsild 2947* (ALTA); Richardson Mtns., west Mackenzie River delta *Porsild 6865* (ALA,ALTA); Great Bear Lake, Scented Grass Hills Peninsula, Etacho Point *Porsild 17072* (ALTA,C); Great Bear Lake, Scented Grass Hills Peninsula, South Etacho Point *Porsild 17073* (ALA); Banks Island, Nelson Head *Porsild 17789* (ALA,ALTA,C); Ellesmere Island, Lake Hazen *Harington 400* (ALTA); Victoria Island, Holman *Bliss s.n.* (ALTA); Ellesmere Island, Hazen Camp *Savile 4567* (ALTA,UBC); Holman Island *Ross 32a* (ALTA); Coppermine *Ross 3* (ALTA); East Tuktoyaktuk harbour *Haag 140* (ALTA); Frobischer Bay, Baffin Island, 2 miles Lake Geraldine Ledger *Owen & Hickman s.n.* (ALTA); Casba Lake, 21 m. below Falls *Bedford s.n.* (ALTA); Bathurst Inlet *Wilk 64* (ALTA); Bathurst Inlet *Wilk 17* (ALTA); Colonel Mtn., Brintnell Lake *Raup & Soper 9384* (ALA,ALTA,UBC); 6 miles east Kittigazuit *A.E. & R.T. Porsild 2530* (MT); Frobisher Bay, Baffin Island *Senn & Calder 3803* (MT); Sylvia Grinnell, Frobisher Bay, Baffin Island *Calder 2153* (MT); Baker Lake *Choque s.n.* (MT); Eureka, Ellesmere Island *Bruggemann 632* (MT); Site 80-62, 80 km northeast Tuktoyaktuk, 15 km south McKinley Bay *Sims 6248B* (UBC); Stanley Point, 65 km SSE Tuktoyaktuk *Sims 6268B* (UBC); 50 km SW Tuktoyaktuk *Sims 6055* (UBC); 50 km southeast Tuktoyaktuk, Split-Lake esker complex *Sims 6334B* (UBC); Imperial Range *Matthews s.n.* (UBC); Inuvik Airfield, quarry near Dolomite Lake *Krajina 65071911* (UBC); Richardson Mtns., Buckhunter Mtn., above Husky Channel *Krajina 63071272* (UBC); Lake Franklin *Oldenburg 46-2108* (UBC); Lake 2 miles north Holman Island post *Oldenburg*

64-207 (UBC); Eureka, Ellesmere Island *Bruggemann 797* (UBC); Imperial Range at Mountain River *Matthews s.n.* (UBC); Richardson Mtns., Buckhunter Mtn., above Husky Channel *Krajina 630711122* (UBC); Baffin Island, Inugsuin Fjord *Hainault 3953* (O); Baffin Island, Inugsuin Fjord *Hainault 3847* (C,O); Baffin Island, Inugsuin Fjord, 2 km northwest Base Camp *Hainault 4027* (C,O); Ellesmere Island, Harbour Fjord, Seagull Rock *Simmons 2585* (C,O); Mackenzie River, limestone hills north Campbell Lake, east Point Separation *A.E. & R.T. Porsild 1973* (O); Banks Island, Bernard River *Maher & MacLean 77* (RM,SASK); Thelon River *Kalenosky & Thomas s.n.* (SASK); 5 miles west Murchison River *Gubbe, Maddison & Burr M855* (SASK); Horn Plateau, South Willow Lake *Rowe 1774* (SASK); Kinga Lake *Gubbe, Maddison & Burr G11* (SASK); Lower Perry River *Matthews 47* (SASK); Trout River, Mackenzie Hwy., 77 miles from Liard Ferry *Skoglund 835* (SASK); East Great Slave Lake, Parry Falls *Johnson et al. 609* (SASK); Herschell Island *Lindström s.n.* (C); Frobisher Bay, Baffin Island *Senn & Calder 3803* (C); Bernard Harbour *Johansen 335,335a* (C); Baker Lake *Dutilly 62989* (C); Pt. Radium, Great Bear Lake *Johnson s.n.* (C); Axel Heiberg Island, Thompson Valley, 500 miles E. Colour Lake *Beschel 10766* (C); Ellesmere Island, Slidre Fiord *Troelsen 89* (C); Ellesmere Island, head Tanguary Fiord *Brassard 1956* (C); Axel Heiberg *Terroux s.n.* (C); Axel Heiberg Island, Thompson Valley, 2 km NE White Glacier Front *Beschel 11187* (C); Victoria Island, Holman Island *Porsild 17336* (C); Victoria Island, Washburn Lake *Porsild 17460* (C); Great Bear River, jnctn. with Big Stick River *A.E. & R.T. Porsild 3248* (C); Baker Lake *Barysted 1123,1129* (C); Banks Island *Krajina 182733* (UBC); Richards Island *Erickson s.n.* (UBC); McTavish Arm, Great Bear Lake *Shacklette 2726* (CAN,ICEL); E. slope Richardson Mtns., W. Mackenzie River Delta *Porsild 6865* (C).

Ontario: Fort Severn *Hustich 1534* (CAN); Mouth of Black Duck River *Moir 2189* (CAN); Goose Creek, 4 mi. S. coast *Moir 1517* (CAN); Junction Fawn and Otter Rivers *Moir 607* (CAN); Coast Hudson Bay, E. Shagamu River *Riley 7121* (CAN); Thunderhouse Falls along Missinaibi River, Scovil Twp. *Shea 11581* (CAN); Between Hawley and Sutton Lakes *Porsild, Baldwin, H. & G. Sjors 19941* (CAN); Island in mouth of Winisk River *Baldwin 7797* (CAN); Mouth of Niskibi River *Moir 2321* (CAN); Island in Severn River opposite mouth Beaver River *Moir 246* (CAN); S.W. Pass Lake, Sibley Prov. Park *Garton 18310* (CAN); Trowbridge Falls on Current River *Garton 18748* (CAN); W. Fort Severn *Moir 1352* (C); Fort Severn, Patricia district *Scott s.n.* (UBC); 15 miles from mouth of Black Duck River, near Manitoba-Ontario border *Moir 2082* (CAN,MT); 35 miles from mouth of Black Duck River *Moir 1869* (CAN,RM); Kenora District, Limestone Island, Winisk and Shamattawa Rivers *Baldwin 7678* (CAN); Kenora District, Shamattawa River *Baldwin 7898* (CAN).

Québec: Payne River *Rousseau 1089* (NY); Fishing Lake Creek, Richmond Gulf *E.C. Abbe, L.B. Abbe & Marr 3549* (CAN,GH,MT,NY,RM); Wakeham Bay, Hudson Strait *Malte 126924* (CAN,GH,NY); Richmond Gulf, east Hudson Bay, Ungava *Dutilly & Lepage 13281* (NY); Port Harrison, east Hudson Bay *Malte 120718* (GH,NY); Richmond Gulf, east Hudson Bay, Ungava *Dutilly & Lepage 13262* (GH,NY); Hudson Bay, Ungava coast *Low 22819* (GH,NY); Cape Prince of Wales, Hudson Strait *Bell s.n.* (CAN,US); Wakeham Bay, Hudson Strait *Malte 120206* (C,CAN,GH,MT,NY,US); Fort Chimo *Hedberg 1959* (O); 5 miles south West Sugluk *Malte 126984* (GH); Fishing Lake Creek, Richmond Gulf, east Hudson Bay *E.C. Abbe, L.B. Abbe & Maarr 3559* (GH); Beach Creek, Richmond Gulf *E.C. & L.B. Abbe 3254* (GH); Gulf Hazard, Richmond Gulf *E.C. & L.B. Abbe 3805* (CAN,GH); George River, Ungava *Spreadborough 14385a* (CAN); Fort Chimo, Ungava Peninsula *Porsild 21885* (CAN); South Hudson Strait, Wolstenholme *Polunin 192* (CAN); Payne River, north Ungava *Carroll s.n.* (CAN); Riviere aux Feuilles *Ouellet s.n.* (CAN); Koksoak River, between Fort Chimo and Larch River *Drummond 55N* (MT); Baie-aux-Feuilles area near Tasiujoq, southwest Ungava *MacInnes 5174* (MT); Wolstenholme *Dutilly 882* (UBC); Payne River *Rousseau 1002* (GH,RM); Fort Chimo *Legault 6791* (MT,SASK); Ile Bylot *Lemieux s.n.* (MT); Wakeham Bay, Ungava *Johansen 1208* (C,O); Cape Wolstenholm, Hudson Strait *Johansen 1055* (C); 30 miles S. Deception Bay, N. Ungava *Matthews 37* (C); Mosquito Bay, east Hudson Bay *Low 23019* (CAN); Sugluk *Huckel 21* (NY); Lake Marymac *Harper 3679* (CAN); Ungava, along the Koksoak River *Spreadborough 14385* (CAN,NY).

Saskatchewan: Crackingstone, Athasbasca Lake *Rawson s.n.* (SASK).

Yukon: Snag Air Station *Noel 12501, 12502, 12503* (UBC); North side Cultus Creek, southeast Kluane Lake *Beamish s.n.* (UBC); Mile 1019 Alaska Hwy., vicinity of Pine Creek *Raup, Drury & Raup 13148* (ALA,UBC); North shore Kluane Lake, near mouth of Big Arm *H.M. & L.G. Raup 12366* (ALA,UBC,C,RM,US); Ross River, *Beamish, Krause & Luitjens 681265* (UBC); Klondyke Valley, Dawson City *Brink s.n.* (UBC); Mile 215 Ross River Rd., Watson Lake *Beamish, Krause & Luitjens 681223* (UBC); 5 miles north Carmacks *Brink s.n.* (UBC); Big Arm, Kluane Lake *H.M. & L.G. Raup 12886* (ALA,UBC); Island, south Kluane Lake *Neilson 691* (US); Dawson *Eastwood 205* (US); Eagle *Collier 44* (US); Carmacks *Eastwood 574* (US); Eagle *Collier 29* (US); Cemetery Hill, Dawson *Eastwood 423* (US); Summit Lake, Richardson Mtns. *Packer 1458* (ALTA); Bell River, 8 miles west La Pierre House *Hettinger 227* (ALTA); Mile 95.8 Dempster Hwy. *Peterson 4* (ALTA); South Moosehide Mtn. *Campbell 31* (MT); Hunker Camp *Campbell 22* (MT); Whitehorse *Mitchell 53* (MT); Swede Creek *Berton 84* (UBC); North Orange Fork of Black River *Cairnes 81601* (US); Along roadside between Steward River Crossing and Dawson City *Langenheim 4130* (UBC); Mile 763.5 Alaska Hwy. *Welsh & Moore 7587* (ALA); Mile 1204 Alaska Hwy. *Welsh & Moore 7957* (ALA); Km 153 Dempster Hwy., Ogilvie Mtns. *Parker 989* (ALA); Teslin Lake *Schreider 12* (ALA); Haines Hwy., 10 miles from Haines Jnctn. *Williams 1375* (ALA); Roadhouse Airstrip, Teslin Junction *Bartholomew 36-63* (ALA); Bear Creek, 8 miles east Dawson *Calder & Billard 3016* (RM); Along Dawson-Whitehorse Hwy. *Schmuck 208* (ALA); Mile 658 Alaska Hwy., 26 miles west Watson Lake *Welsh & Moore 7469* (ALA); Mile 1105 Alaska Hwy. *Welsh & Moore 7890* (ALA); Mile 1111 Alaska Hwy. *Welsh & Moore 7907* (ALA); 12 miles up Firth River at Weir Site One *Reid 1436* (ALTA); Mile 132 Canol Rd., Lower Lapie River Crossing, *Porsild & Breitung 9756* (ALA,ALTA,C,O); 90 miles northwest Dawson City, Mt. Klotz *Greene 295* (ALTA); 90 miles northwest Dawson City, 2 miles south Mt. Klotz *Greene 226* (ALTA); Mile 112.3 Dempster Hwy. *Peterson 2* (ALTA); Mile 102.4 Dempster Hwy. *Peterson 3* (ALTA); Babbage River, east Little Trout Lake *Lambert & Morrison 65071602* (UBC); Northeast Fish Lake *Beamish, Krause & Luitjens 681443* (UBC); Lapie Lakes *Beamish, Krause & Luitjens 681350* (UBC); 7 miles east Little Atlin Lake *Raup & Correll 11212* (ALA,UBC); Dew Line Site, Barl, Komakuk Beach *Parmelee 2855* (UBC); Northwest Slim's River, Kluane Lake *D.F. & B.M. Murray 776* (ALA); Rusty Glacier Terminus, west Burwash Landing, Kluane Lake *Murray 1616* (ALA); Steele Glacier, St. Elias Mtns. *D.F. & B.M. Murray 1355* (ALA); King Point *Lindstrom s.n.* (O); King Point *Hansen s.n.* (C); Herschell Island *Lindstrom s.n.* (O); Northwest Slim's River *D.F. & B.M. Murray 745* (ALA); Ogilvie Mtns., Windy Pass *Parker 1016,1048* (ALA); Canol Road, Rose-Lapie River Pass, west mile 118 *Porsild & Breitung 10146* (ALA); Dog Creek, 6 miles northwest Sam Lake *Welsh & Rigby 10273* (ALA); South Kluane Lake at IRRP fieldcamp *Murray 413* (ALA); Km 1.6 Mayo Rd. *Dudynsky 7801* (ALTA); 108 km N. Stewart Crossing *Dudynsky 7802* (ALTA); Km 132 Dempster Hwy. *Dudynsky 7803* (ALTA); Km 137 Dempster Hwy. *Dudynsky 7804* (ALTA); Km 138 Dempster Hwy. *Dudynsky 7805* (ALTA); Dawson City *Dudynsky 7806* (ALTA); Km 270 Klondike Hwy. *Wolf 294* (ALTA); 7.5 km S. Haines Junction *Dudynsky 7825* (ALTA); 26 km S. Haines Junction *Dudynsky 7829* (ALTA); Km 1788 Alaska Hwy. *Dudynsky 7824* (ALTA); Mile 112.3 Dempster Hwy. *Peterson 2* (ALTA); Mile 102.4 Dempster Hwy. *Peterson 3* (ALTA); Mile 95.8 Dempster Hwy. *Peterson 4* (ALTA); Mile 2.5 Dempster Hwy. *Gornall 8* (ALTA); Mile 1243.5 Alaska Hwy. near border *Dudynsky 7823* (ALTA); Kathleen R. Bridge, Alaska Hwy. *Dudynsky 7826* (ALTA); Alaska Hwy. at Porcupine Creek Campground; 3 mi. N. Slana *Dudynsky 7822* (ALTA); Canol Rd., Rose-Lapie R. Pass, Mile 105 *Porsild & Breitung 10932* (CAN); Mile 136-138 Canol Road, Pelly River Valley *Porsild & Breitung 9787* (C).

FINLAND: Lapponia Enontekiensis (?) *Kotilainen 1394* (C,O).

GREENLAND: South Disko, Sinigfik *Porsild s.n.* (MT); Disko, Arktisk Station *Porsild s.n.* (C,MT,RM); Nugssuaq Halvo, Kugssinerssuaq *M.P & R.T. Porsild s.n.* (MT,O); Northwest Lach Fyne, Hudson Land *Seidenfaden 169* (C,MT); Disko Island *Burk 36* (MT); Godhavn *Kleist s.n.* (MT); Scoresbysund, Sydkap-oen *Sorensen 162* (MT); Disko, Vaigat, Atanikerdluk *Porsild s.n.* (MT,O); Sermermiut area south Ilulissat (Jakobshavn) *Harris 1748* (ALTA); Disko, Godhavn *Lagerkranz s.n.* (RM); Northeast Mesters Vig, Sortebjorn Mtn. *G. & S.M. Argent 44125774* (ALA,C,RM); Clavering Island, Soppbukta *Vaage s.n.* (ALA); Gaseland, Faxe So *Holmen & Laegaard 67* (ALA,C,ICEL,O); Disko, Mudderbugten between Alakariaq and Pingo *Andersen & Hanfgarn 557* (ALA,C,O); Kong Oscars Fjord, Mesters Vig *Anonymous* (ICEL); Sondre Stromfjord *Porsild s.n.* (ICEL); Nugssuaq *Guojonsson s.n.* (ICEL); Jkorfat *Guojonsson s.n.* (ICEL); Scoresby Land, Holges Danskes Briller *Einarsson 335* (ICEL); Kutsiaq, Nugssuaq *Guojonsson s.n.* (ICEL); Clavering Island *Hofseth s.n.* (O); Hurry Fjord *Pedessen s.n.* (O); Ymers Island, Sofiasundet *Vaage s.n.* (O); Ymers Island, Cape Humboldt *Vaage s.n.* (O); Husbukta *Vaage s.n.* (O); Sanddalen *Vaage s.n.* (O); Green Valley, NE Clavering Island *Seidenfaden 738* (O); Kangerdlugssuatsiaq, Braudal *Scholander s.n.* (O); Kangerdlugssuatsiaq, Storfjord Radio *Scholander s.n.* (O); Storfjorden, Brandal *Tornoe s.n.* (O); Kong Oscars Fjord *Hauken & Sulebak s.n.* (O); Godhavn *Fries s.n.* (O); Disko, Aurwaruhigsuk *Porsild 59* (O); Christianshaab *Mathiesen s.n.* (O); Varderyggen *Lundager 1151* (O); Godhavn *M.P. & R.T. Porsild s.n.* (O); Disko, Kvandalen *Andersen & Hanfgarn 268* (C,O); Disko, Mudderbugten, Alakariaq *Andersen & Hanfgarn 2* (C,O); Liverpool Land, near Hurry Fjord *Taggart 17* (O); Godhavn, Lyngmarken *Simmons 73* (O); Traill Island *Vaage s.n.* (O); Noskusoksefjorden *Vaage s.n.* (O); Cape Herschel *Vaage s.n.* (O); Clavering Island *Vaage s.n.* (O); Clavering Fjord *Vaage s.n.* (O); Jameson Land *Pedessen s.n.* (O); Murchison Sound, Tydlolnar *Nygaard s.n.* (O); Disko, Nugssuaq Halvo, Atanikerdluk *Porsild s.n.* (O); N. Sarfardlisivik Island between Tugtilik and Nigertussaq Fjords *Elsley 130/67* (C); Mtn. N. Devaux Bjaerg *Stocken 8/69* (C); Angmagssalik, Qingertivaq, Cassiopefjeld *Astrup & Kliim-Nielsen 724* (C); Angmagssalik, Karale Gletscher *Lenarcic s.n.* (C); Angmagssalik, S. Glacier de France *Angerer s.n.* (C); Mesters Vig *Olsen s.n.* (C); Jameson Land, Cape Hooker *Gelting 64* (C); N. Scoresby Land, S. Sefstroms Gletscher *Schwarzenbach 840* (C); N. Scoresby Land, N. Vikingebrae, Alpefjord *Schwarzenbach 877* (C); Scoresby Land, Lummen So *Chamberlain 179* (C); Scoresby Land, Syd Kap *Chamberlain 177* (C); Mesters Vig, Kong Oscars Fjord *H.M., L.G. Raup & Washburn 22,53,385* (C); Liverpool Land, Roscoe Bjerge, E. Hurry Inlet *Marris 9* (C); Scoresby Land, South Pingodal *Chamberlain 122* (C); Jameson Land, Lollandselv, 12 km along estuary *Moore PM15* (C); Charcots Land, Gromso *Laegaard 694* (C); Mesters Vig, Blyminen *Laegaard 1432* (C); Scoresby Land, Syd Kap *Laegaard 1210* (C); Jameson Land, Gurreholm *Laegaard 964,1071* (C); Charcots Land *Laegaard 610* (C); Rypefjord *Laegaard 356* (C); Jameson Land, Cape Stewart *Behrndt s.n.* (C); Scoresbysund *Behrndt s.n.* (C); Danmarks Island *Hartz s.n.* (C); Scoresbysund, Syd Kap *Sorensen 162* (C); Liverpool Land, Scoresbysund *Pedersen s.n.* (C); Scoresbysund *Hagerup s.n.* (C); Hurry Inlet *Thule 1209* (C); Liverpool Land, Store Fjord *Noe-Nygaard 44,45* (C); Jameson Land *Pedersen 55* (C); Liverpool Land, near Hurry Inlet at Fame Islands *Tullnius 47,48,49,50* (C); Liverpool Land, Hurry Inlet *Kruuse 528,612* (C); Liverpool Land, Fleming Inlet *Kruuse 720* (C); Lyells Land, N. Forsblads Fjord *Schwarzenbach 904* (C); Nathorsts Land, head of Forsblads Fjord *Schwarzenbach 839* (C); Storedal *Kruuse s.n.* (C); Shannon Island, Cape David Gray *Bruch & Hjort s.n.* (C); Hochstetters Forland, S. Muschelbjaerg *Bruch & Elander s.n.* (C); Cape Herschel *Vaage s.n.* (C); Clavering Island *Gelting 31,32,35* (C); Eskimo Bay, Clavering Island *Gelting 33* (C); Halle Mtns., Clavering Island *Gelting 34* (C); Traill Island, Gudenelv *Argent 234* (C); Geographical Society Island *Vaage s.n.* (C); Fjaldmark, Clavering Island *Seidenfaden 102* (C); Ole Romers Land, Vibeke So *Schwarzenbach 508a,511* (C); Granta Fjord *Schwarzenbach s.n.* (C); Wollaston Forland, Mt. Zackenberg *Schwarzenbach s.n.* (C); Dove Bugt, Cape Tenfel *Schwarzenbach s.n.* (C); Grandjeanfjord, Magenaes *Holmen s.n.* (C); Traill Island *Sorensen 3025,3026* (C); Nordre Stromfjord, Spirit *Bocher 836* (C); Nordre Stromfjord *Bocher 788* (C); Arfersiorfikfjord, Aulatsivik *Bocher & Laegaard 326* (C); Arfersiorfikfjord, Eqalugarssuit *Bocher & Laegaard 85* (C); Arfersiorfikfjord, Nunatarujuk *Bocher & Laegaard 113,176* (C); Nordre Stromfjord, Ungoriarfik *Kornerup s.n.* (C); Isortorefjord *Kornerup s.n.* (C); Nordre Stromfjord, Tiggak *Sorensen s.n.* (C); Nordre Stromfjord, Nordmann s.n. (C); Niyak Bugt *Porsild s.n.* (C); Kangersuneq *Bocher 1191* (C); Godhavn, Disko *Holmen s.n.* (C); Disko, Nordfjord *Fredskild 5664* (C); Disko, Nordfjord, at entrance of Stordalen *Fredskild 5618* (C); Nugssuaq *Petersen s.n.* (C); Cape Dalton *Kruuse 376* (C); Kangerdlugssuaq *Bocher 405* (C); Storfjorden, Brandal *Tornoe s.n.* (C); Nikisfjord *Jorgensen 12* (C); Scoresbysund, N. Rolige Brae *Hvenegard 17* (C); Mesters Vig *G. & S.M. Argent 24/18774* (C); Kong Oscars Fjord, Lower E. Skeldal *Elkington s.n.* (C); E. Skeldal *Spearing & Lasca s.n.* (C); Skeldal *Spearing, Lasca, Baad & Schmidt 141* (C); Gaseland, Faxe So *Laegaard 230* (C); Scoresbysund, Fohn Fjord *Lund 2* (C); Scoresbysund, Gletscher *Lund 7* (C); Jameson Land *Hartz s.n.* (C); Skeldal, 12 km from coast *Schwarzenbach 130* (C); Cape Mary, Clavering Island *Seidenfaden 47* (C); S. Clavering Island *Bartlett 45* (C); Cape Stosch, Hold with Hope Peninsula *Koie 4213,4214* (C); Loch Fynes Bugt *Seidenfaden 891* (C); Cape Oswald, Ella Island *Holmen s.n.* (C); Gauss Peninsula, Moskusoksefjord *Povelsen s.n.* (C); Ymers Island, Dusen Fjord *Povelsen s.n.* (C); Ymers Island *Sorensen 3027* (C); Wollaston Forland *Rosenberg s.n.* (C); Ole Romers Land, Krumme Langso *Schwarzenbach 1258* (C); Ole Romers Land *Schwarzenbach 1238* (C); Ymers Island *Schiotz s.n.* (C); Franz Joseph Fjord *Anonymous* (C); Skiepfjord, head Van Clausen Fjord *Sorensen 1531* (C); Adam Bierings Land, S. Inuiterk So *Bennike s.n.* (C); Khud Rasmussen Land, Hyde Fjord, Volvedal *Bennike s.n.* (C); Kaugarssup nuna *Ollgaard 68-1333* (C); Sdr. Isortoq, E. Nukagpiaq *Hansen & Holt 383* (C); Sdr. Isortoq,

E. Nukagpiaq *Alstrup 77805* (C); Head of Sdr. Isortoq, Kangerdluk *Hansen & Holt 189* (C); Sdr. Isortoq, Tupertalik *Alstrup 77544a* (C); Head of Sdr. Isortoq, Isuitsup *Hansen & Holt 128* (C); Sdr. Isortoq, Nugarssuk *Holt 302* (C); Godthaabsfjord, Karra *Alstrup 1197* (C); Amitsuatsiaq *Bennike s.n.* (C); Sukkertoppen, Amitsuatsiaq *Holthe 83* (C); Godthaabsfjord, head of Ilulialik *Kruuse 1119* (C); E. Sondre Isortoq, W. Lake Kangiata *Holt 1651* (C); Godthaabsfjord, Austmannadalen *Skouv 345* (C); E. Sondre Isortoq, Amitsuatsiaq *Holt 1566* (C); Godthaabsfjord; NE Ujaragssuit *Alstrup 69266* (C); Sondre Stromfjord, Angujartopfiup nuna *Ravn & Alstrup 62* (C); Itivdleq, N. Eqalugarssuit *Holt 1758,1990* (C); Sondre Stromfjord Airbase *Bocher 320,325* (C); Holsteinsborg *Fredericksen 1041,1145* (C); Holsteinsborg *Laegaard s.n.* (C); Nugarssuk *Porsild s.n.* (C); Sondre Stromfjord Airbase *Ollgaard 68-252* (C); Disko Bugt, Sydostbugten *Moller, Pederson & Wilquin 498,516* (C); Sondre Stromfjord, Nordsiden *Porsild s.n.* (C); Tasersiaq, Sukkertoppen *McCormick 232* (C); Tasersiaq *McCormick 168* (C); Holsteinsborg near Isunguata *Feilberg 1575* (C); Holsteinsborg *Sorensen 665* (C); Holsteinsborg *Brummersheath s.n.* (C); Holsteinsborg *Deidmann s.n.* (C); Holsteinsborg *Holm s.n.* (C); Ikertoq, head of N. branch of Akugdleq Bay *Bay GBU 78-1701* (C); Ikertoq, head of S. branch of Akugdleq Bay *Bay & Hanfgarn GBU 78-1506* (C); Sondre Stromfjord, Mt. Hassel, N. Sandflugtdalen, 3 km W. Keglen *Holt 1220* (C); Sondre Stromfjord, Isunguata *Holt 1305* (C); Dragefjeldine *Bocher 568,573* (C); Sondre Stromfjord, Nakajauga ridge *Bocher 980* (C); Kegleu, Sondre Stromfjord *Bocher 328* (C); Sondre Stromfjord, Mt. Hassel *Bocher 326,327* (C); Disko Island *Pedersen 921* (C); Disko, Godhavn *Holmen s.n.* (C); Blasedaln *Laegaard 62* (C); Disko, Mudderbugten *Laegaard 259* (C); Disko, Skansen *Porsild s.n.* (C); Disko *Pedersen 95,724,921,999,1882* (C); Karajak nunatak, Umanakfjord *Vanhoffen 82(206)* (C); Disko, Sydkysten *Grontved 524,525* (C) Igdlorssuit *M.P. & R.T. Porsild s.n.* (C); Disko, Lyngmarken *Fries s.n.* (C); Disko, Mellemfjord *Porsild 724* (C); Disko, Muddenbugten *Porsild 95* (C); Disko, Godhavn, near Lyngmarks Glacier *Porsild 8035* (C); Nugssuaq, Lydkysten *Grontved 523* (C); Diskofjord, between Kangerdluarssuk and Eqalunguit *Fredskild, Moller, Pedersen & Wilquin 134,157* (C); Kvandalen *Laegaard 1330* (C); Shansen *Laegaard 1328* (C); Bredidal *Laegaard 1544* (C); Skarvefjeld *Gelting s.n.* (C); Amitsuarsuk fjord, Kingua *M.P. & T. Porsild 1* (C); Upernivik *Johansen s.n.* (C); Svartenhuk Halvo *Porsild s.n.* (C); Upernivik, Sandsten *M.P. & R.T. Porsild s.n.* (C); Melville Bugt, Tugtuligssuaq, E. Itivdlipalak *Bay & Fredskild 358* (C); Melville Bugt, Tugtuligssuaq, Tuperssuai *Bay & Fredskild 413* (C); Melville Bugt, Tugtuligssuaq, between Itivdlipalak and Point 480 *Bay & Fredskild 329* (C); Siorapaluk *Salomonsen s.n.* (C); Hartstene Bugt, Uingasoq *Kristensen s.n.* (C); Cape Atholl *Brink s.n.* (C); Thule *Holmen s.n.* (C); Akinarssuk at Thule Airbase *Fredskild 6185,6276* (C); Disko, Paiobshavn *Vahl s.n.* (C); Cape Jelik *Revier s.n.* (C).

NORWAY, Finnmark: Alta, Haldefjellet *Ryvarden s.n.* (O); Alta, Bekkarfjord *Ryvarden s.n.* (O); Kautokeino *Knaben s.n.* (O); Porsangen Inlet *Dahl s.n.* (O); Lakselv *Dahl s.n.* (O); Alta *Dahl s.n.* (O); Kistrand *Dahl s.n.* (O); Kistrand *Roll-Hansen s.n.* (O); Kautokeino *Dahl s.n.* (O); Varangerhalvoya, Batsfjord *Dahl s.n.* (O); Varangerhalvoya, Batsfjord *Resvoll-Holmsen s.n.* (O); Varangerhalvoya, Vardo *Dahl s.n.* (O); Nallovarre, Alten *Fridtz 20387* (O); Skovikhaugene, Batsfjord, Varangerhalvoya *Resvoll-Holmsen s.n.* (O); Alten, Kafjord *Fridtz s.n.* (O).
Nordland: Ny-Sulitjelma *Dahl & Woodhagen s.n.* (O); Tysfjord *Michelsen & Sivertsen s.n.* (O); Hamaroy *Sivertsen E6* (O); Hamaroy, Lulemusjokka *Apold & Brodal s.n.* (O); Fauske; Brattfjell, Sulitjelma *Noto s.n.* (O); Ny-Sulitjelma *Landmark s.n.* (O).
Troms: Bardu, Botnfjell, towards Isroa *Engelskjon s.n.* (O); Bardu, Gaudnjavatn *E. & T. Engelskjon s.n.* (O); Bardu, Melhuskletten *Noto s.n.* (O); Kafjord *Hanssen s.n.* (O); Kafjord *Zetterstedt s.n.* (O); Kvaenangen, Corrovarre *Noto s.n.* (O); Kvaenangen, Abbojavrre *Noto s.n.* (O); Kvaenangen, Slaeroidvarre *Noto s.n.* (O); Lyngen, Guolasjavre *Haglund & Kallstrom s.n.* (O); Lyngen, Guolasjavre *Jorgensen s.n.* (O); Lyngen *Haglund s.n.* (O); Malselv, Rubben *Engelskjon s.n.* (O); Malselv, Alappen *Landmark s.n.* (O); Malselv, Alappen *Resvoll-Holmsen s.n.* (O); Nordreisa, Balgesoaive *Fridtz 20391* (O); Nordreisa, Venevarre *Fridtz 20390* (O); Nordreisa, Venevarre *Jorgensen s.n.* (O); Nordreisa, Roggilnjunne *Fridtz 20389* (O); Nordreisa, Gaetkotoaive *Fridtz 20392* (O); Nordreisa, Getkosoaive *Mejland s.n.* (O); Nordreisa, Jertafjeld *Jorgensen s.n.* (O); Nordreisa, Nieidavuobme *Jorgensen s.n.* (O); Nordreisa, Gakkovarre *Mejland s.n.* (O); Nordreisa, Javroaive *Mejland s.n.* (O); Nordreisa, Caravarre *Mejland s.n.* (O); Nordreisa, Vuoddavarre *Mejland s.n.* (O); Nordreisa, Fossen *Mejland s.n.* (O); Nordreisa, Balgesoaive *Fridtz s.n.* (O); Nordreisa, Balgesoaive *Mejland s.n.* (O); Nordreisa, Batfjell

Jorgensen s.n. (O); Nordreisa, Awko *Mejland s.n.* (O); Overbygd, Njunnesvarre *Engelskjon & Thoresen s.n.* (O); Overbygd, Beinelvdal *Engelskjon s.n.* (O); Overbygd *Benum s.n.* (O); Overbygd, Langfjell *Engelskjon s.n.* (O); Overbygd, Garanasgaisa *Benum 250* (O); Skjervoy, Fattavarre *Fridtz 20393* (O); Skjervoy, Fattavarre *Mejland s.n.* (O); Skjervoy, Oksfjorddal, Lohtana *Mejland s.n.* (O); Storfjord, Rieppecakka *Engelskjon s.n.* (O); Storfjord, Rieppegaisi *Engelskjon s.n.* (O); Tromsoysund, Floyfjell *Landmark s.n.* (O); Tromsoysund, Floyfjell *Bleyht s.n.* (O); Tromsoysund, Tromsdalstind *Blytt s.n.* (O).

SPITSBERGEN: Colbay *Resvoll-Dieset s.n.* (C,O); Bellsund, Van Mijenfjorden *Lynge s.n.* (O); Eckmannssfjellet *Mikaelsen s.n.* (O); S. Sorbreen, Wijdefjorden, W. Ny Friesland *Spicer s.n.* (O); Bellsund *Lid 21* (O); Entrance to Littledalen, E. Kaldbukta, Van Mijenfjorden *Halliday H540* (C,O); Purpurdalen(?) *Hoeg s.n.* (O); Cross Bay *Dupray s.n.* (O); Cape Thordsen *Nathosson s.n.* (O); Colbay *Resvoll-Holmsen s.n.* (O); Adrentdalen(?) *Hadoc 425* (O); Lomfjorden, Lomfjordbotnen *Scholander s.n.* (O); N. Andredalen, W. Wijdefjorden *Neilson 1015* (C); Advent Bay, Armikadalen *Lid s.n.* (C).

SWEDEN: Lake Tornetrask, Mt. Luopakte *Alm 2128* (RM); Lake Tornetrask, Nissonreppejokk R. *Alm 1555* (ALA,C,O); Jukkasjarvi, Nissontjarro, Nissonreppejokk R. *Alm 482* (RM); Abisko *Einarsson s.n.* (ICEL); Jokkmokks *Bjorkman s.n.* (ICEL); Karesuando, Peldsavagge *Smith s.n.* (O); Karesuando, Peldsavagge *Alm & Tengwall s.n.* (C).

U.S.A., Alaska: South Ogotoruk Creek *Packer 2113* (ALTA); Crowbill Ridge, Ogotoruk Creek *Packer 2351* (ALTA); Prudhoe Bay, 158 miles northnorthwest Arctic Village *Hettinger 456* (ALTA); Camp 3, Meade River *Geist s.n.* (ALA); Ikpikpuk River Basin, Camp VII *Geist s.n.* (ALA); 2 miles below Meade River Village *Geist s.n.* (ALA); Candle Quad., Buckland River drainage *Lipkin 80-121* (ALA); Arctic Natl. Wildlife Range, Ikiakpaurak Valley, tributary of Cache Creek *Murray 3324* (ALA); Yukon River at Texas Creek *Dean 42* (ALA); Shainin Lake *Johnson s.n.* (ALA); Old John Lake area *Shetler 1058-AF* (ALA); Between Iteriak and Otuk Creeks, vicinity of Lisburne Test Well *Murray 6838* (ALA); Camp 3, Meade River *Geist s.n.* (ALA); Kikitaliorak Lake, Noatak River *Young 4654* (ALA); Kathul Mtn. *Batten & Dawe 78-345* (ALA); 21 miles Chena Hot Springs Road *Lotspeich s.n.* (ALA); Mt. McKinley Park *Frohne 54-237* (ALA); Arctic Quad. *Wetzel 13* (ALA); Haul Road, Coldfoot Camp area 15 km south Cathedra; Mtn. *Foote 3453* (ALA); Mile 114 Taylor Hwy. 1.6 km north O'Brien Creek *Khokhryakov, Yurtsev & Murray 6388* (ALA); Porcupine River *Howenstein & Borron 15,131* (ALA); Bonanza Ridge, Wrangall Mtns. *Sc[illegible]nilt & Nordell 90* (ALA); Meade River Field Station near Atkasook *Correll 45713* (ALA); Small Lake area *Shetler 673-AF* (ALA); Fort Yukon *Maguire 26* (ALA); Mancha Creek, Arctic Natl. Wildlife Range *Maeton s.n.* (ALA); Northeast Mancha Creek *Maeton s.n.* (ALA); Wiseman *Brockman 24* (ALA); Ambresvajan Lake *A.R. & C.G. Batten 75-217* (ALA); Meade River *Argus & Chunys 5330* (SASK); Utukok River, Driftwood to Carbon Creeks *Thompson s.n.* (US); Utukok River, Driftwood Camp *Holmen s.n.* (C); Utukok River, below Driftwood Creek, 10 mi. W. Meat Mtn. *Ward 1269* (US); Sheenjek Valley *Mertie s.n.* (US); Old Crow River 40 miles above Timber Creek *Murie 35* (AKA,US); 55 miles above mouth of Dall River *Mendenhall s.n.* (US); Coal Creek Hill, Yukon River *Furston 90* (US); No Locality info. *Dall s.n.* (US); Independent Ridge *Spetzman 100* (US); Upper Yerrick Creek *Spetzman 817* (US); Fort Yukon *Schrader s.n.* (US); Fairbanks *Scammon 1667* (US); 1 mile north Okpilak Lake *Cantlon & Malcolm 58-0150* (US); Dall River, near Dall City *Mendenhall s.n.* (US); Mt. McKinley Natl. Park, roadside between Park Station and Park roadside *A. & R. Nelson 3677* (ALA,US); Mt. McKinley Natl. Park, between Park Station and 1st mile post *A. & R. Nelson 3659* (ALA,US); Jackzena River *Schrader & Hartman 51* (US); Iuland River, Valley No-To-Ask *Stoney s.n.* (US); Franklin, Fortymile district *Anderson & Gasser 7218* (ALA). Manley Hot Springs *Welsh 4371* (ALA); Mile 271 Prudhoe Bay Haul Rd. *Murray & Johnson 6418* (ALA); Spenard *Bidlake s.n.* (ALA); Mile [illegible]8 Hwy. 3, Nenana *Williams 3646* (ALA); Wickersham Dome *Batten 76-139* (ALA); Mile 1255 Alaska Hwy. *Welsh & Moore 8024* (ALA); 35 miles southwest Tok, Mile 91 Slana-Tok Hwy.. *Welsh & Moore 8065* (ALA); Mineral Lakes *Frohne 49-55* (RM); College, University ski slope *Argus 338* (ALA,RM); Richardson Hwy. *Frohne 49-221* (RM); Eagle, Mission Creek area *Khokhryakov, Yurtsev & Murray 6267* (ALA); Mt. McKinley Park *Frohn[illegible]-96a* (ALA); Northway *Rose 100* (ALA); Mile 50 Taylor Hwy. *Nava 54* (ALA); 6 Bl[illegible]e Avenue, Fairbanks *Nava 46* (ALA); Mile 45 Steese Hwy. *Kessel 14*

(ALA); Porcupine River, 170 miles from mouth *Murie 15* (ALA); Thoroughfare River *Viereck 1078* (ALA); Sheenjek River, north jnctn. with Old Woman Creek, east Lobo Lake *Kessel S-35,S-154* (ALA); University Campus *Rutledge 23* (ALA); Fairbanks Quad. *Rutledge 88,176* (ALA); Mt. Michelson Quad., Brooks Range *Batten 523* (ALA); Jnctn. College and Farmer's Loop Roads *O'Farrell 39* (ALA); 2 miles south Nenana, Nenana River *Harms 3699* (ALA); Mile 141 Steese Hwy. *Harms 6177* (ALA); 3 miles south Central, Circle Hot Springs *Harms 6249* (ALA); University Campus *Maguire LOF-1-1* (ALA); West University Campus *Harms 2703* (ALA,C); Mile 125 Steese Hwy. *Harms 6211* (ALA); Mile 6 Circle Hot Springs Rd. *Harms 2761* (ALA,C); 1 mile south Arctic Village, east fork Chandalar River *Harms 3780* (ALA); Mile 64.2 Taylor Hwy., west Chicken *Harms 3043* (ALA); Fort Yukon *Harms 3754* (ALA); Lake Peters *Batten 440* (ALA); Tulugak Pingo, Mission Lowland *Young 4193* (ALA); Mile 64.4 Taylor Hwy., Mosquito Fork River *Khokhryakov, Yurtsev & Murray 6409* (ALA); Fairbanks Quad., Ester Dome *Freer s.n.* (ALA); Fairbanks Quad., 4.5 miles Farmer's Loop *Robus 15* (ALA); Lignite *Kelso 84-63* (ALA); Kantishna River, 40 miles from mouth *Viereck 7282* (ALA); Alaska Hwy. near Tok *Viereck 7985* (ALA); Big Lake, Fish Hook Creek *Shetler 324-AF* (ALA); Wiseman *Johnson s.n.* (ALA); 10 mi. S.W. Livengood *J. & C. Taylor 19294* (NY); Boundary *Dudynsky 7807* (ALTA); Km 79 Taylor Hwy. *Dudynsky 7808* (ALTA); Mile 1307-1309 Alaska Hwy. *Dudynsky 7810* (ALTA); Mile 1366 Alaska Hwy. *Dudynsky 7811* (ALTA); Mt. McKinley Park, 150 yds. west Hotel *Booth 13* (ALA).

U.S.S.R.: S. Novay Zemlya, Matochkin Shar *Kasansky 112* (C); Novay Zemlya *Lynge s.n.* (C,O); Turuchansk District *Awramemok 3620* (C); No Locality Information (Ref. No. Q-46-12) *Vodoplanova & Ivanov 2524* (ALTA); S. Novaya Zemlya, Matochkin Shar, Gubin Bay *Kasansky s.n.* (C); Taimyrland, Jamu-Tarida *Tolmatchew 272* (C); Chukotsky Peninsula, R. Chegitun *Sekretareva, Yurtsev & Sitin s.n.* (ALTA); Chukotsky Peninsula, E. of R. Chegitun *Sekretareva, Yurtsev & Sitin s.n.* (ALTA); Yakutskaya *Michelova s.n.* (ALTA); W. Chukotsky, Yanuyskoye, R. Boginden *Koroyeva & Petrovsky s.n.* (ALTA); Yakutskaya, between Leni and Kuramis Rivers *Norin, Petrovsky & Schtepa s.n.* (ALTA); Yakutskaya, R. Shangrin *Korobkov & Kulshina s.n.* (ALTA); Chukotsky Peninsula, Anadirskiy, R. Bolshoy Osinovoy near Lake Baranyevo *Korobkov & Sekretareva s.n.* (ALTA); Chukotsky Peninsula, Anadirskiy *Afonina, Korobkov & Razhiivin s.n.* (ALTA); Yakutskaya, R. Shangrin *Korobkov & Kulshina s.n.* (ALTA); Vorkimi *Tolmatchew s.n.* (O); Sibiria orientalis, Channagh Berg. *Bunge s.n.* (C).

Scoggan (1979) has retained the epithet var. *linearis* Hultén for plants belonging to subsp. *attenuata* having linear basal leaves, a character prevalent throughout the *A. angustifolia* aggregate. Ediger and Barkley (1978) had previously placed this name under synonymy with subsp. *attenuata*. Material is typical of *A. angustifolia* subsp. *angustifolia*. Since the range of *A. angustifolia* subsp. *tomentosa* does not extend into Alaska, Hultén has described plants which are covered in a grayish pubescence as var. *vestita*. Scoggan (1979) has questionably assigned these plants to *A. angustifolia* subsp. *tomentosa*, and Ediger and Barkley (1978) have placed this name in synonymy with subsp. *attenuata*. Until more specimens which have been annotated by Hultén as var. *vestita* can be seen, this taxon should remain in *A. angustifolia* subsp. *angustifolia*.

Arnica lowii and *A. terrae-novae* appear to be inseparable from typical *A. angustifolia* subsp. *angustifolia* (Maguire 1943). Although the type material of *A. sornborgeri* var. *ungavensis* Boivin was not seen, specimens determined by Boivin as var. *ungavensis* (*Calder 227*, *Rousseau 1183*) are similar to *A. angustifolia* subsp. *angustifolia*.

Plants described or annotated as *A. plantaginea* are few, for less than twenty-five collections are available. With the exception of oblanceolate involucral bracts, Maguire (1943) has described this taxon to be very similar to eastern Canadian *A. angustifolia* subsp. *angustifolia*. However, oblanceolate bracts are not unique to this species and can be found in *A. angustifolia*. In this study, specimens identified as *A. plantaginea* were found to be indistinguishable from *A. angustifolia* subsp. *angustifolia*.

6b. **Arnica angustifolia** subsp. **tomentosa** (Macoun) G.W. Dougl. & G. Ruyle-Dougl., Can. J. Bot. 56:1710. 1978. *A. tomentosa* Macoun, Ottawa Nat. 13:166. 1899. *A. alpina* subsp. *tomentosa* (Macoun) Maguire, Madrono 6:153. 1942. *A. alpina* var. *tomentosa* (Macoun) Cronquist, Vas. Pl. Pac. N. W. 5:46. 1955. TYPE: "Sheep Mountain, Waterton Lake, Rocky Mts., July 31, 1895. *J. Macoun 11606*". (HOLOTYPE CAN!, PHOTO CAN!). Figure 31. Generalized illustration Figure 32.

A. pulchella Fernald, Rhodora 27:18. 1915. TYPE: "Table Mountain. Region of Port au Port Bay, Newfoundland. July 16 and 17, 1914 *M.L. Fernald & H. St. John 10874*". (HOLOTYPE GH, PHOTO CAN!, ISOTYPE CAN!, PHOTO CAN!)

A. tomentosa Macoun ex Greene, Pittonia 4:168, 1900. TYPE: "Mountains near Athabasca River near Lac Brule, Rocky Mts. June 20, 1898. *W. Spreadborough 19635*". (ISOTYPE CAN!, PHOTO CAN!)

Plants 0.8 to 2.0 (rarely 3.0) dm high; *lower cauline leaves* 3.5 to 10.5 cm long, 0.3 to 1.2 cm broad, narrowly lanceolate, apex acute, margins entire to rarely denticulate, petioles broad-winged and short, the leaves densely spreading woolly-villous; *capitula* solitary (rarely 3); *ligulate florets* 7 to 12, 14.5 to 30.0 mm

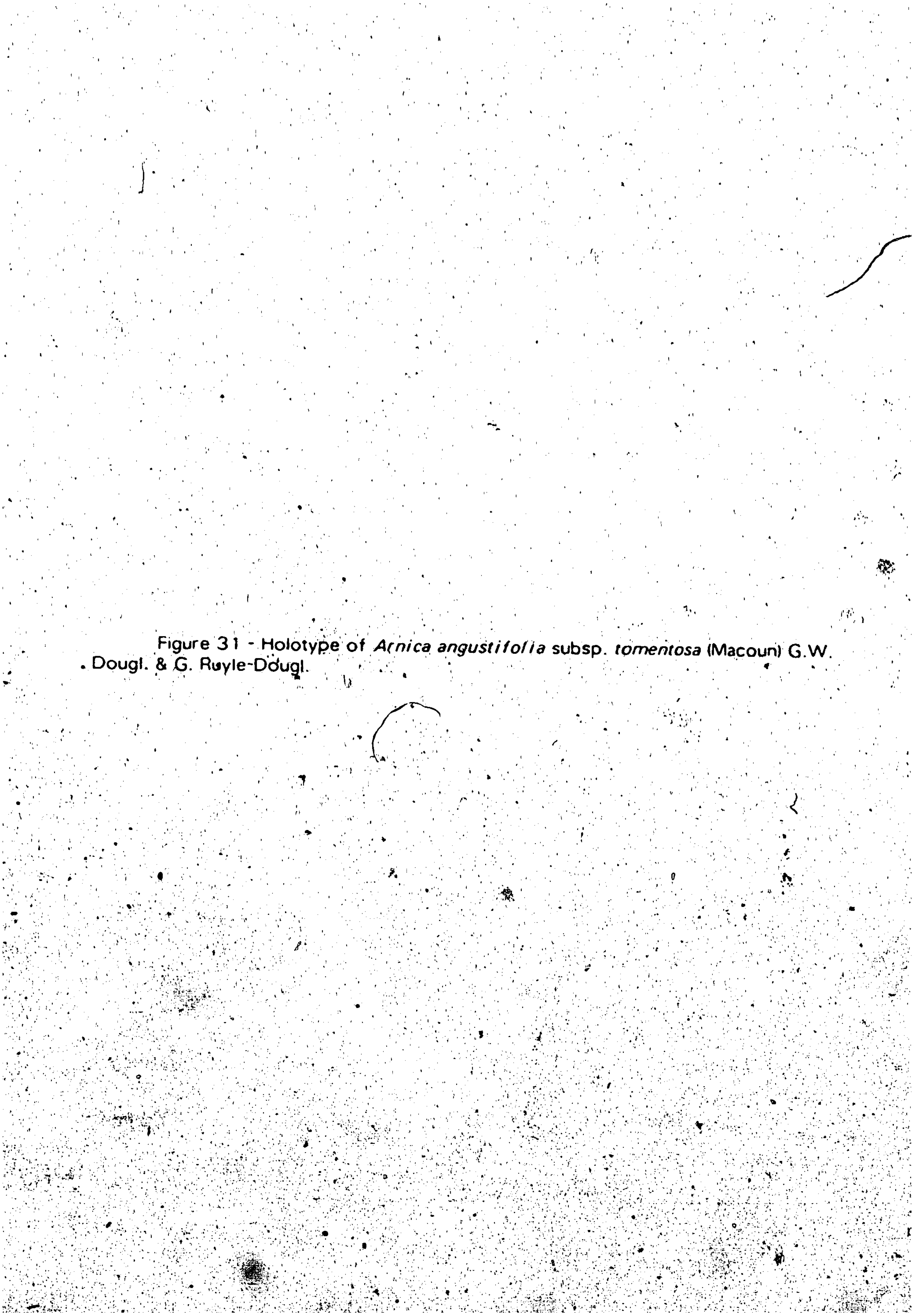
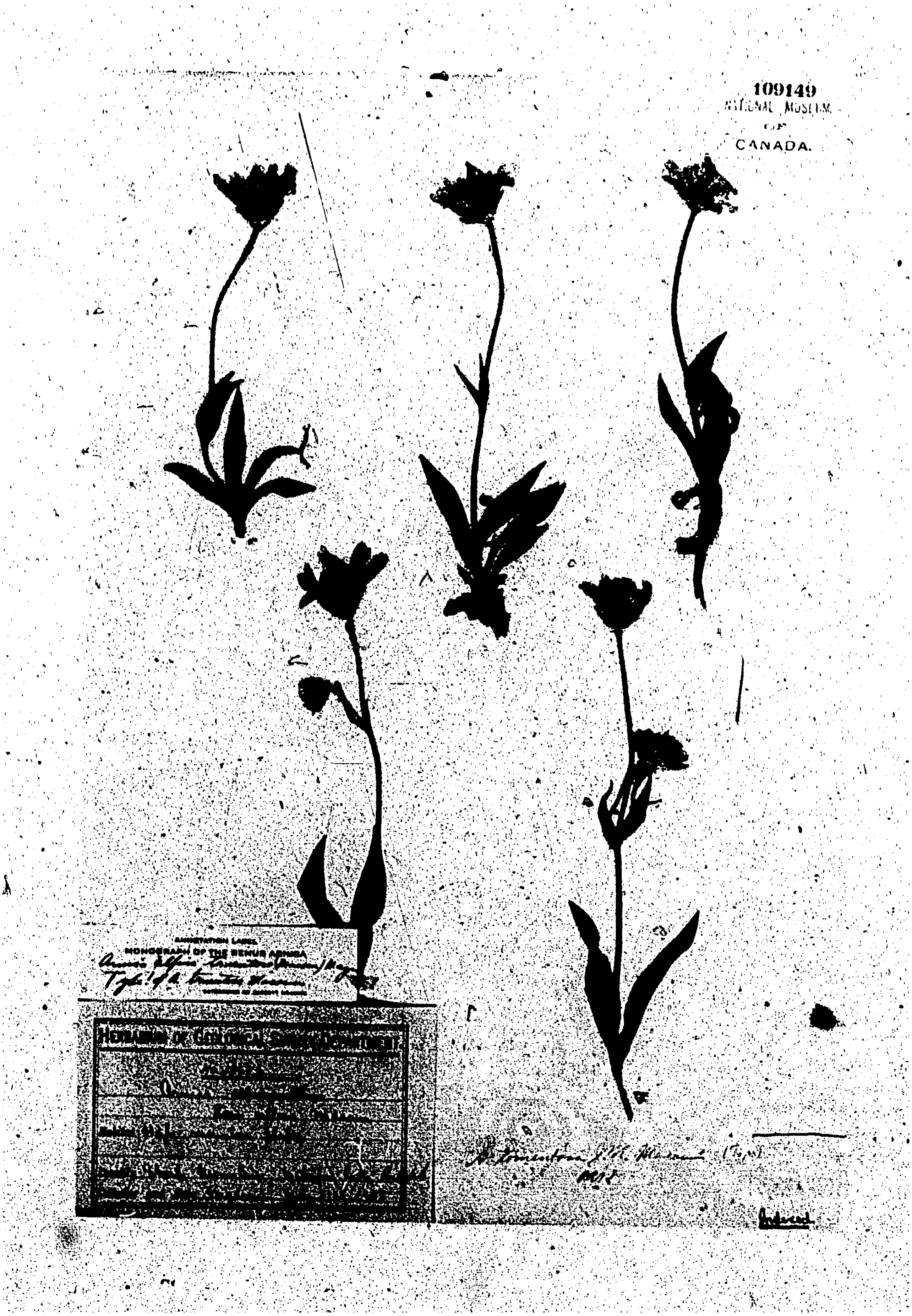


Figure 31 - Holotype of *Arnica angustifolia* subsp. *tomentosa* (Macoun) G.W. Dougl. & G. Ruyle-Dougl.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MONOGRAPH OF THE GENUS ARNICA

Figure 32 - Generalized illustration of *Arnica angustifolia* ssp. *tomentosa* (based on *Downie 620* [ALTA]).

long, the lobes 0.5 to 3.5 mm long; *periclinium* densely pilose and densely stipitate-glandular: *achenes* 4.5 to 7.6 mm long; chromosome number 2n=57 and 76.

DISTRIBUTION AND HABITAT: Infrequent in the Mackenzie delta region becoming more common southward in the Rocky Mountains of Alberta, British Columbia and Montana. Plants of bare rocky alpine slopes and subalpine meadows. Disjunct populations infrequent in exposed rocky areas and dry limestone barrens of northwestern Newfoundland. Figure 33.

REPRESENTATIVE SPECIMENS: **CANADA, Alberta:** Eagles Nest Creek area, Wilderness Park *Pegg 1725* (ALTA); Snow Creek Pass, Banff Park *Porsild 21435* (CAN); Southwest slope Bare Mtn., Panther River, Banff Park *Porsild & Breitung 16261* (CAN); Mt. Carthew, Waterton Lakes Park *Breitung 16703* (ALTA); Cadomin *Moss 10328* (ALTA,CAN); Vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13606* (CAN); Snow Creek Pass, Cascade Valley, Banff Park *Porsild 21369* (CAN); Snow Creek Pass *Porsild 22625* (CAN); Citadel Mtn., Vicinity of Sunshine Ski Lodge *Porsild & Breitung 15968* (CAN); Tie Creek, Brazeau Natl. Forest *Porsild 20787* (CAN); Baldy Mtn., Clearwater Forest Reserve *Porsild 20588* (CAN); Mtn. west Highwood Pass Rd., 7 miles north Coleman *Porsild & Lid 19393* (CAN); Wind Mtn., Rocky Mtn. Forest Reserve *Porsild & Lid 19313* (CAN); Citadel Mtn., Vicinity of Sunshine Ski Lodge *Porsild & Lid 19573* (CAN); Fitzhugh Mtn., Jasper Park *Macoun 96015* (CAN); Goat Mtn., Jasper Park *Macoun 96014* (CAN); Shovel Pass, Jasper Park *Kindle 93493* (CAN); Wart Mtn. *Malte & Watson 22064* (CAN); Mt. Coliseum, Nordegg *Malte & Watson 1486* (CAN,RM); Crow's Nest Pass *Dawson 14707* (CAN); Porcupine Hills, north Cowley *Malte & Watson 607* (CAN); Wart Mtn. *Malte & Watson 2287* (CAN); Between Sheep Creek and Lake MacBrien, Continental Divide *Lambert 372* (CAN); Mt. Whistler, Jasper Park *Laing 373* (CAN); Shovel Pass, Jasper Park *Macoun 96013* (CAN); Vicinity of Sunshine Ski Lodge *Porsild & Breitung 13640* (CAN); Moose Mtn., near source of Elbow *Macoun 22826* (CAN); Quartz Ridge, vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 14182* (CAN); Cairn Mtn., vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13668* (CAN); Headwaters of North Saskatchewan River, mile 114 Banff-Jasper Hwy., Banff Park *Porsild & Breitung 14574* (CAN); Citadel Peak, vicinity of Sunshine Ski Lodge *Porsild & Breitung 14012* (CAN); Citadel Peak, vicinity of Sunshine Ski Lodge *Porsild & Breitung 14244* (CAN); Mountain Park *Packer 3063* (ALTA); 2.5 km west Mt. Indefatigable, Kananaskis Park *Kondla 1840* (ALTA); Mt. Allan *Carroll 497* (ALTA); Mountain Park *Russell s.n.* (ALTA); Plateau Mtn., southwest of High River *Ringius 1382* (ALTA); 0.5 km north Signal Mtn. summit, Jasper Park *Lee & Peterson s.n.* (ALTA); Ram Mtn., west of Rocky Mtn. House *Dumais 7504* (ALTA); Prospect Mtn., 10 miles southwest Cadomin *Mortimer 597* (ALTA); Snow Creek Pass, 40 miles northnortheast Banff *Moss 12673* (ALTA); North Kootenay Mtn. *Packer & Silberhorn 197139* (ALTA); Cameron-Alderson trail, Waterton Lakes Park *Kuchar 2802* (ALTA); Upper Rowe Lakes, Waterton Lakes Park *Packer 4187a* (ALTA); Snow Creek Pass, 40 miles northnortheast Banff *Moss 12672* (ALTA); Halfway House, Banff Park *Dudynsky 7836* (ALTA); Columbia Icefields, Jasper Park *Dudynsky 7828* (ALTA); Mt. Fairview, Lake Louise, Banff Park *Dudynsky 7838* (ALTA); Mountain Park *Forbes 771133A* (ALTA); Opal Hills, Maligne Lake, Jasper Park *Dudynsky 7842* (ALTA); Opal Hills, Maligne Lake, Jasper Park *Forbes 771100* (ALTA); Opal Hills, Maligne Lake, Jasper Park *Dudynsky 7852* (ALTA); Opal Hills, Maligne Lake, Jasper Park *Dudynsky 7844* (ALTA); Signal Mtn., Jasper Park *Hurlon 176* (UBC); Near Banff *Macoun s.n.* (Q); Banff *Macoun s.n.* (C).
British Columbia: Mt. McLean, near Lillooet *Macoun 96011* (CAN); Muncho Lake *Beamish, Krause & Luitjens* (CAN); Mt. Selwyn *Raup & Abbe 3939* (CAN,MT); Stewart's Mtn. *Macoun 14709* (CAN); Dash Plateau *Selby s.n.* (UBC); Overlooking Nine Mile Creek *Bell s.n.* (UBC); Akamina Ridge, adjacent to Waterton Lakes Park *Taylor, Calder &*

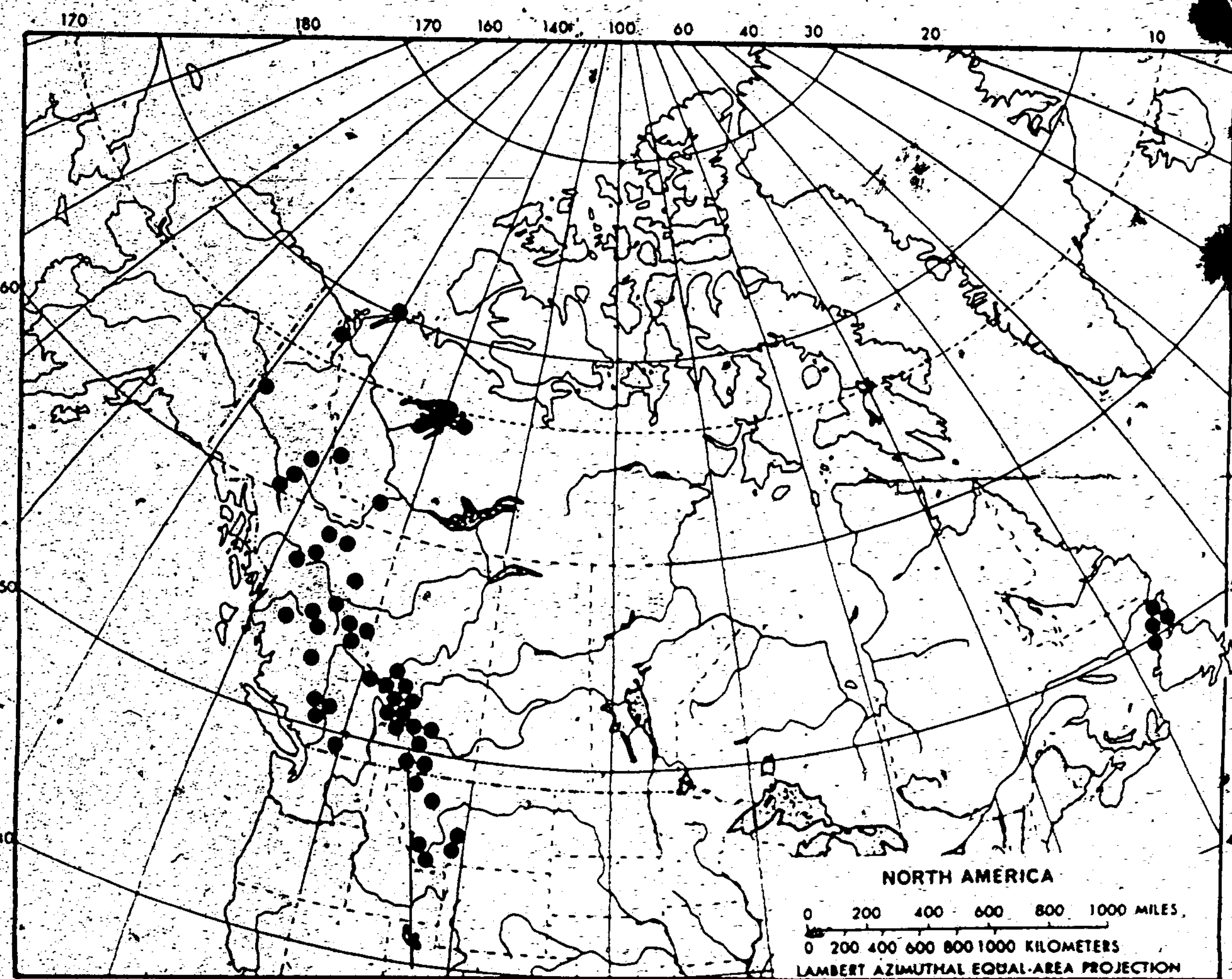

Figure 33 - Distribution of *Arnica angustifolia* subsp. *tomentosa*.

Ferguson 3556 (ALA); Mile 458 Alaska Hwy., Muncho Lake Park *Calder & Gillett 25364* (ALA).
Newfoundland: Pointe Riche Peninsula, St. Barbe South district *Hay & Bouchard 74032* (CAN,MT); St. Pauls Inlet, Sandy Barren, St. Barbe South district *Hay & Bouchard 74033* (CAN,MT); Eastern Point, St. John Bay *Fernald, Long & Fogg 2129* (MT,NY); Old Port Au Choix, St. John Bay *Fernald, Long & Fogg 2127* (C,MT,NY); Old Port Au Choix, St. Barbe district *Penson s.n.* (MT); Old Port Au Choix, St. John Bay *Fernald, Long & Fogg 2128* (C,MT).
Northwest Territories: Red Mtn., vicinity of Brintnell Lake *Raup & Soper 9730* (ALA,ALTA,RM); Cape McDonnel, Great Bear Lake *A.E. & R.T. Porsild 5162A* (CAN); Richardson Mtns. *Porsild 6728* (CAN); Liard River between Nahanni Butte and Simpson *Crickmay 113* (CAN); Atkinson Point, Arctic Coast *A.E. & R.T. Porsild 2670* (CAN).
Yukon: Canol Rd., pass between Teslin and Nisutlin Rivers *Porsild & Breitung 11053* (CAN); 2 miles Carcross Rd. *Lortie GML-11* (ALA); Mile 1105 Alaska Hwy. *Williams 894* (ALA); Dawson Quad. *Odsather 254* (ALA).

U.S.A., Montana: BEAVERHEAD CO.: Pioneer Mtns. *Hitchcock & Muhlick 12965* (MONT,NY,RM); Wisdom, summit of Saddle Mtn. *Booth s.n.* (MONT); GALLATIN CO.: Bridger Mts., north Sacajawea area *Forcella 69300* (MONT); Bridger Mts., Frazier Lake, east of Hardscrabble Peak *Forcella 69299* (MONT); GLACIER NATIONAL PARK: Piegan Pass *Nelson 1092* (RM); TETON CO.: East Front Mtns., Choteau Mtn. *Lackschewitz 4436* (NY).

While observing material of *A. angustifolia* subsp. *tomentosa* from Newfoundland, and noting very little difference between this taxon and *A. pulchella*, Fernald (1933) subsequently placed *A. pulchella* under synonymy with the former. *Arnica pulchella* is typical of *A. angustifolia* subsp. *tomentosa*.

Greene (1900) has also taken up the name *A. tomentōsa* but has attributed it to Macoun in herb. This specimen is listed with Macoun's original description of the taxon and should be treated as a paratype.

7. **Arnica lonchophylla**, Pittonia 4: 164. 1900.

Stems simple or branched, glabrous to sparsely puberulent and moderately stipitate-glandular, becoming densely pubescent and glandular upwards; *upper cauline leaves* sessile and reduced; *lower cauline leaves* acute, evidently petiolate, the petiole slender-winged and approximately equalling the blade, stipitate-glandular; *capitula* erect, campanulate-turbinate; *involucral bracts* narrowly lanceolate, apex acute; *ligulate florets* yellow, 3-toothed; *achenes* densely hirsute throughout.

Arnica lonchophylla is an extremely variable species, especially in the northern part of its range where it tends to resemble *A. angustifolia* subsp. *angustifolia*.

Douglas and Ruyle-Douglas (1978) have recognized the similarity between this taxon and *A. angustifolia* and have treated it as *A. angustifolia* subsp. *lonchophylla*. However, in the southern and eastern portions of its range, *A. lonchophylla* is quite distinct and can be recognized by its regularly dentate or denticulate long-petioled basal leaves and its campanulate-turbinate capitula. *Arnica lonchophylla* is also a plant of montane or lowland habitats, whereas *A. angustifolia* is arctic and alpine.

In his monographic treatment of the genus, Maguire (1943) recognized three infraspecific taxa within *A. lonchophylla*: subspecies *genuina*, *chionopappa* and *arnoglossa*. The subspecific epithet *genuina* is illegitimate and should be treated as *lonchophylla*. Ediger and Barkley (1978), however, have not recognized any infraspecific taxa within *A. lonchophylla* and maintain that the small differences among these taxa are not enough to warrant taxonomic segregation. Material from eastern Canada, previously recognized as subsp. *chionopappa*, is inseparable from widespread northwestern Canadian populations. Based on publication priority, *A. lonchophylla* in Canada is treated as *A. lonchophylla* subsp. *lonchophylla*, and not *A. chionopappa* as previously suggested by Fernald (1933). Two infraspecific taxa are recognized within *A. lonchophylla*: *A. lonchophylla* subsp. *lonchophylla*, and *A. lonchophylla* subsp. *arnoglossa*. The morphological characters delimiting these taxa are described below.

KEY TO SUBSPECIES OF *ARNICA LONCHOPHYLLA*

Leaves narrowly lanceolate to ovate, 3 to 11 times as long as wide, moderately pilose, sparsely glandular; disc corolla goblet-shaped, densely long pilose, sparsely glandular; periclinium and involucral bracts moderately pilose and glandular .... subsp. *lonchophylla*

Leaves broadly lanceolate to ovate, 3 to 5 times as long as wide, glabrous to sparsely puberulent; uniformly short-stipitate glandular; disc corolla narrowly goblet-shaped, scarcely short pilose, densely glandular; periclinium and involucral bracts glabrous to sparsely puberulent, densely stipitate-glandular .... subsp. *arnoglossa*

7a. **Arnica lonchophylla** Greene subsp. **lonchophylla**, Pittonia 4:164, 1900. *A. lonchophylla* subsp. *genuina* Maguire, Brittonia 4:430, 1943. *A. alpina* var. *lonchophylla* (Greene) Welsh, Great Basin Nat. 28:149, 1968. *A. alpina* subsp. *lonchophylla* (Greene) G.W. Dougl. & G. Ruyle-Dougl. in Taylor and MacBryde, Can. J. Bot. 56:185. 1978. *A. angustifolia* subsp. *lonchophylla* (Greene) G.W. Dougl. & G. Ruyle-Dougl., Can. J. Bot. 56:1710. 1978. TYPE: "Athabasca River, Lat. 53.30, Alberta, June 25, 1898. *W. Spreadborough 19647*". (HOLOTYPE ND!, ISOTYPE CAN!, PHOTO CAN!). Figure 34. Generalized illustration Figure 35.

A. wilsonii Rydb., N. Am. Fl. 34:332. 1927. TYPE: "W. of James Bay, 140 miles up Kapiscow River, Ont. July 15, 1902. *W.J. Wilson 54043*" (HOLOTYPE CAN!)

Arnica chionopappa Fern., Rhodora 7:148. 1905. *A. lonchophylla* subsp. *chionopappa* (Fern.) Maguire, Brittonia 4:430. 1943. TYPE: "Wet cliffs, Banks of the Grand River, Gaspé County, Québec, June 30-July 3, 1904. *M.L. Fernald s.n.*". (HOLOTYPE GH!, PHOTO CAN!)

A. gaspensis Fern., Rhodora 7:148. 1905. TYPE: "Dry precipitous ledges of a hill at Cap Tourelle near St. Anne des Monts, Gaspê Co., Lower Canada. July 16, 1881. *J.A. Allen s.n.*". (HOLOTYPE GH!, PHOTO CAN!)

A. fernaldii Rydb., N. Am. Fl. 34:333. 1927. TYPE: "Newfoundland, Region of Port au Port Bay, Dry exposed ledges and shingle on the limestone tableland, Table Mountain. July 16 and 17, 1914. *M.L. Fernald & H. St. John 10875*". (HOLOTYPE NY, ISOTYPES CAN!, GH!(2 specimens), RM!)

Plants 1.2 to 5.0 dm high; *cauline leaves* 3 to 7 pairs; *lower cauline leaves* 3.5 to 14.0 cm long, 0.5 to 3.7 cm broad, narrowly to broadly lanceolate to sometimes ovate, margins denticulate to predominantly dentate, glabrous to moderately pilose, 3 to 5 nerved; *capitula* 1 to 5, occasionally 7 or 8, 7.0 to 20.0 mm broad, 8.0 to 16.0 mm high; *periclinium* moderately white pilose, stipitate-glandular; *involucral bracts* 10 to

Figure 34 - Holotype of *Arnica lonchophylla* Greene ssp. lonchophylla.

EX HERB. GEOL. SURVEY DEPT., CANADA.

No. 18,647

Arnica foliosa, Nutt.

Figure 35 - Generalized illustration of *Arnica lonchophylla* ssp. *lonchophylla* (based on *Downie 462* [ALTA]).

15, 7.0 to 11.5 mm long, 1.3 to 3.5 mm broad, pilose throughout, stipitate-glandular; ligulate florets 6 to 14, 13.0 to 26.0 mm long, 3.0 to 7.1 mm broad, the lobes 0.1 to 2.1 mm long; *disc florets* 5.1 to 9.5 mm long, goblet-shaped, densely pilose, not glandular, the tube 1.9 to 4.0 mm long; *achenes* 3.0 to 5.9 mm long; *chromosome number* 2n=57 and 76.

DISTRIBUTION AND HABITAT: Common in dry to mesic, open montane slopes of the Canadian Rockies extending northward in the interior lowlands to the Arctic Circle. Very common in the vicinity of Athabasca Lake and along the gravelly slopes of the Mackenzie, Peace, Athabasca and Churchill Rivers. Its range extends from the Yukon Territory, eastward through southwestern Northwest Territories, the northern regions of Saskatchewan and Manitoba to Hudson Bay with disjunct populations in northeastern Minnesota and adjacent Ontario. In eastern Canada, plants are found in open woodlands, river gravels, shorelines and calcareous rocky outcrops and precipices of the Gaspé Peninsula and Anticosti Island, and from dry cliffs in Sisson Gorge, the only reported locality in New Brunswick (Hinds 1983). Rare in Nova Scotia (Bouchard *et al.* 1983) having only been observed from the Cape Breton Highland region (Hinds, pers. comm.). Abundant and scattered amongst the turfy talus of limestone sea-cliffs and gravelly limestone barrens of western Newfoundland. Figure 36.

REPRESENTATIVE SPECIMENS: **CANADA. Alberta:** Shelter Point, Lake Athabaska *Raup 1411* (GH); Shelter Point, Lake Athabaska *Raup 1412* (GH); Wood Buffalo Park, 16 miles east of Moose (Eight) Lake *Raup 3376* (CAN,GH,NY); Wood Buffalo Park, along road to Salt River *Raup 3374* (CAN,GH); Rocky Mountains *Bourgeau s.n.* (GH); Near Athabaska Falls *Ostheimer s.n.* (GH); Forget-me-not Mtn., near source of the Elbow River, Rocky Mountains *Macoun 22815* (CAN,GH,NY); vicinity of Banff *Hunnewell 6273* (GH); Kananaskis *Macoun 14695* (CAN,GH); Lake Louise *Butters & Holway 191* (GH); Slave River bank, below Fort Smith *Raup 1409* (CAN); 5 miles south of Kananaskis Forest Expt. Station *Porsild & Lid 19439* (CAN); 3 miles west of Kananaskis Forest Expt. Station *Porsild & Lid 19244* (CAN); Mtn. west Highwood Pass Road, 7 miles north Coleman *Porsild & Lid 19395* (CAN); Wood Buffalo Park, Pine Lake district *Raup 3375* (CAN); Mt. Coliseum, Nordegg *Malte & Watson 1474,1475* (CAN); Cadomin *Moss 10328a* (CAN); Cadomin *Moss 10330* (CAN); Wood Buffalo Park, Government Hay Camp district *Raup 3377* (CAN); Near Pine Lake *Raup 3373* (CAN); Bowness Park, Calgary *Malte & Watson 1290* (CAN,RM); North of Morley, near Seebee *Brinkman 3456* (CAN); Mt. Coliseum, Nordegg *Malte & Watson 1542* (CAN); Brule, Athabaska River *Macoun 96067* (CAN); Fitzhugh Mtn., Jasper Park *Macoun 96074* (CAN,NY); Pyramid Mtn., Jasper Park *Porsild & Breitung 16354* (CAN); Brule *Macoun 96064* (CAN,NY); Bow River Pass *Macoun 14700* (CAN); Moose Mtn. *Macoun 72720* (CAN,NY); Banff Park, West of pass *Porsild & Breitung 14933* (CAN); Vicinity of Sunshine Ski Lodge, Banff Park *Porsild & Breitung 13603* (CAN); Citadel Mtn., Banff Park *Porsild & Breitung 15972* (CAN); Head of Devil's Lake *Macoun 14723* (CAN); Mt. Shunda, Clearwater Forest Reserve *Porsild 20719* (CAN);

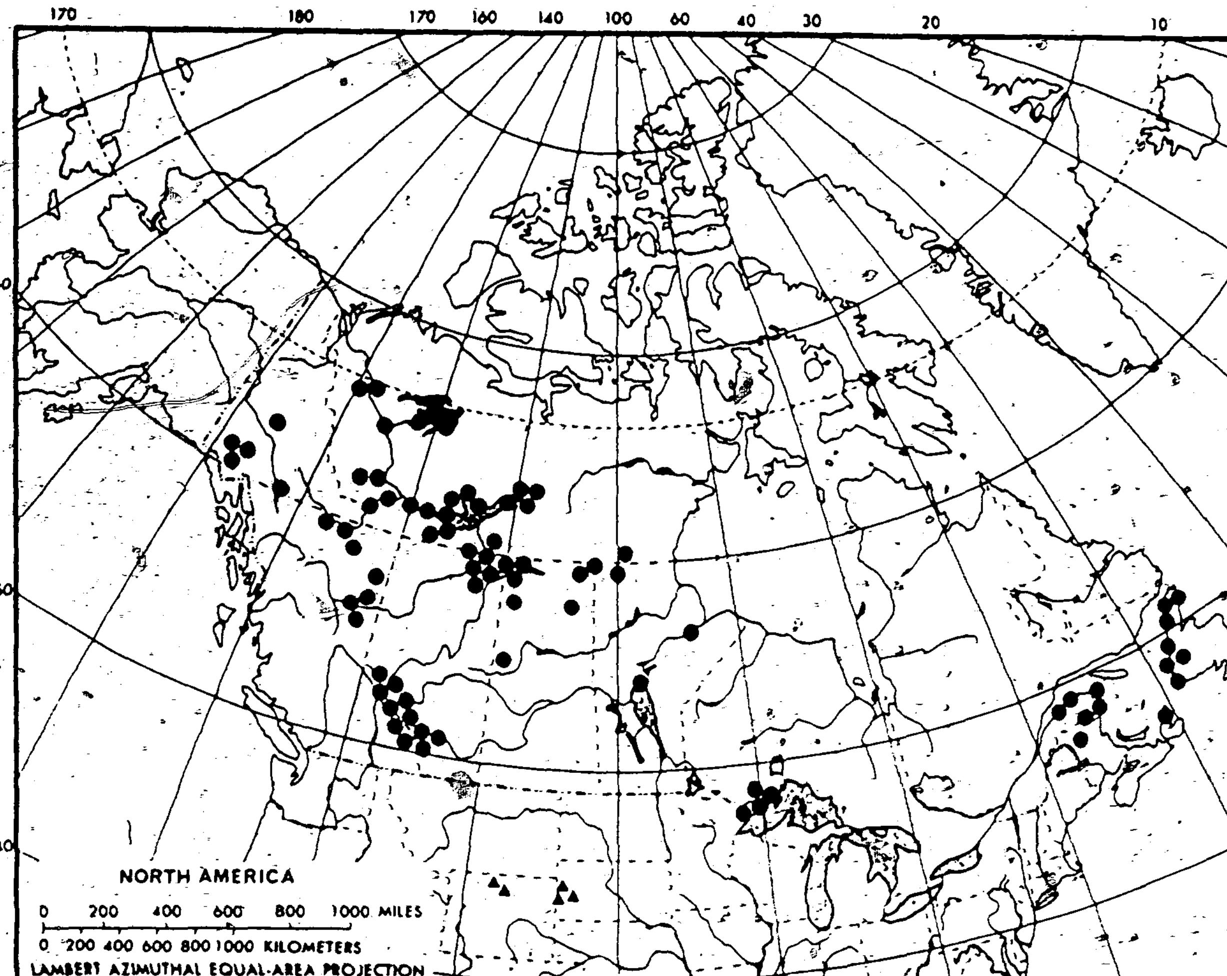

Figure 36 - Distribution of *Arnica lonchophylla* subsp. *lonchophylla* (●) and *A. lonchophylla* subsp. *arnoglossa* (▲).

Vicinity of Talbot Lake, Jasper Park *Porsild 22367* (CAN); North spur of Panther Mtn., Banff Park *Porsild & Breitung 16281* (CAN); North spur of Panther Mtn., Banff Park *Porsild & Breitung 16282* (CAN); East slope of Mt. Patterson, Banff Park *Porsild & Breitung 16163* (CAN); Spray River valley, Banff Park *Porsild & Breitung 12378* (CAN); Tie Creek, Brazeau National Forest *Porsild 20786* (CAN); Baldy Mtn., Clearwater Forest Reserve *Porsild 20643* (CAN); Wart Mtn., Mountain Park *Malte & Watson 2306* (CAN); "Miner's Roof", Mountain Park *Malte & Watson 1966* (CAN); Mt. Coliseum, Mountain Park *Malte & Watson 2057* (CAN); "Miner's Roof", Mountain Park *Malte & Watson 1993* (CAN); "Miner's Roof", Mountain Park *Malte & Watson 2032* (CAN); Lake Chiniki, Stoney Indian Reservation *McCalla 10533* (ALTA); Shunda Creek, Clearwater Forest Reserve *Cormack 722* (ALTA); East of DeWinton *Brethour s.n.* (ALTA); Bank of Athabaska River and Falls *Turner 5109* (ALTA); Northeast Peace-Athabasca delta, Revillon Coupe *Doherty 265a* (ALTA); Junction of Spray R. and Bow R., Banff Park *McCalla 6658* (ALTA); 2 km southeast of Cadomin *Russell s.n.* (ALTA); 2 km southeast of Cadomin *Russell s.n.* (ALTA); Northeast Peace-Athabasca delta, Revillon Coupe *Doherty 265* (ALTA); Cadomin *Moss 10330* (ALTA); 16 miles northwest of Calgary *McCalla 1227b* (ALTA); Lake Chiniki, Stoney Indian Reserve *McCalla 10533* (UBC); Elbow River valley, vicinity of Calgary *Moodie 1059* (NY); Elbow River *Macoun 22818* (NY); Lake Louise, Banff Park *Macoun 65524* (NY); Banff *Murray s.n.* (SASK); Between Little Lake and Lake Athabasca *Whitehorn 350* (SASK); Jackfish Creek, East Richardson's Lake *Whitehorn & Barber 187* (SASK); Kananaskis Lakes area, Streeter and Marmot Creek Basins *Badny s.n.* (SASK); 13 miles north Ft. Fitzgerald *Cody & Loan 4085* (NY,RM); Along Miette Rd. near mile 9 *McCalla 7086* (UBC).

British Columbia: Muncho Lake *Rand 2* (CAN); Wicked River near Peace River *Raup & Abbe 3869* (GH); Mt. Selwyn *Raup & Abbe 3966* (GH); Mile 385 Alaska Hwy., near Tetsa River *Jackson s.n.* (UBC); Nevis Creek *Luckhurst s.n.* (UBC); Radium Hot Springs *Eastham s.n.* (UBC); Kicking Horse Valley, vicinity of Field *Brown 298* (NY); Summit Lake, Cassiar district *Straley 78465* (UBC).

Manitoba: W. Great Island, Seal River area *Ritchie 1879* (CAN); Mouth of Little Churchill River *Cairnes 89677* (CAN); Hayes River, 110 miles southwest of York Factory *Scoggan 5698* (CAN); Hayes River, near Berwick Falls *Scoggan 5649* (CAN); Hayes River, 100 miles southwest of York Factory *Scoggan 5805* (CAN,GH); Nueltin Lake, Thlewiaza River *Baldwin 2275* (CAN,GH); Cross Lake, 45 miles north of Lake Winnipeg *Scoggan 3429* (ALTA,CAN).

New Brunswick: Sisson Gorge *Hay 72* (GH).

Newfoundland: Burnt Cape, White Bay *Tuomikoski 214* (CAN); Tuckers Head St. Barbe South District *Bouchard & Hay 73112* (CAN); Portland Head, St. Barbe South District *Hay & Bouchard 74029* (CAN); Eastern Point, St. John Bay *Fernald, Long & Fogg 2136* (GH,MT); Pointe Riche, between St. John Bay and Ingornachoix Bay *Fernald, Long & Fogg 2135* (GH,MT,NY); Old Port Au Choix, St. John Bay *Fernald, Long & Fogg 2133* (GH,MT,NY); Table Mtn., 2nd dome *Mackenzie & Griscom 10477* (GH); Druid's (or Raglan) Head, Middle Arm, Bay of Islands *Fernald, Long & Fogg 2132* (GH,MT,NY); Crow's Head, St. John Bay *Fernald, Long & Fogg 2134* (GH,MT); Burnt Cape, Pistolet Bay *Fernald et al. 29209112* (GH); Shag Cliff, Bonne Bay *Fernald, Long & Fogg 2137* (GH,MT); Green Gardens, Cape St. George *Mackenzie & Griscom 11030* (GH,NY); Stanleyville, Bonne Bay *Fernald, Long & Fogg 2138* (GH); West Big Barachois, Middle Arm, Bay of Islands *Fernald, Long & Fogg 2130* (GH,MT); Penguin Head, Middle Arm, Bay of Islands *Fernald, Long & Fogg 2131* (GH,MT); Goose Arm, Blue Cliff *Rouleau 2989* (CAN,MT,NY,RM); St. John Island, St. John Bay *Fernald et al. 29211* (GH); Bard Harbor Hill, Highlands of St. John *Fernald & Long 29212* (GH); Goose Arm, William Wheller Point *Rouleau 177* (MT); Tucker's Head, Bonne Bay *Rouleau 3365* (MT); Old Port Au Choix, St. Barbe District *Penson s.n.* (MT,US); Penguin Arm, Deep Cove *Rouleau 981* (MT); Doctor's Hill, Highlands of St. John *Tuomikoski 343* (MT); Port Au Port, Table Mtn. *Rouleau 3746* (MT); Northwest Englee, Canada Bay, between Bide Head and Handy Harbour *Rouleau 4653* (MT); 2 miles north Gargamelle on Route 73 *Rouleau 8225* (MT); Wigwam Pond, 8 miles north Goose Arm Road *Rouleau & Rast 10166* (MT); Beachy Point, Bonne Bay, St. Barbe District *Rouleau 3340* (MT); Fire Tower Mtn., Little Bonne Bay pond, St. Barbe District *Rouleau 3809* (MT); Corner Brook Gorge, Humber District *Rouleau 3546* (MT); Port Au Choix Peninsula, St. Barbe South District *Hay & Bouchard 74026* (CAN,MT); Portland Head, St. Barbe South District *Hay & Bouchard 74027* (CAN,MT); Deer Cove, Bateau Barrens, St. Barbe South District *Hay & Bouchard 74030* (CAN,MT); St. Pauls Inlet, Sandy Barren, St. Barbe South District *Hay & Bouchard 74028* (CAN,MT).

Northwest Territories: Good Hope *Dutilly 38* (GH); Fairchild Point, Great Slave Lake *Raup 1407* (GH); Fairchild Point, Great Slave Lake *Raup 1410* (GH); Liard Range, 15 miles northwest of Fort Liard *Jeffrey 423* (CAN); Northwest shore Great Bear Lake between Jones Point and Fort Rae *Bedford s.n.* (CAN); Mile 16 Enterprise-Mackenzie River Hwy. *Thieret & Reich 4873* (CAN,NY); Bear Rock, Fort Norman *Hume 103416* (CAN); Liard River between Nahanni Butte and Simpson *Crickmay 112* (CAN); Nahanni Mtn. *Wynne-Edwards 8523* (CAN); Nahanni Mtn. *Wynne-Edwards 8524* (CAN); Lone Mtn. *Wynne-Edwards 8525* (CAN); Windy Point, Great Slave Lake *Hvone 102689* (CAN); Old Fort Rae *Russell 23* (CAN); Gordon Lake *Henderson 30a* (CAN); Sawmill Bay, northeast Leith Peninsula, Great Bear Lake *Shacklette 2960* (CAN); Fort Smith *Seton & Preble 78293* (CAN); Artillery Lake *Radford 132368* (CAN); Gagnon Lake, Taltson River area *Scotter 3182* (CAN); Windy River, Northwest Nueltin Lake *Harper 2344* (CAN); 0.5 mile south of Mile 81, Mackenzie Hwy. *Talbot 2246* (ALTA); Fort Reliance *Wilk 12* (ALTA); Louise Falls, Hay River *Lewis 570* (ALTA,NY); Yellowknife Bay *Morrison 85* (ALTA); Mackenzie River 4 miles east Trout River *Cody & Spicer 11376* (UBC,NY); Fort Good Hope *Onion, Kennicott & Hardisty s.n.* (NY); Mile 42.5 Yellowknife Hwy. *Thieret & Reich 6933* (NY); Mile 103 Mackenzie R.-Yellowknife Hwy. *Thieret & Reich 7720* (NY); Mile 96.8 Mackenzie R.-Yellowknife Hwy. *Thieret & Reich 7078* (NY); Mile 96.8 Mackenzie R.-Yellowknife Hwy. *Thieret & Reich 7081* (NY); Chick Lake, delta at mouth of upper Donnelly *Gubbe 75(14)* (ALTA); Chick Lake *Gubbe 147(52)* (ALTA); Yellowknife, road to Giant Mine *Cody 2401* (RM); East Great Slave Lake, south Portage Inlet *Johnson, Harris & Traynor 285* (SASK); East Great Slave Lake, northeast Porter Lake *Johnson, Harris & Traynor 648* (SASK); 3 miles south Enterprise *Skoglund 874* (SASK); Fort Smith *Holsworth s.n.* (SASK); 13 mi. W. Enterprise on Hwy 1 *Dumais & LaRoi 127b* (ALTA).
Nova Scotia: IVERNESS CO.: Grand Anse River *Yellowknife Cody & McCanse 2701* (CAN); N. bank Flat River, Mackenzie Mtns. *Talbot T5040-A* (CAN); Twisted Mtn. *Talbot T5006* (CAN); Liard Range, 13 mi. N.W. Fort Liard *Jeffrey 366* (CAN); Smith, Taylor, Webster & Slipp 6474 (CAN,MT).
Ontario: Junction of Fawn River and Mink Creek *Moir 816* (GH); North Fowl Lake, Pigeon River *Morton & Venn NA6113* (WAT); Thunder Bay, Current River at Trowbridge Falls *Garton 1410* (NY,RM); Cavern Lake, 10 miles northnorthwest of Dorion Station *Britton s.n.* (UBC); Cavern Lake, 10 miles northnorthwest of Dorion Station *Garton 15032* (UBC).
Québec: Ilet d'Amour, Bic *Scoggan 1159* (CAN); 6 miles up Bonaventure River *Scoggan 2185, 2186* (CAN); Grande Coupe, Percé *Scoggan 2187* (CAN); Mt. St. Alban, Gaspé *Scoggan 512* (CAN); Grosses Roches *Scoggan 797* (CAN); Cap des Rosiers *Grandtner 6630* (CAN); Grand River *Scoggan 1000* (CAN); Cap des Rosiers *Scoggan 1364* (CAN); Tourelle *Scoggan 1338* (CAN); Saint Alban *Morisset 71193* (CAN); Mont Blanc, Percé *Terrill 3962A, 4490* (CAN); Cap Tourelle *Fernald & Pease 25337* (GH,MT,NY); Grand Coupe, Percé *Pease 20175* (GH); Percé *Mitchell s.n.* (GH); Grande Coupe, Percé *Fernald & Collins 1201* (CAN,GH,MT,NY); Mont Saint-Alban *Marie-Victorin & Rolland-Germain 49412* (GH,MT); Percé Mtn., Percé *Williams, Collins & Fernald s.n.* (GH,NY); Mont Saint-Alban, Cap Rosier *Brunel & Rousseau 17524* (GH,MT); Trois-Soeurs, Gaspé *Marie-Victorin et al. 17525* (GH); Mt. St. Alban, Gaspé Co. *Wells 38025* (GH); Cape Rosier, Gaspé Co. *Pease 20197* (GH); Between Balde and Baie des Chaleurs, Bonaventure River, Bonaventure Co. *Collins, Fernald & Pease 5905* (GH); Anticosti Island, Riviere Chicotte *Marie-Victorin & Rolland-Germain 27547* (CAN,GH,MT,NY); Anticosti Island, Riviere Vaureal *Marie-Victorin & Rolland-Germain 27546* (GH,MT); Gaspé Peninsula *Clausen 3188* (NY); Gros Morne, Gaspé Co. *Fernald & Weatherby 2476* (GH); Monts Appalaches, near Cape Rosier *Stebbins 825* (GH); Anticosti Island, Riviere Saumon *Rousseau 52228* (MT); Anticosti Island, Riviere Saumon *Rousseau 52213* (MT); Anticosti Island, Riviere Vaureal *Rousseau 52136* (MT); Anticosti Island, Riviere Vaureal *Rousseau 52119* (MT); Anticosti Island, Riviere Chicotte *Rousseau 52346* (MT); Anticosti Island, Riviere Chicotte *Marie-Victorin & Rolland-Germain 25361* (CAN,MT); Cap Bon-Ami, Gaspé Peninsula *Grandtner, Rousseau & Gerardin 8106* (DAO); Ste. Anne des Monts, Gaspé *Macoun s.n.* (NY).
Saskatchewan: Vicinity of Hasbala Lake *Argus 162-63* (CAN,GH,RM,SASK); Charlot Point, Lake Athabaska *Raup 6222* (CAN,GH,NY); Charlot Point, Lake Athabaska *Raup 6260* (CAN,GH,NY); Fish Hook Bay, Lake Athabaska *Raup 6577* (CAN,GH,NY); Charlot Point, Lake Athabaska *Raup 6127* (GH); Camsell Portage, Lake Athabaska *Raup 6194* (CAN,GH,NY); Cornwall Bay, Lake Athabaska *Raup 6519* (GH); Charlot Point, Lake Athabaska *Raup 6231* (CAN,GH,NY); Fish Hook Bay, Lake Athabaska *Raup 6557* (ALTA); Near lake on Tazin River, "Black Lake dogtooth" *Harper s.n.* (CAN); Quillwort lake, south

Hasbala Lake *Argus 998-62* (NY,SASK); Quillwort Lake, south Hasbala Lake *Argus 817-62* (SASK); Clearwater River, Smoothrock Falls, 2.5 km below Gould Rapids *Harms & Wright 25748,25929* (CAN,SASK); 2 km west Island Lake, 8 km west Cluff Lake *Skoglund & Wright 24418* (SASK); 8 km west Cluff Lake *Harms 23889, 23889A* (SASK); Mile 142 Hwy. 105, Wollaston Lake Rd., 1 mile south Hidden Bay *Harms 22233* (SASK). **Yukon:** 7 miles east of Little Atlin Lake *Raup & Correll 11191* (GH); Burwash Creek Road, 0.5 mile west of Alaska Hwy. *G.W. & G.G. Douglas 5825* (CAN); Mile 1022 Alaska Hwy. *Schofield & Crum 7463* (UBC); Mile 114 Alcan Road *Williams s.n.* (UBC); Roadside between Steward River crossing and Dawson City *Langenheim 4130* (UBC); Mile 1021 Alaska Hwy., Kluane Natl. Park *G.W. & G.G. Douglas 9297* (KLUANE); Congdon Creek Horse Plot #5, Destruction Bay *Elliot 15* (KLUANE); Kluane Natl. Park Headquarters, Mile 1019 *Cobus 136* (KLUANE); 2 km east Bates Lake *G.W. & G.G. Douglas 9263* (KLUANE); Mile 1054 Alaska Hwy., near Arctic Institute, Kluane Natl. Park *G.W. & G.G. Douglas 7495* (KLUANE); Halfbreed Creek, 17 km southsouthwest Burwash Landing, Kluane Natl. Park *G.G. & G.W. Douglas 562* (KLUANE); N. shore Kluane Lake, Big Arm *H.M. & L.G. Raup 12366* (C).

U.S.A., Minnesota: COOK CO.: South Clearwater Lake *Butters & Abbe 93* (GH); LAKE CO.: 65 miles north Duluth, north shore Lake Superior *Lakela 3095* (GH,RM).

Collections of *A. lonchophylla* from Lake Superior and vicinity have been previously recognized as *A. wilsonii* Rydb. Maguire (1943) has suggested that this taxon may represent a hybrid between *A. lonchophylla* and *A. angustifolia* subsp. *tomentosa*. With the exception of one anomalous specimen which was found to have numerous linear, entire, glabrous leaves (*Britton s.n.*; UBC), all collections are typical *A. lonchophylla*.

In 1927, Rydberg reduced *A. chionopappa* to *A. arnoglossa*, and described the Newfoundland *A. chionopappa* as *A. fernaldii*. Fernald (1933) was unable to detect any differences between *A. chionopappa* from Gaspé, Anticosti Island, New Brunswick and Newfoundland, and inferentially reduced *A. fernaldii* to *A. chionopappa*. Maguire (1943) has noticed that plants from Newfoundland are usually somewhat smaller and more narrowly-leaved that those of Québec. The greater number of herbarium specimens examined during this study showed no differences between Newfoundland and Québec material.

Arnica gaspensis was proposed by Fernald in 1905 for plants similar to *A. chionopappa* but having larger, less hirsute achenes; oblanceolate bracts; more sharply toothed ligules; and a creamy-white pappus. These plants are confluent with *A. lonchophylla* subsp. *lonchophylla*.

7b. **Arnica lonchophylla** subsp. **arnoglossa** (Greene) Maguire, Brittonia 4:431. 1943. *A. arnoglossa* Greene, Pittonia 4:166. 1900. *A. lonchophylla* var. *arnoglossa* (Greene) Boivin, Nat. Can. 87:27. 1960. TYPE: "Black Hills, near Fort Meade, S. Dakota. June 11, 1887. *W.H. Forwood 232 1/2*". (HOLOTYPE US!, PHOTO CAN!). Figure 37. Generalized illustration Figure 38.

A. arcana A. Nels., Bot. Gaz. 37:276. 1904. TYPE: Doyle Creek, Big Horn Mtns., Wyoming. July 26, 1902. *Goodding 377*, *fide* Maguire (1943).

A. rydbergii dubia A. Nels. ex Hayward, Bot. Gaz. 85:384. 1928. TYPE: Dark Canyon, Deadwood, South Dakota. *fide* Maguire (1943)

Plants 1.7 to 4.5 dm high; *cauline leaves* 3 to 5 pairs; *lower cauline leaves* 4.5 to 11.0 cm long, 1.2 to 3.0 cm broad, broadly lanceolate to sometimes ovate, margins denticulate to occasionally dentate, glabrous to rarely scantly short-pilose, 5 to 7 nerved; *capitula* 3 to 7, rarely solitary or 8, 7.0 to 13.0 mm broad, 9.0 to 13.0 mm high; *periclinium* glabrous to rarely sparse-pilose, white, evidently stipitate-glandular; *involucral bracts* 6.1 to 10.0 mm long, 1.2 to 2.4 mm broad, sparingly pilose otherwise glabrous, stipitate-glandular; *ligulate florets* 7 to 10, 10.0 to 17.5 mm long, 3.0 to 5.0 mm broad, the lobes 0.2 to 1.1 mm long; *disc florets* 5.0 to 8.5 mm long, narrowly goblet-shaped, moderately pilose, stipitate-glandular, the tube 2.0 to 3.2 mm long; *achenes* 3.0 to 5.0 mm long, short-stipitate glandular; *chromosome number* 2n=38.

DISTRIBUTION AND HABITAT: Extremely localized in the Big Horn Mountains of northcentral Wyoming and the Black Hills region of South Dakota (Figure 36). Apparently quite rare. Plants of moist rocky soils and open woodlands.

REPRESENTATIVE SPECIMENS: U.S.A., South Dakota: Black Hills *Pratt 130* (NY); Box Elder Creek, Black Hills *Rustey s.n.* (NY); CUSTER CO.: State Game Park *Over 16212* (US); Custer Peak *Hayward 1778* (RM); Near Sylvan Lake *Osterhout 2829* (RM); Needles Trail, Harney Peak Region *Hayward 1947* (RM); LAWRENCE CO.: 5 miles west Nemo, Ponderosa Woods *Johnson 178* (NY); Piedmont and Little Elk Creek *Rydberg 823* (NY,US); 5 miles west Nemo, Ponderosa Woods *Johnson 243* (NY); 2 1/2 miles east, 5 miles north Savoy Woods at Bridle Veil Falls, Spearfish Canyon *Stephens & Brooks*

Figure 37 - Holotype of *Arnica lonchophylla* subsp. *arnoglossa* (Greene) Maguire.

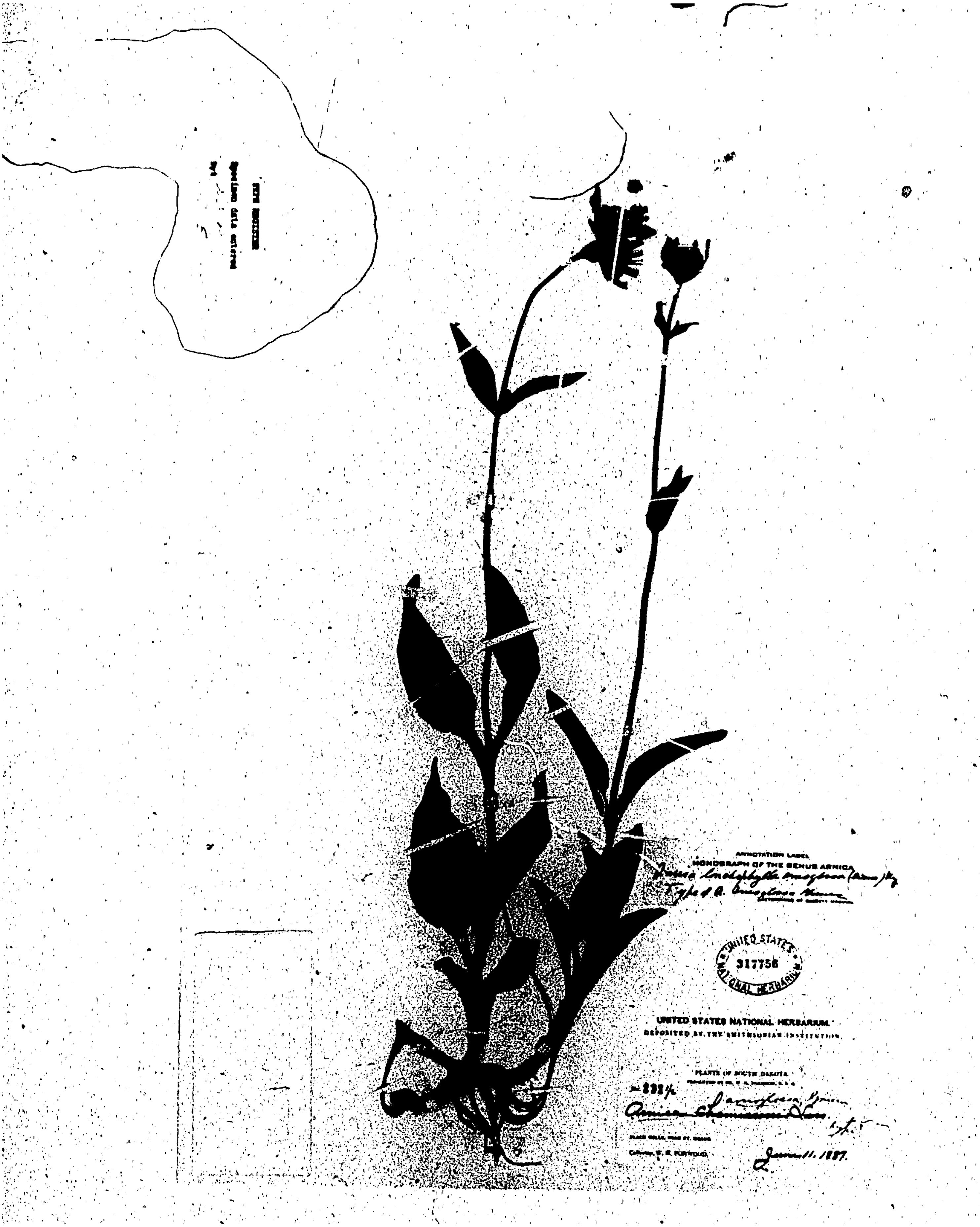
ANNOTATION LABEL
MONOGRAPH OF THE GENUS ARNICA
UNITED STATES NATIONAL HERBARIUM
317756
UNITED STATES NATIONAL HERBARIUM.
DEPOSITED BY THE SMITHSONIAN INSTITUTION
PLANTS OF SOUTH DAKOTA

Figure 38 - Generalized illustration of *Arnica lonchophylla* ssp. *arnoglossa* (modified from *Rydberg 823* [US]).

40471 (GH); Deadwood *Hayward 1379* (RM); MEADE CO.: Piedmont *Pratt s.n.* (NY); Black Hills, near Fort Meade *Forwood 632 1/2* (US); PENNINGTON CO.: Rapid Canyon *Over 1633* (US); Rapid Canyon *Over 1638* (US); 8 1/2 miles west Rapid City *Stephens & Brooks 31790* (NY); White Tail Peak, 5 or 6 miles southwest Rockford *Barr 1051* (RM); Rapid City Canyon (Dark Canyon) *Hayward 826* (RM); Harney Peak Trail *Lee s.n.* (RM); Harney Peak *Hayward 1702* (RM); Harney Peak *Visher 1612* (RM); Harney Peak, Sylvan Lake Trail *McIntosh 1066* (RM).

Wyoming: JOHNSON CO.: Big Horn Mtns., North Fork Crazy Woman Creek, 13 miles southwest Buffalo *Hartman 9686* (RM); SHERIDAN CO.: Big Horn Mtns., 1 mile northwest Freeze Out Point *Hartman 10209* (RM).

Arnica lonchophylla subsp. *arnoglossa* is a rare taxon, being restricted to the Black Hills of South Dakota and the Big Horn mountains of Wyoming. It is readily distinguished from *A. lonchophylla* subsp. *lonchophylla* by its broader leaves, narrower disc corollas, and glandular but sparsely puberulent leaves, disc corollas, periclinium and involucral bracts.

The type of *A. arcana* was not seen during this study, and had already been placed in synonymy under *A. lonchophylla* by Ediger and Barkley (1978). Rydberg (1927) has described this species as possessing short-plumose light-brown pappus, orange-yellow ligules, and short-petioled basal leaves. It is doubtful if this species belongs in *A. lonchophylla*.

Arnica rydbergii dubia A. Nels. was listed by Hayward (1928) as a new addition to the flora of the Black Hills. The origin of this name is doubtful for it is not reported in any of Aven Nelson's earlier works. Maguire (1943) has described this name as a *nomen nudum*, since no description was ever assigned. The authoritive citation, *ex* Hayward, may be erronous since Hayward probably had no intention of describing a new species.

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Appendix 1. Collections used in numerical analyses of *Arnica* subgenus *Arctica*.

ANALYSIS 1. *ARNICA FRIGIDA - LOUISEANA*

OTU No.	OTU Code	OTU Description
1	A-65519	Banff National Park, Mt. Paget *Macoun s.n.* (US)
2	A-72	W. Hailstone Butte *Norris 72* (DAO)
3	A-2938	Banff National Park, Mt. Wilson *Breitung, Porsild & Boivin 2938* (DAO)
4	A-37189	Jasper National Park, Mt. Edith Cavell *Calder 37189* (DAO)
5	A-56257	Whitegoat Wilderness *Lee s.n.* (ALTA)
6	A-17454	Waterton Provincial Park, Mt. Richards *Breitrung 17454* (NY)
7	A-16067	Banff National Park, Mt. Saskatchewan *Porsild & Breitung 16067* (CAN)
8	A-5239	Whitehorse Creek, Nicanassin Range *Dumais & Andrewchow 5239* (CAN)
9	A-1067	Banff National Park, Lake Louise *Farr s.n.* (PH) TYPE: *A. louiseana*
10	A-7854	Cadomin *Dudynsky 7854* (ALTA)
11	A-546	Jasper National Park, Bald Hills *Downie 546* (ALTA)
12	A-547	Jasper National Park, Maligne Lake *Downie 547* (ALTA)
13	A-544	Jasper National Park, Columbia Icefields *Downie 544* (ALTA)
14	A-449	Banff National Park, Moraine Lake *Downie 449* (ALTA)
15	A-450	Banff National Park, Peyto Lake *Downie 450* (ALTA)
16	A-17457	Waterton Provincial Park, Mt. Richards *Breitung 17457* (ALTA)
17	A-1607	Banff National Park, S.W. Moraine Lake *Straley 1607* (DAO)
18	A-438	Prospect Mtn., 10 mi. S.W. Cadomin *Mortimer 438* (ALTA)
19	N-2139	St. John Bay, Eastern Point *Fernald, Long & Fogg 2139* (US)
20	N-2140	St. John Bay, Eastern Point *Fernald, Long & Fogg 2140* (US)
21	N-2141	St. John Bay, Eastern Point *Fernald, Long & Fogg 2141* (US)
22	N-2142	St. John Bay, S.W. Port Au Choix *Fernald, Long & Fogg 2142* (US)
23	N-2143	Pointe Riche, St. John Bay *Fernald, Long & Fogg 2143* (GH)
24	Q-26082	Matane Co., Mt. Mattaouisse *Fernald et al. 26082* (US)
25	Q-26083	Matane Co., Mt. Logan *Pease & Smith 26083* (NY)
26	Q-26084	Matane Co., Mt. Mattaouisse *Fernald & Smith 26084* (GH) TYPE: *A. griscomii*
27	N-29216	St. John Island *Fernald et al. 29216* (GH)
28	N-74031	Port Au Choix, St. Barbe *Hay & Bouchard s.n.* (CAN)
29	Q-49028	Forillon Park, Mt. Saint-Alban *Marie-Victorin et al. 49028* (DAO)

30	BC-452	Stone Mtn. Prov. Park, Summit Lake *Downie 452* (ALTA)
31	BC-838	Teresa Island, Atlin Lake *Buttrick 838* (UBC)
32	BC-916	Mile 83 Haines Road *Taylor, Szczawinski & Bell 916* (CAN)
33	BC-1103	Mile 60 Haines Road *Taylor, Szczawinski & Bell 1103* (CAN)
34	BC-7827	Mile 82 Haines Road *Dudynsky 7827* (ALTA)
35	BC-10507	Summit Pass *Raup & Correll 10507* (GH)
36	BC-60645	Spatsizi Plateau *Krajina s.n.* (UBC)
37	BC-81811	Stonehouse Creek, Haines Road *Beamish, Krause & Luitjens 681811* (UBC)
38	BC-78430	Stone Mtn. Prov. Park, Summit Lake *Rose 78430* (UBC)
39	YT-33	Herschel Island, Beaufort Sea *Cooper 33C* (NY)
40	YT-208	Firth River, near coast *McEwen 208* (CAN)
41	YT-421	S. Mt. Klotz, 90 mi. W. Dawson City *Greene 421* (ALTA)
42	YT-469	Km 32.5 Taylor Hwy. *Downie 469* (ALTA)
43	YT-470	Km 34.5 Taylor Hwy. *Downie 470* (ALTA)
44	YT-471	Km 38.5 Taylor Hwy. *Downie 471* (ALTA)
45	YT-474	Km 73.5 Dempster Hwy. *Downie 474* (ALTA)
46	YT-476	Km 75 Dempster Hwy. *Downie 476* (ALTA)
47	YT-477	Km 80 Dempster Hwy. *Downie 477* (ALTA)
48	YT-478	Km 76 Dempster Hwy. *Downie 478* (ALTA)
49	YT-3767	20 mi. E. Dawson City *Calder & Billard 3767* (DAO) TYPE: *A. frigida* var. *glandulosa*
50	YT-6345	Profile Mtn., 16 mi. N.W. Dawson City *G.W. & G.G. Douglas 6345* (DAO)
51	YT-8271	Mile 100 Haines Road *Schofield & Crum 8271* (CAN)
52	YT-9755	Mile 132 Canol Road *Porsild & Breitung 9755* (CAN)
53	YT-10080	Canol Road, Ross-Lapie R. pass *Porsild & Breitung 10080* (CAN)
54	YT-11307	Little Atlin Lake *Raup & Correll 11307* (GH)
55	YT-12158	Kluane Lake *H.M. & L.C. Raup 12158* (GH)
56	YT-13760	N.E. Ptarmigan Heart *H.M. Raup, Drury & K.A. Raup 13760* (GH)
57	NWT-83	Horn Lake, 37 mi. N.W. McPherson *Youngman & Tessier 83* (CAN)
58	NWT-1530	Inuvik, Mackenzie River Delta *Lambert s.n.* (DAO)
59	NWT-3964	5 mi. W. Horne Lake, Richardson Mtns. *Calder 33964* (DAO)
60	NWT-6647	Lone Mtn., lower N. Nahanni River *Porsild 16647* (CAN)
61	NWT-9197	Keele River, Mackenzie Mtns. *Cody & Scotter 19197* (DAO)
62	AK-19	White Mtns., central Alaska *Gjaerevoll 19* (CAN)
63	AK-46	Chitaslene Glacier, Copper River region *Poto 46* (US) TYPE: *A. brevifolia*
64	AK-71	Katmai Region, Alaska Peninsula *Hagelbarger 71* (US)
65	AK-78	Tikchik Lakes, mtn. above Upnuk Lake *Densmore 78* (ALA)
66	AK-116	Onion Portage, Brooks Range *Schweger 116* (ALA)

67	AK-163	Nogheling Trail, Lake Iliamna *Gorman 163* (US) TYPE: *A. illiamnae*
68.	AK-184A	Lake Iliamna, Alaska Peninsula *Donaldson 184a* (ALA)
69	AK-196	Noluck Lake, Misheguk Mtn. *Parker 196* (ALA)
70	AK-273	Hwy. Pass, Mt. McKinley National Park *Gornall 273* (UBC)
71	AK-283	E. Carnivore Creek, Brooks Range *Batten 283* (ALA)
72	AK-367	138 mi. N.N.E. Arctic Village *Hettinger 367* (CAN)
73	AK-379	70 mi. S. Point Barrow, near Atkasook *Komarkova, Hansell & Seabert 379* (ALA)
74	AK-475	Mile 40 Taylor Hwy. *Downie 475* (ALTA)
75	AK-503	S. Delta Junctión *Downie 503* (ALTA)
76	AK-504	Mile 250 Richardson Hwy. *Downie 504* (ALTA)
77	AK-505	Mile 84.8 Steese Hwy. *Downie 505* (ALTA)
78	AK-506	Mile 105 Steese Hwy. *Downie 506* (ALTA)
79	AK-515	Mile 13 Denali Hwy., W. Paxson *Downie 515* (ALTA)
80	AK-516	Mile 22 Denali Hwy., W. Paxson *Downie 516* (ALTA)
81	AK-517	Mile 11 Denali Hwy., W. Paxson *Downie 517* (ALTA)
82	AK-680	Mt. McKinley National Park *Scamman 680* (GH)
83	AK-685	Arrigetch Creek Valley, Brooks Range *Cooper CV-685* (DAO)
84	AK-1192	56 km. E. Chitina, McCarthy Road *Harris 1192* (ALTA)
85	AK-1302	Anvil Mtn., 7 km. N.N.E. Nome *Harris 1302* (ALTA)
86	AK-1366	Seward Peninsula, Mile 49 Nome-Taylor Hwy. *Harris 1366* (ALTA)
87	AK-1478	E. Oumalik, Arctic Alaska *Ward 1478* (GH)
88	AK-1776	W. Burwash Landing, Rusty Glacier *Murray 1776* (CAN)
89	AK-1833	Teller Reindeer Station, Port Clarence *Walpole 1833* (US)
90	AK-1891	Anaktuvuk Pass *Spetzman 1891* (CAN)
91	AK-1960	Umiat *Hultén s.n.* (GH)
92	AK-2129	King Salmon *Schofield 2129* (DAO)
93	AK-2610	10 mi. N. Isabel Pass, Richardson Hwy. *Smith 2610* (ALA)
94	AK-2654	Ogotoruk Creek, N.W. Alaska *Packer 2654* (ALTA)
95	AK-2084	21 mi. S. Delta Junction *Harms 2084* (GH)
96	AK-3492	Moose Pass *A. & R. Nelson 3492* (ALA)
97	AK-4167	13 mi. W. Paxson on Denali Hwy. *Harms 4167* (GH)
98	AK-4248	Gold Bay *Piper 4248* (US)
99	AK-5621	Mt. Marathon, Seward Peninsula *Calder 5621* (US)
100	AK-6265	Mt. Fairplay, between Chicken and Tok *Scamman 6265* (GH)
101	AK-6713	Mile 95 Yukon R. - Prudoe Bay Haul Rd. *Murray 6713* (ALA)
102	AK-6673	Mile 77-78 Dalton Hwy. *Khokhryakov, Yurtsev & Murray 6673* (ALA)
103	AK-7813	6.73 mi. S. Delta Junction *Dudynsky 7813* (ALTA)

104	AK-7814	Donnelly Dome *Dudynsky 7814* (ALTA)
105	AK-7817	Mile 79.5 Richardson Hwy. *Dudynsky 7817* (ALTA)
106	AK-7820	Hatcher's Pass *Dudynsky 7820* (ALTA)
107	AK-7821	Caribou Creek, Mile 106 Glenn Hwy. *Dudynsky* 7821 (ALTA)
108	AK-8371	12 mi. N.W. Kurupa Lake, Arctic Slope *Hodgdon, Glazier & Piedeman 8371* (GH)
109	AK-19113	Thompson Pass, N. Valdez *J. & C. Taylor 19113* (NY)
110	AK-20384	Iliamna Bay *Gorman s.n.* (US)
111	AK-26069	Eielson Visitor's Center, Mt. McK. Park *Richey s.n.* (ALA)
112	AK-52992	Naknek *Norberg s.n.* (CAN)
113	AK-54238	Mt. McKinley National Park *Frohne 54-238* (ALA)
114	AK-75132	32 km. N. Ambresvajun Lake *A.R. & C.G. Batten 75-132* (ALA)
115	AK-77409	Old Man Creek, Koyukuk River *Mendenhall s.n.* (US) TYPE: *A. mendenhallii*
116	UR-89929	Km 159 Route Egvekinot-Iultin *Petrovsky s.n,* (ALTA)
117	UR-89932	Chukotsky Peninsula, Iultin *Zimarskaya, Korobkov & Yurtsev s.n.* (ALTA)
118	UR-89937	Chukotsky National Area, Anadyr Hills *Karenin & Petrovsky s.n.* (ALTA)
119	UR-89938	Chukotsky National Area, Mt. Pevek *Shamurin & Yurtsev s.n.* (ALTA)
120	UR-89939	Chukotsky Peninsula, Chegitun R. *Sekretareva, Sytin & Yurtsev s.n.* (ALTA)
121	UR-89940	Chukotsky Peninsula, Matuchan R. *Katenin et al. s.n.* (ALTA)
122	UR-89941	Chukotsky Peninsula, Lavrentiya *Korobkov s.n.* (ALTA)

ANALYSIS 2. *ARNICA FULGENS* AND *A. SORORIA*

OTU No.	OTU Code	OTU Description
1	A-548	N. Calgary near Balzac off Hwy. 566 *Downie 548* (ALTA)
2	A-549	W. Cochrane, Hwy. 1A *Downie 549* (ALTA)
3	A-551	S.W. Pincher Creek near Beauvais Lake Prov. Park *Downie 551* (ALTA)
4	A-552	N. Police Outpost Prov. Park near Lee Creek crossing *Downie 552* (ALTA)
5	A-554	S. junction Hwys. 36 and 9 near Hanna *Downie 554* (ALTA)
6	A-555	Hwy. 36, S.E. Hanna *Downie 555* (ALTA)
7	A-559	S. Junction Hwys. 1 & 41 near Medicine Hat *Downie 559* (ALTA);
8	A-562	S. Cypress Hills *Downie 562* (ALTA)
9	A-563	0.5km N. Bare Creek, Hwy. 41 *Downie 563* (ALTA)

10	A-564	Bare Creek Road, 3km off Hwy 41 *Downie 564* (ALTA)
11	A-565	Bare Creek Reservoir *Downie 565* (ALTA)
12	A-566	Bare Creek Reservoir *Downie 566* (ALTA)
13	A-571F	Hwy. 880, N. Aden *Downie 571F* (ALTA)
14	WY-697	Big Horn Co., Milepost 38 Hwy. 14A, Big Horn Natl. Forest *Downie 697* (ALTA)
15	WY-698	Big Horn Co., E. Medicine Wheel Arch. St. Rd., Big Horn Natl. Forest *Downie 698* (ALTA)
16	WY-699	Johnson Co., S.W. Buffalo *Downie 699* (ALTA)
17	WY-700	Campbell Co., N. Savageton *Downie 700* (ALTA)
18	WA-109	Asotin Co., Big Butte *Downen 109* (ALTA)
19	MO-310	Gallatin Co., Bozeman *Blankinship 310* (MT)
20	MO-709	Toole Co., 2 km W. Sweetgrass *Downie 709* (ALTA)
21	MO-710	Toole Co., 15 km. W. Sweetgrass *Downie 710* (ALTA)
22	MO-711	Liberty Co., N. Whitlash *Downie 711* (ALTA)
23	MO-712	Liberty Co., near Port of Whitlash border crossing *Downie 712* (ALTA)
24	MO-713	Pondera Co., S.W. Conrad on Hwy. 219 *Downie 713* (ALTA)
25	MO-714	Judith Basin Co., junction Hwys. 80 & 87 *Downie 714* (ALTA)
26	MO-719	Sweetgrass Co., S. Harlowton, E. Porcupine Butte *Downie 719* (ALTA)
27	MO-1497	Missoula Co., N. Missoula *Straley 1497* (UBC)
28	ND-95776	Rolette Co., Dunsieth *Lunell s.n.* (PH)
29	ID-1939	Idaho Co., White Bird *Constance 1939* (PH)
30	A-11648	10 miles N. Elkwater Lake *McCalla 11648* (UBC)
31	A-161927	Scotfield, S.E. Hanna *Brink s.n.* (UBC)
32	A-16903	Kananaskis *Aikenhead s.n.* (ALTA)
33	WY-1841	Crook Co., W. Sundance *Straley 1841* (UBC)
34	CO-1463	Larimer Co., N. Virginia Dale *Straley 1463* (UBC)
35	CO-4382	Boulder Co., Boulder *Bethel & Clokey 4382* (PH)
36	OR-744	Harney Co., Steens Mtns. *Hansen 744* (NY)
37	S-4312	Cypress Hills Prov. Park *Breitung 4312* (ALTA)
38	BC-530	Harry Lake, Hat Creek *Johns 530* (UBC)
39	M-11040	30 miles W. Brandon *Scoggan 11040* (ALTA)
40	A-11866	N.E. Cochrane *McCalla 11866* (ALTA)
41	A-2749	E. Banff *Straley 2749* (UBC)
42	A-1174	Seven Persons *Klar 1174* (ALTA)
43	A-557	Hwy. 1, 2 km E. Suffield *Downie 557* (ALTA)
44	A-558	Hwy. 41, E. Medicine Hat *Downie 558* (ALTA)
45	A-568	Manyberries *Downie 568* (ALTA)
46	A-569	Pendant Orielle *Downie 569* (ALTA)

47	A-570	W. Pendant Orielle *Downie 570* (ALTA)
48	A-571S	Hwy. 880, N. Aden *Downie 571S* (ALTA)
49	A-572	W. McNab, N.W. Warner *Downie 572* (ALTA)
50	A-573	S. side Milk River Ridge Reservoir *Downie 573* (ALTA)
51	A-574	Milk River Ridge Reservoir *Downie 574* (ALTA)
52	UT-588	Rich Co., N.W. Sage Creek Junction *Snyder & Hawkins 588* (NY)
53	UT-13815	Cache Co., W. Spring Hollow *Maguire et al. 13815* (UC)
54	NE-13460	Elko Co., E. Angel Lake *Raven & Solbrig 13460* (NY)
55	ID-717	Latah Co., Moscow *Abrams 717* (UC)
56	ID-4765	Clark Co., Monida Pass *Maguire 4765* (ALTA)
57	ID-3293	Nez Perces Co., Lake Wawa *A.A. & E.G. Heller 3293* (UC)
58	ID-26659	Owyhee Co., between Silver City and War Eagle Mtn. *Maguire & Holmgren 26659* (UC)
59	CA-866	Lassen Co., Madeline Plains *Applegate 866* (US)
60	CA-1788	Lassen Co., N. Madeline *Babcock & Stebbins 1788* (UC)
61	WY-58727	No Locality Information *Tweedy s.n.* (US)
62	OR-1929	No Locality Information *Cusick 1929* (US)
63	OR-2387	Harney Co., Steens Mtns. *Leiberg 2387* (ALTA)
64	MO-715	Wheatland Co., Judith Gap, N. Harlowton *Downie 715* (ALTA)
65	MO-716	Wheatland Co., 12 miles W. Harlowton, Hwy. 12 *Downie 716* (ALTA)
66	MO-717	Wheatland Co., 0.5 miles E. Shawmut, Hwy. 12 *Downie 717* (ALTA)
67	MO-718	Golden Valley Co., Junction Hwys. 3 & 12 *Downie 718* (ALTA)
68	MO-4743	Clark Co., S. Helena *McCalla 4743* (ALTA)
69	MO-4510	Glacier Co., Glacier Natl. Park *McCalla 4510* (ALTA)
70	MO-11499	Missoula Co., W. Greenough *Hitchcock & Muhlick 11499* (UC)
71	WA-4461	Lincoln Co., Davenport *Maguire 4461* (ALTA)
72	WA-551	Ferry Co., Northport *Rogers 551* (UC)
73	OR-7360	Grant Co., Dayville *Cronquist 7360* (UC)
74	WA-8064	No Locality Information *Sheldon 8064* (US)
75	A-15768	Waterton Lakes Natl. Park *Breitung 15768* (ALTA)
76	A-16893	Castle River Region *Cormack s.n.* (ALTA)
77	BC-702	S. Fairmont Hot Springs *Downie 702* (ALTA)
78	BC-703	Wasa, N. Cranbrook *Downie 703* (ALTA)
79	BC-705	Osoyoos Lake *Downie 705* (ALTA)
80	BC-706	N. Osoyoos on way to Oliver, Hwy. 97 *Downie 706* (ALTA)
81	BC-707	S. Kamloops on Hwy. 5 *Downie 707* (ALTA)
82	BC-708	Near Tranquille, N.W. Kamloops *Downie 708* (ALTA)
83	BC-8157	35 miles N. Cranbrook *McCalla 8157* (ALTA)

84	BC-9552	Canal Flat *McCalla 9552* (ALTA)
85	BC-9519	E. Cranbrook *McCalla 9519* (ALTA)
86	BC-11565	Cariboo *Eastham 11565* (CAN)
87	NT-3416	Fort Norman *Hume(?) s.n.* (CAN)
88	A-14723	Devil's Lake *Macoun 14723* (CAN)
89	NT-7081	Mile 96.8 Mackenzie River-Yellowknife Hwy. *Thieret & Reich 7081* (NY)
90	A-426	Prospect Mtn., S.W. Cadomin *Mortimer 426* (ALTA)
91	NT-140	Tuktoyaktuk harbour *Haag 140* (ALTA)
92	BC-7015	Natural Bridge, Yoho National Park *McCalla 7015* (ALTA)

ANALYSIS 3. *ARNICA ANGUSTIFOLIA*

OTU No.	OTU Code	OTU Description
1	A-426	Prospect Mtn., 10 mi. S.W. Cadomin *Mortimer 426* (ALTA)
2	A-12682	Banff National Park, Snow Creek Pass *Moss 12682* (ALTA)
3	BC-688	Teresa Island, Atlin Lake *Buttrick 688* (UBC)
4	M-2133	Fort Churchill *Ritchie 2133* (UBC)
5	M-90423	Churchill, along Hudson Bay *Wolf s.n.* (ALTA)
6	L-431	Torngat Region, Razorback Mtn., Ryan's Bay *Woodworth 431* (GH)
7	L-570	Torngat Region, Rowsell Harbour *Abbe & Odell 570* (GH)
8	L-573	Torngat Region, Razorback Harbour *Abbe 573* (GH)
9	L-639	Gerin Mtn *Viereck 639* (ALA)
10	L-7136	Komaktorvik Fjord *Wynne-Edwards 7136* (CAN)
11	L-8661	52 mi. W.S.W. Hebron *Gillett 8661* (GH)
12	N-2124	St. John Bay, Eastern Point *Fernald, Long & Fogg 2124* (GH)
13	N-2126	Ingornachoix, Gargamelle Cove *Fernald, Long &Fogg 2126* (GH)
14	N-29208	Straits of Belle Isle, Savage Cove *Fernald, Pease & Long 29208* (GH)
15	N-29213	Pistolet Bay, Cape Norman *Wiegard, Griscom & Hotchkiss 29213* (GH)
16	N-29215	Ha-Ha Mtn *Fernald & Long 29215* (GH)
17	NT-3	Coppermine *Ross 3* (ALTA)
18	NT-140	E. Tuktoyaktuk *Haag 140* (ALTA)
19	NT-1906	Herschell Island *Lindstrom s.n.* (O)

20	NT-1963	Baker Lake *Choque s.n.* (MT)
21	NT-3847	Inuqsuin Fjord, Baffin Island *Hainault 3847* (O)
22	NT-224	N. Tununuk Point *Hernandez 224* (ALTA)
23	O-224	Fort Severn *Scott s.n.* (UBC)
24	O-7678	Limestone Island, Winisk R. *Baldwin 7678* (CAN)
25	Q-192	Wolstenholme *Polunin 192* (CAN)
26	Q-1957	Ile Bylot *Lemieux s.n.* (MT)
27	Q-3254	Beach Creek, Richmond Gulf *Abbe & Abbe 3254* (GH)
28	Q-5174	Tasiujaq, S.W. Ungava *MacInnes 5174* (MT)
29	Q-6791	Fort Chimo *Legault 6791* (MT)
30	Q-379188	Riviére aux Feuilles *Ouellet s.n.* (CAN)
31	Y-226	90 mi. N.W. Dawson City, Mt. Klotz *Greene 226* (ALTA)
32	Y-1616	Rusty Glacier, W. Burwash Landing *Murray 1616* (ALA)
33	Y-9756	Mile 132 Canol Road *Porsild & Breitung 9756* (ALTA)
34	Y-71602	Babbage R., E. Little Trout Lake *Lambert & Morrison 65071602* (UBC)
35	Y-13148	Pine Creek, Mile 1019 Alaska Hwy *Raup, Drury & Raup 13148* (UBC)
36	Y-168243	N. Cultus Creek, Kluane Lake *Beamish s.n.* (UBC)
37	FD-1394	Lapponia Enontekiensis *Kotilainen 1394* (C)
38	G-2	Disko, Mudderbugten, Alakoriaq *Andersen & Hanfgarn 2* (C)
39	G-9	Liverpool Land, Roscoe Bjerge, E. Hurry Inlet *Marris 9* (C)
40	G-24	Mesters Vig, Hamma Hut *Argent & Argent 24/18774* (C)
41	G-31	Clavering Island *Gelting 31* (C)
42	G-102	Cape Herschel *Vaage s.n.* (C)
43	G-143	Storfjorden, Brandal *Tornoe s.n.* (C)
44	G-150	Lower E. Skeldal, Kong Oscars Fjord *Elkington s.n.* (C)
45	G-157	Diskofjord, between Kangerdluarssuk and Equalunguit *Fredskild et al. 157* (C)
46	G-188	Adam Bierings Land, S. Inuiterk So *Bennike s.n.* (C)
47	G-383	Sdr. Isartoq, E. Nukagpiaq *Hansen & Holt 383* (C)
48	G-413	Melville Bugt, Tugtuligssuaq, Tuperssuai *Bay & Fredskild 413* (C)
49	G-724	Angmagssalik District, Qingertivaq *Astrup & Kliim-Nielsen 724* (C)
50	G-1220	Sondre Stromfjord, Mt. Hassel, N. Sandflugtdalen *Holt 1220* (C)
51	G-1305	Sondre Stromfjord, S.E. Isunguata Sermia *Holt 1305* (C)
52	G-1651	E. Sondre Isortoq, W. Lake Kangiata taserssuatsiava *Holt 1651* (C)
53	G-1701	Ikertaq, Akugdleq *Bay 78-1701* (C)
54	G-6276	Akinarssuk, Thule Air Base *Fredskild 6276* (C)
55	G-681333	Kaugârssup nuna *Ollgard 68-1333* (C)
56	NY-4	Troms, Overbygd *Benum s.n.* (C)

57	NY-6	Troms, Alap, Maalselven *Lundmark s.n.* (O)
58	NY-1908B	Troms, Alap, Maalselven *Lundmark s.n.* (O)
59	NY-1913	Troms, Storfjord, Rieppegaisi *Engelskjon & Spjelkavik s.n.* (O)
60	NY-1973	Troms, Bardu, Gavdnjavatn S. *Engelskjon & Engelskjon s.n.* (O)
61	NY-1978	Nordland, Hamaroy *Sivertsen E6* (O)
62	NY-20387	Finnmark, Nallovarre, Alten *Fridtz 20387* (O)
63	SV-7	Colbay *Resvoll-Dieset s.n.* (C)
64	SV-12	Advent Bay, Armikadalen *Lid s.n.* (C)
65	SV-540	Litledalen, van Mijenfjorden *Halliday H540* (O)
66	SV-1926	Bell Sund, Lagfjorden *Lynge s.n.* (O)
67	SV-1949	Eckmannsfjellet *Mikaelsen s.n.* (O)
68	SN-14	Karesuando, Peldsavagge *Alm & Tengwall s.n.* (C)
69	SN-546	Jokkmokks, Vaisa, Kalpik *Bjorkman s.n.* (ICEL)
70	SN-1555	Lake Tornetrask, Nissonreppejokk R. *Alm 1555* (O)
71	AK-2113	S. Ogotoruk Creek *Packer 2113* (ALTA)
72	AK-6838	Between Iteriak and Otuk Creeks *Murray 6838* (ALA)
73	AK-27904	Camp 3 Meade River *Geist s.n.* (ALA)
74	AK-2703	College *Harms 2703* (C)
75	AK-3677	McKinley Park Station *Nelson & Nelson 3677* (US)
76	UR-11	Yakurskaya, R. Shangrin *Korobkov & Kulshina s.n.* (ALTA)
77	UR-13	Yakurskaya, between Leni and Kuramis Rivers *Norin, Petrovsky & Schtepa s.n.* (ALTA)
78	UR-14	Chukotsky Peninsula, R. Boginden *Koroyeva & Petrovsky s.n.* (ALTA)
79	UR-15	Yakurskaya *Michelova s.n.* (ALTA)
80	UR-17	Chukotsky Peninsula, R. Chegitun *Sekretareva, Yurtsev & Sitin s.n.* (ALTA)
81	UR-28	Sibiria orientalis, Channagh Bereg. *Bunge s.n.* (C)
82	UR-272	Lake Taymyr, Taymyr *Tolmatchew 272* (C)
83	UR-1924	Novaya Zemlya, Machiggin *Lynge s.n.* (O)
84	UR-2524	No locality, reference no. Q-46-12. *Vodoplanova & Ivanov 2524* (ALTA)
85	A-597	Prospect Mtn., 10 mi. S.W. Cadomin *Mortimer 597* (ALTA)
86	A-607	Porcupine Hills, S. Cowley *Malte & Watson 607* (CAN)
87	A-1382	Plateau Mtn., S.W. High River *Ringius 1382* (ALTA)
88	A-1725	Eagles Nest Creek Area *Pegg 1725* (ALTA)
89	A-7504	Ram Mtn., S.W. Nordegg *Dumais 7504* (ALTA)
90	A-10328	Cadomin *Moss 10328* (ALTA)
91	A-13668	Banff National Park, Cairn Mtn. *Porsild & Breitung 13668* (CAN)
92	A-16703	Waterton National Park, Mt. Carthew *Breitung 16703* (ALTA)
93	A-96014	Jasper National Park, Goat Mtn. *Macoun 96014* (CAN)

94	BC-69739	Dash Plateau *Selby s.n.* (UBC)
95	BC-81107	Muncho Lake Provincial Park *Beamish et al. 681107* (CAN)
96	N-2127	Old Port Au Choix *Fernald, Long & Fogg 2127* (MT)
97	N-2128	St. John Bay *Fernald, Long & Fogg 2128* (MT)
98	N-2129	Eastern Point *Fernald, Long & Fogg 2129* (MT)
99	MO-12965	Beaverhead Co., Pioneer Mtns. *Hitchcock & Muhlick 12965* (NY)

ANALYSIS 4. *ARNICA* SUBGENUS *ARCTICA*

OTU No.	OTU Code	OTU Description
1	A-65519	Banff National Park, Mt. Paget *Macoun s.n.* (US)
2	A-56257	Whitegoat Wilderness *Lee s.n.* (ALTA)
3	A-1067	TYPE: *A. louiseana*
4	A-544	Jasper National Park, Columbia Icefields *Downie 544* (ALTA)
5	A-449	Banff National Park, Moraine Lake *Downie 449* (ALTA)
6	A-450	Banff National Park, Peyto Lake *Downie 450* (ALTA)
7	A-17457	Waterton Provincial Park, Mt. Richards *Breitung 17457* (ALTA)
8	A-1607	Banff National Park, S.W. Moraine Lake *Straley 1607* (DAO)
9	A-438	Prospect Mtn., 10 mi. S.W. Cadomin *Mortimer 438* (ALTA)
10	N-2139	St. John Bay, Eastern Point *Fernald, Long & Fogg 2139* (US)
11	N-2140	St. John Bay, Eastern Point *Fernald, Long & Fogg 2140* (US)
12	N-2141	St. John Bay, Eastern Point *Fernald, Long & Fogg 2141* (US)
13	N-2142	St. John Bay, S.W. Port Au Choix *Fernald, Long & Fogg 2142* (US)
14	N-2143	Pointe Riche, St. John Bay *Fernald, Long & Fogg 2143* (GH)
15	Q-26082	Matane Co., Mt. Mattaouisse *Fernald et al. 26082* (US)
16	Q-26083	Matane Co., Mt. Logan *Pease & Smith 26083* (NY)
17	Q-26084	TYPE: *A. griscomii*
18	N-29216	St. John Island *Fernald et al. 29216* (GH)
19	N-74031	Port Au Choix, St. Barbe *Hay & Bouchard s.n.* (CAN)
20	Q-49028	Forillon Park, Mt. Saint-Alban *Marie-Victorin et al. 49028* (DAO)
21	BC-7827	Mile 82 Haines Road *Dudynsky 7827* (ALTA)

22	BC-10507	Summit Pass *Raup & Correll 10507* (GH)
23	BC-60645	Spatsizi Plateau *Krajina s.n.* (UBC)
24	BC-78430	Stone Mtn. Prov. Park, Summit Lake *Rose 78430* (UBC)
25	YT-33	Herschel Island, Beaufort Sea *Cooper 33C* (NY)
26	YT-3767	TYPE: *A. glandulosa*
27	YT-10080	Canol Road, Ross-Lapie R. pass *Porsild & Breitung 10080* (CAN)
28	NWT-83	Horn Lake, 37 mi. N.W. McPherson *Youngman & Tessier 83* (CAN)
29	NWT-6647	Lone Mtn., lower N. Nahanni River *Porsild 16647* (CAN)
30	AK-46	TYPE: *A. brevifolia*
31	AK-163	TYPE: *A. illiamnae*
32	AK-367	138 mi. N.N.E. Arctic Village *Hettinger 367* (CAN)
33	AK-685	Arrigetch Creek Valley, Brooks Range *Cooper CV-685* (DAO)
34	AK-77409	TYPE: *A. mendenhallii*
35	UR-89932	Chukotsky Peninsula, Iultin *Zimarskaya, Korobkov & Yurtsev s.n.* (ALTA)
36	UR-89939	Chukotsky Peninsula, Chegitun R. *Sekretareva, Sytin & Yurtsev s.n.* (ALTA)
37	SD-178	Lawrence Co., 5 mi. W. Nemo *Johnson 178* (NY)
38	SD-243	Lawrence Co., 5 mi. W. Nemo *Johnson 243* (NY)
39	SD-1638	Pennington Co., Rapid Canyon *Over 1638* (US)
40	SD-31790	Pennington Co., W. Rapid City *Stephens & Brooks 31790* (NY)
41	SD-16212	Custer Co., State Game Park *Over 16212* (US)
42	N-2132	Middle Arm, Druid's (or Raglan) Head *Fernald, Long & Fogg 2132* (GH)
43	N-2133	Old Port Au Choix *Fernald, Long & Fogg 2133* (GH)
44	N-2134	St. John Bay, Crow's Head *Fernald, Long & Fogg 2134* (MT)
45	N-2135	Pointe Riche *Fernald, Long & Fogg 2135* (GH)
46	N-2989	Goose Arm, Blue Cliff *Rouleau 2989* (MT)
47	NB-72	Sisson Gorge *Hay 72* (GH)
48	Q-2476	Gaspé, Gros Morne *Fernald & Weatherby 2476* (GH)
49	Q-17524	Gaspé, Mont. St.-Alban, Cap Rosier *Marie-Victorin et al. 17524* (GH)
50	Q-25337	Gaspé, Cap Tourelle *Fernald & Pease 25337* (NY)
51	Q-27547	Anticosti Island, Chicotte R. *Marie-Victorin & Rolland-Germain 27547* (MT)
52	A-265	Revillon Coupe, Peace-Athabasca Delta *Doherty 265* (ALTA)
53	A-6658	Banff Natl. Park, Spray River *McCalla 6658* (ALTA)
54	BC-71642	Mile 385 Alaska Hwy. *Jackson s.n.* (UBC)
55	M-3429	Cross Lake, N. Lake Winnipeg *Scoggan 3429* (ALTA)
56	NT-85	Above Yellowknife Bay *Morrison 85* (ALTA)
57	NT-8524	Mackenzie R., Nahanni Mtn. *Wynne-Edwards 8524* (NY)
58	NT-03416	Fort Norman, Bear Rock *Hume(?) 103416* (CAN)

59	O-816	Junction Fawn R. and Mink Creek *Moir 816* (GH)
60	S-16263	Hasbala Lake *Argus 162-63* (GH)
61	Y-7463	Mile 1022 Alaska Hwy., Vic. of Mackintosh *Schofield & Crum 7463* (UBC)
62	A-2714	Waterton Lakes Natl. Park, Sofa Mtn. *Kuchar 2714* (ALTA)
63	A-22626	Banff Natl. Park, Snow Creek Pass *Porsild 22626* (CAN)
64	BC-4	Boss Mtn., Takomkane Mtn. *Williams & Luitjens 4* (UBC)
65	BC-50092	Mt. Idaho, E. Slocan Lake *Beamish et al. 750092* (UBC)
66	ID-12552	Idaho Co., Heaven's Gate *Christ 12552* (NY)
67	MO-9098	Flathead Co., Bob Marshall Wilderness *Lackschewitz 9098* (NY)
68	MO-12867	Beaverhead Co., E. Pintlar Peak *Hitchcock & Muhlick 12867* (NY)
69	UT-14771	Duchesne Co., Uinta Mtns. *Goodrich 14771* (NY)
70	WA-1496	Okanogan Co., Okanogan Natl. Forest, W. Twisp *Straley 1496* (UBC)
71	WY-998	Albany Co., W. Lake Marie *Rollins 998* (NY)
72	A-563	0.5km N. Bare Creek, Hwy. 41 *Downie 563* (ALTA)
73	A-565	Bare Creek Reservoir *Downie 565* (ALTA)
74	A-566	Bare Creek Reservoir *Downie 566* (ALTA)
75	A-571F	Hwy. 880, N. Aden *Downie 571F* (ALTA)
76	WY-699	Johnson Co., S.W. Buffalo *Downie 699* (ALTA)
77	ND-95776	Rolette Co., Dunsieth *Lunell s.n.* (PH)
78	A-11648	10 miles N. Elkwater Lake *McCalla 11648* (UBC)
79	A-161927	Scotfield, S.E. Hanna *Brink s.n.* (UBC)
80	CO-1463	Larimer Co., N. Virginia Dale *Straley 1463* (UBC)
81	A-569	Pendant Orielle *Downie 569* (ALTA)
82	A-570	W. Pendant Orielle *Downie 570* (ALTA)
83	A-571S	Hwy. 880, N. Aden *Downie 571S* (ALTA)
84	UT-588	Rich Co., N.W. Sage Creek Junction *Snyder & Hawkins 588* (NY)
85	ID-4765	Clark Co., Monida Pass *Maguire 4765* (ALTA)
86	WY-58727	No Locality Information *Tweedy s.n.* (US)
87	WA-4461	Lincoln Co., Davenport *Maguire 4461* (ALTA)
88	A-16893	Castle River Region *Cormack s.n.* (ALTA)
89	BC-8157	35 miles N. Cranbrook *McCalla 8157* (ALTA)
90	A-7504	Ram Mtn., S.W. Nordegg *Dumais 7504* (ALTA)
91	A-10328	Above Cadomin *Moss 10328* (ALTA)
92	A-13668	Cairn Mtn., S. Healy Creek, Banff Natl. Park *Porsild & Breitung 13668* (CAN)
93	A-14244	Citadel Peak, Banff Natl. Park *Porsild & Breitung 14244* (CAN)
94	A-16703	Mt. Carthew *Breitung 16703* (ALTA)
95	A-19313	Rocky Mtn. Forest Reserve *Porsild & Lid 19313* (CAN)

96	A-96014	Goat Mtn., Jasper Natl. Park *Macoun 96014* (CAN)
97	BC-69739	Dash Plateau *Selby s.n.* (UBC)
98	MO-4436	Teton Co., Choteau Mtn. *Lackschewitz 4436* (NY)
99	MO-12965	Beaverhead Co., Pioneer Mts. *Hitchcock & Muhlick 12965* (NY)
100	G-2	Disko, Mudderbugten, Alakoriaq *Andersen & Hanfgarn 2* (C)
101	G-24	Mesters Vig, Hamma Hut *Argent & Argent 24/18774* (C)
102	G-150	Lower E. Skeldal, Kong Oscars Fjord *Elkington s.n.* (C)
103	G-413	Melville Bugt, Tugtuligssuaq, Tuperssuai *Bay & Fredskild 413* (C)
104	G-724	Angmagssalik District, Qingertivaq *Astrup & Kliim-Nielsen 724* (C)
105	G-1220	Sondre Stromfjord, Mt. Hassel, N. Sandflugtdalen *Holt 1220* (C)
106	G-1305	Sondre Stromfjord, S.E. Isunguata Sermia *Holt 1305* (C)
107	G-1701	Ikertaq, Akugdleq *Bay 78-1701* (C)
108	G-6276	Akinarssuk, Thule Air Base *Fredskild 6276* (C)
109	G-13067	N. Sarfard Lisivik Island *Elsley 130167* (C)
110	G-TYPE	TYPE: *A. angustifolia*
111	L-157	TYPE: *A. sornborgeri*
112	L-TYPE	TYPE: *A. plantaginea*
113	BC-64979	TYPE: *A. stricta*
114	BC-64987	TYPE: *A. sororia*
115	FULTYPE	TYPE: *A. fulgens*
116	N-10874	TYPE: *A. pulchella*
117	A-11606	TYPE: *A. tomentosa*
118	MO-891	TYPE: *A. rydbergii*
119	A-72719	TYPE: *A. ovalis*
120	Q-1881	TYPE: *A. gaspensis*
121	Q-1904	TYPE: *A. chionopappa*
122	N-10875	TYPE: *A. fernaldii*
123	AK-29	TYPE: *A. louiseana* var. *pilosa*
124	A-19647	TYPE: *A. lonchophylla*
125	SD-232	TYPE: *A. arnoglossa*
126	Y-1025	TYPE: *A. attenuata*
127	UR-199	TYPE: *A. iljinii*
128	NY-4	Troms, Overbygd *Benum s.n.* (C)
129	NY-1908A	Troms, Alap, Maalselven *Lundmark s.n.* (O)
130	NY-1908B	Troms, Alap, Maalselven *Lundmark s.n.* (O)
131	NY-1913	Troms, Storfjord, Rieppegaisi *Engelskjon & Spjelkavik s.n.* (O)
132	NY-1973	Troms, Bardu, Gavdnjavatn S. *Engelskjon & Engelskjon s.n.* (O)

133	NY-20387	Finnmark, Nallovarre, Alten *Fridtz 20387* (O)
134	SV-7	Colbay *Resvoll-Dieset s.n.* (C)
135	SV-12	Advent Bay, Armikadalen *Lid s.n.* (C)
136	SN-1555	Lake Tornetrask, Nissonreppejokk R. *Alm 1555* (O)

Appendix 2. Characters used in numerical analyses

1. (1,2,3,4)[a] Plant height (cm). 2. (1,2,3,4) Basal leaf length (cm). 3. (1,2,3,4) Basal leaf width (cm). 4. (1,2,4) Basal leaf length/width ratio. 5. (1,2,3,4) Capitula width (mm). 6. (1,2,3,4) Capitula height (mm). 7. (1,2,3,4) Achene length (mm). 8. (1,2,3,4) Involucral bract length (mm). 9. (1,2,3,4) Involucral bract width (mm). 10. (1,2,4) Involucral bract length/width ratio. 11. (1,2,3,4) Ligule tooth length (mm). 12. (1,2,3,4) Ligule length (mm). 13. (1,2,3,4) Ligule width (mm). 14. (1,2,4) Ligule length/width ratio. 15. (1,2,3,4) Ligule number (per capitulum). 16. (1,2,3,4) Capitula number (per stem). 17. (2,3,4) Disc corolla length (mm). 18. (2,3,4) Disc corolla tube length (mm). 19. (2,3,4) Cauline leaves (number of pairs). 20. (2,4) Number major veins per leaf. 21. (1,2,3,4) Habit: stem unbranched/ stem branched. 22. (2,3,4) Stem pubescence: glabrous to sparse/ moderate/ dense. 23. (1,2,4) Stem glandularity: absent or inconspicuous/ abundant. 24. (1,2,3,4) Leaf margin: entire/ entire to occasionally denticulate/ denticulate to occasionally dentate/ dentate. 25. (2,3,4) Leaf pubescence: glabrous to sparse/ moderate/ dense. 26. (1,2,4) Leaf glandularity: absent or inconspicuous/ abundant. 27. (2,3,4) Basal leaf petiole: sessile (or subsessile) or very short and broad winged/ narrow or broad winged and shorter than blade/ slender winged and approximately equaling the blade. 28. (2,4) Basal leaf apex: acute or acuminate/ obtuse. 29. (2,3,4) Basal leaf shape: linear to narrowly lanceolate/ narrowly to broadly lanceolate/ broadly lanceolate (to sometimes ovate)/ narrowly oblong to oblanceolate/ oblanceolate to spathulate/ elliptic to elliptic-lanceolate. 30. (1,2,3,4) Periclinium and peduncle pubescence: glabrous to sparse/ moderate/ dense. 31. (1,2,4) Periclinium colour: white/ yellow to yellowish-gold. 32. (1,2,3,4) Periclinium and peduncle glandularity: absent or inconspicuous/ abundant. 33. (1,2,3,4) Involucral bract pubescence: sparingly pilose, otherwise glabrous/ pilose at base, glabrous above/ pilose throughout/ dense woolly-villous. 34. (1,2,3,4) Involucral bract shape: narrowly lanceolate/ broadly lanceolate/ oblanceolate. 35. (1,2,3,4) Involucral bract glandularity: absent or

[a]Numbers in parentheses represent the numerical analysis in which the character was used. See text for additional information.

inconspicuous/ abundant. 36. (1,2,4) Capitulum position: erect/ nodding. 37. (2,4) Capitulum shape: broadly hemispheric/ campanulate-turbinate. 38. (2,4) Ligule margin: entire to minutely denticulate/ prominently dentate. 39. (2,4) Disc corolla pubescence: glabrous to sparse/ moderate/ dense. 40. (2,4) Disc corolla glandularity: absent or inconspicuous/ abundant. 41. (1,2,4) Achene pubescence: sparsely hirsute above middle, glabrous below/ sparse hirsute throughout/ densely hirsute throughout. 42. (1,2,4) Achene glandularity: absent or inconspicuous/ abundant. 43. (2,4) Dense tufts of hair in axils of basal leaves: absent/ present. 44. (1) Percent pollen stainability: 0-94%/ 95-100%. 45. (1) Geographic distribution: western North America/ eastern North America/ northern North America and U.S.S.R.

Appendix 3. Data matrices used in numerical analyses

ANALYSIS 1. *ARNICA FRIGIDA - LOUISEANA*

(2A4,21F2.0,1X,F4.1,F5.1,F4.1,F3.1,2F4.1,F3.1,F4.1,2F3.1,F4.2,
F4.1,2F3.1,F4.1,F3.0,F2.0)
A-65519 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 9.3 35.0 9.03.913.511.53.8
10.02.54.00.6014.03.84.2 6.7 0 0
A-72 0 1 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 12.0 55.317.33.213.0 9.53.5
10.42.64.00.5714.53.34.6 5.7 0 0
A-2938 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 9.3 37.0 9.53.915.311.74.1
10.92.83.90.3717.03.84.5 7.0 0 0
A-37189 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 6.5 37.3 8.84.310.810.53.6
11.32.44.80.5519.03.45.6 8.5 0 0
A-56257 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 5.5 23.8 6.83.514.710.73.7
9.52.43.90.4513.02.84.7 6.5 0 0
A-17454 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 6.0 47.710.74.510.510.5-9
8.32.53.30.4016.94.04.2 6.5 0 0
A-16067 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 10.0 41.014.72.815.511.3-9
10.51.95.70.6016.33.44.8 9.7 0 0
A-5239 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 6.7 44.313.33.310.7 9.64.0
8.52.14.20.4713.02.84.6 8.3 0 0
A-1067 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 11.0 38.3 8.84.411.311.34.6
8.52.04.30.7316.13.54.7 9.7 -9 0
A-7854 0 2 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 10.0 43.711.33.912.511.33.8
9.32.43.80.9316.33.74.5 8.7 0 0
A-546 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 9.0 55.815.23.711.311.73.5
12.42.06.30.6318.53.45.4 5.7 0 0
A-547 0 1 2 1 0 0 1 1 0 1 1 1 1 1 2 1 0 0 0 1 1 8.2 50.213.33.812.011.03.9
9.82.14.80.3518.33.25.7 5.5 0 0
A-544 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 8.0 44.011.83.713.410.63.8
10.72.44.40.7214.73.24.5 6.3 0 0
A-449 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 10.3 42.812.53.414.310.73.9
9.72.44.10.6615.72.85.5 5.7 0 0
A-450 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 11.0 42.010.64.015.011.04.0
9.62.04.90.6815.83.64.3 6.0 0 0
A-17457 0 1 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 9.0 43.312.53.516.814.34.2
10.02.54.00.6013.32.65.2 7.5 0 0
A-1607 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 7.0 44.515.03.019.016.04.0
11.62.84.1-9 -9 -9 -9 -9 0 0
A-438 0 2 2 1 0 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 7.0 28.510.02.915.510.5-9
11.12.64.30.5314.73.93.8 5.5 0 0
N-2139 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 11.4 44.513.33.418.715.23.8
10.93.53.10.8717.53.84.6 7.4 0 1
N-2140 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 14.0 51.414.33.619.715.04.2
12.43.43.71.0219.84.44.5 9.6 0 1
N-2141 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 13.4 60.920.63.021.213.83.6
11.33.33.50.8418.84.54.2 9.0 0 1
N-2142 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 14.6 49.113.53.620.617.44.0
11.93.63.30.8817.65.13.5 9.2 0 1
N-2143 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 10.2 40.414.62.817.813.03.4
10.33.92.71.2718.04.14.5 8.0 0 1
Q-26082 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 13.3 40.813.53.018.712.32.8
10.62.73.90.9515.94.03.9 9.5 0 1
Q-26083 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 13.8 35.0 8.84.017.515.04.1

10.82.83.90.8216.63.25.2 9.0 0 1
Q-26084 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 16.3 47.4 9.55.018.513.03.9
10.13.43.00.5016.23.44.8 8.6 -9 1
N-29216 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 13.9 41.811.53.620.515.34.0
12.03.53.51.1816.04.04.0 9.0 0 1
N-74031 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 8.5 49.314.03.519.012.3-9
11.43.63.2-9 -9 -9 -9 -9 0 1
Q-49028 0 1 0 1 0 0 1 0 0 1 0 0 1 0 1 0 1 1 0 0 1 13.0 43.811.33.916.313.73.8
11.03.23.50.92 -9 -9 -9 -9 0 1
BC-452 0 2 0 0 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 13.3 35.5 7.84.617.713.04.5
11.13.13.60.9425.23.96.5 8.0 0 2
BC-838 0 2 0 1 0 0 0 0 0 1 1 1 1 0 2 0 1 1 0 0 1 7.3 18.3 8.32.217.012.35.0
9.43.32.81.2 21.34.44.8 7.5 0 2
BC-816 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 8.0 18.5 8.52.215.013.04.5
10.03.82.61.6016.24.33.810.0 0 2
BC-1103 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 5.0 14.7 6.32.311.010.04.2
8.33.32.50.9017.83.84.7 9.0 0 2
BC-7827 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 9.0 22.3 9.52.314.010.53.5
10.43.53.01.1016.02.85.710.0 0 2
BC-10507 0 2 0 1 0 0 2 0 0 1 1 1 1 0 1 0 1 1 0 0 1 10.6 29.3 9.53.118.010.5-9
10.13.33.10.3321.84.05.5 8.5 0 2
BC-60645 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 7.2 17.0 9.31.814.710.34.0
8.84.12.10.5814.72.75.4 9.0 0 2
BC-81811 0 2 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 12.7 33.014.32.320.311.74.8
10.83.33.31.2323.75.94.0 9.0 0 2
BC-78430 0 2 0 1 0 0 2 0 0 1 1 1 1 0 1 0 1 1 0 0 1 11.0 53.311.34.719.011.0-9
10.43.43.10.3714.73.04.910.0 0 2
YT-33 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 16.5 34.0 9.03.817.013.04.7
11.33.53.21.2028.83.77.810.0 0 2
YT-208 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 15.7 41.010.73.814.310.73.6
8.63.12.81.1020.35.43.811.0 0 2
YT-421 0 1 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 1 16.8 25.8 9.32.814.810.8-9
11.31.76.61.0019.33.85.1 9.7 0 2
YT-469 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 17.0 32.710.73.112.014.34.8
12.72.74.71.3820.44.84.3 8.0 0 2
YT-470 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 1 0 0 0 1 21.5 42.013.73.116.013.04.7
10.31.95.41.3020.33.16.511.0 0 2
YT-471 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 1 1 0 0 1 24.8 53.813.44.019.514.05.0
13.23.53.82.2032.64.37.6 9.8 0 2
YT-474 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 18.4 41.3 9.84.214.316.75.0
11.83.53.42.5427.95.35.3 9.0 0 2
YT-476 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 18.5 60.814.64.223.516.85.2
12.63.04.23.9534.45.46.412.7 0 2
YT-477 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 23.0 67.020.73.221.015.05.1
13.03.24.12.3235.95.76.312.0 0 2
YT-478 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 0 0 0 1 16.5 39.714.02.820.014.04.0
11.51.86.41.7222.14.54.913.5 0 2
YT-3767 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 0 1 1 0 0 1 24.0 41.313.33.114.314.74.1
11.93.04.02.0025.04.26.0 8.5 -9 2
YT-6345 0 2 0 1 0 0 0 0 0 1 0 1 1 0 1 0 2 0 0 0 1 7.7 23.0 6.33.716.810.84.0
10.32.05.21.5022.74.25.410.0 0 2
YT-8271 0 1 0 1 0 0 0 0 0 1 0 1 1 0 2 0 1 1 0 0 1 17.5 40.010.73.715.310.75.0
9.23.13.01.4016.03.05.312.0 0 2
YT-9755 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 0 0 0 1 19.0 37.311.33.320.311.04.9
9.53.42.81.9019.04.74.011.7 0 2
YT-10080 0 1 0 1 0 0 0 0 0 1 1 1 1 0 2 0 1 1 0 0 1 10.3 24.310.02.414.511.04.4
10.63.82.80.8319.33.85.110.0 0 2
YT-11307 0 2 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 9.8 31.012.02.615.013.04.2
9.43.22.92.5021.34.44.811.5 0 2
YT-12158 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 2 1 0 0 1 29.5 80.020.73.915.517.05.6
13.33.93.42.4029.35.85.1 8.0 0 2
YT-13760 0 2 0 1 0 0 0 0 0 1 0 1 1 0 2 0 2 1 0 0 1 19.3 68.817.04.020.115.84.9

12.13.83.21.8031.84.27.611.7 0 2
NWT-83 0 1 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 13.2 43.5 9.04.820.011.03.3
10.92.83.91.8017.54.73.710.0 0 2
NWT-1530 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 20.5 46.012.03.815.511.04.0
11.33.13.61.3023.54.65.1 7.5 0 2
NWT-3964 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 1 0 0 1 10.3 40.015.02.715.011.0-9
9.14.12.21.7024.36.63.7 7.0 0 2
NWT-6647 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 15.5 50.013.73.618.013.04.0
13.03.14.21.6030.83.88.1 9.0 0 2
NWT-9197 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1
32.0100.014.37.020.711.74.9 12.33.14.00.9030.04.66.5 8.5 0 2
AK-19 0 1 0 1 0 0 0 0 0 1 0 1 1 0 2 0 2 0 0 0 1 19.3 54.710.05.520.016.03.7
11.92.35.21.0026.35.54.810.0 1 2
AK-46 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 2 1 0 0 1 11.5 16.7 9.31.816.510.53.8
9.03.52.61.4017.55.13.4 8.5 -9 2
AK-71 0 1 0 1 0 0 0 1 0 1 0 1 1 0 1 0 1 1 0 0 1 17.7 40.010.53.821.714.74.7
11.83.13.80.5025.75.34.810.0 0 2
AK-78 0 2 0 1 0 0 0 0 0 1 0 1 1 0 2 0 1 1 0 0 1 12.7 33.8 8.83.818.515.35.8
12.92.84.6-9 -9 -9 -9 10.0 1 2
AK-116 0 1 0 1 0 0 0 0 0 1 0 1 1 0 2 0 1 1 0 0 1 32.0 64.026.02.516.015.04.5
9.93.03.30.7524.04.45.5 8.0 0 2
AK-163 1 1 0 1 2 0 0 1 0 3 0 1 1 0 1 1 1 0 0 0 1 13.6 32.310.73.020.011.74.8
9.02.14.3-9 19.43.85.110.0 -9 2
AK-184A 0 1 0 1 0 0 0 1 0 1 0 1 1 0 1 0 1 1 0 0 1 14.3 36.010.73.418.313.05.4
12.22.84.41.9032.75.65.8 7.0 0 2
AK-196 0 2 0 1 0 0 1 0 0 1 0 1 2 0 1 0 2 0 0 0 1 10.5 35.0 8.74.015.011.74.2
10.02.24.50.7520.34.94.1 8.5 0 2
AK-273 0 2 0 1 0 0 2 0 0 1 1 1 2 0 3 0 3 1 0 0 1 10.5 44.012.73.518.011.04.3
12.83.04.31.0324.64.55.510.7 1 2
AK-283 0 2 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 12.0 37.511.53.317.311.0-9
12.74.13.11.6022.83.95.8 8.5 1 2
AK-367 0 1 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 10.5 31.311.32.817.510.03.8
10.22.93.50.4321.04.05.3 9.0 0 2
AK-379 0 2 0 1 0 0 ~~1 0 0 1 1 1 1 0~~ 1 0 1 0 0 0 1 20.0 36.7 9.04.116.011.34.0
10.42.54.20.65 -9 -9 -9 9.0 0 2
AK-475 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 1 0 0 0 1 18.5 37.312.53.015.812.84.2
10.62.05.31.4022.44.74.812.5 0 2
AK-503 0 1 0 1 0 0 0 0 0 1 0 1 1 0 2 0 2 1 0 0 1 18.5 45.730.31.517.012.04.0
10.72.93.70.3022.74.64.9 7.0 1 2
AK-504 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 2 1 0 0 1 15.0 54.319.52.815.312.04.2
9.92.83.51.3518.35.13.6 9.5 1 2
AK-505 0 2 0 1 0 0 0 0 0 1 1 1 1 0 2 0 2 1 0 0 1 23.8 54.315.33.513.513.84.7
11.13.23.50.9323.84.45.4 9.5 1 2
AK-506 0 2 0 1 0 0 1 0 0 1 1 1 1 0 2 0 2 1 0 0 1 22.3 62.815.84.019.814.34.7
13.23.14.31.7031.66.44.911.3 1 2
AK-515 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 2 1 0 0 1 14.0 46.013.53.417.713.74.6
10.82.74.01.0423.16.13.810.5 1 2
AK-516 0 2 0 1 0 0 0 0 0 1 0 1 1 0 2 0 2 1 0 0 1 12.0 40.010.73.714.312.34.6
9.12.83.30.5219.95.23.8 8.0 1 2
AK-517 0 2 0 1 0 0 0 0 0 1 0 1 2 0 3 0 3 1 0 0 1 14.6 44.613.83.222.614.44.7
11.83.33.62.6631.25.35.911.8 1 2
AK-680 0 2 0 1 0 0 1 0 0 1 0 1 2 0 3 0 3 1 0 0 1 7.0 23.0 9.52.415.011.54.5
9.23.32.81.4025.34.95.2 9.0 -9 2
AK-685 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 17.8 38.810.03.914.312.75.0
10.33.33.11.4423.34.25.5 9.0 0 2
AK-1192 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 1 1 0 0 1 25.0 31.711.02.917.015.55.1
9.93.72.72.2027.87.23.9 8.0 0 2
AK-1302 0 1 0 1 0 0 1 0 0 1 1 1 1 0 1 0 2 0 0 0 1 12.8 36.311.03.316.311.34.4
10.82.34.71.0022.93.76.210.0 0 2
AK-1366 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 0 1 9.0 42.311.73.614.311.34.1
9.62.04.80.8322.75.34.3 8.5 1 2
AK-1478 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 2 0 0 0 1 22.7 81.716.35.013.012.54.5

9.82.63.80.9323.74.35.5 7.0 0 2
AK-1776 0 1 0 1 0 0 1 0 0 1 0 1 2 0 1 0 2 1 0 0 1 18.5 40.010.33.915.312.3-9
11.03.43.21.2024.74.06.2 8.7 0 2
AK-1833 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 2 1 0 0 1 14.3 52.415.03.517.810.3-9
11.23.03.70.4320.04.94.110.0 0 2
AK-1891 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 0 0 0 1 9.3 26.7 9.03.014.0 9.3-9
10.62.54.21.0021.73.85.712.0 0 2
AK-1960 0 1 0 1 0 0 0 0 0 1 1 1 1 0 2 0 1 0 0 0 1 27.0 53.311.74.614.312.74.1
9.32.63.61.5023.53.66.5 9.0 0 2
AK-2129 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 1 1 1 0 1 1 14.3 40.011.33.518.012.34.9
12.02.94.11.7020.34.15.014.0 1 2
AK-2610 0 2 0 1 0 0 1 0 0 1 0 1 2 0 2 0 3 1 0 0 1 13.2 44.315.03.014.311.74.4
9.73.62.71.6024.35.54.4 9.5 1 2
AK-2654 0 2 0 1 0 0 1 0 0 1 0 1 1 0 2 0 2 1 0 0 1 13.5 68.812.35.616.813.5-9
10.73.72.91.4530.55.85.310.0 0 2
AK-2804 0 2 0 1 0 0 1 0 0 1 1 1 2 0 3 0 3 0 0 0 1 17.3 42.518.02.420.315.34.5
11.72.54.72.7526.75.84.613.3 1 2
AK-3492 0 2 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 13.3 39.310.73.722.711.3-9
11.82.94.10.8024.03.56.910.5 1 2
AK-4167 0 2 0 1 0 0 1 0 0 1 1 1 2 0 3 0 3 1 0 0 1 11.0 42.314.33.019.010.5-9
10.82.83.91.7023.53.76.413.0 1 2
AK-4248 0 2 0 1 0 0 1 0 0 1 1 1 1 0 1 1 1 1 0 0 1 8.0 28.5 8.03.615.715.05.0
10.42.44.30.9021.03.16.8 8.0 -9 2
AK-5621 0 1 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 13.3 41.710.34.015.711.0-9
11.03.33.30.7023.34.65.1 8.5 0 2
AK-6265 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 30.0 97.526.33.723.516.05.2
11.03.53.11.3034.85.16.813.0 0 2
AK-6673 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 26.5 85.015.55.516.512.54.4
11.33.23.50.7328.05.84.8 8.5 0 2
AK-6713 0 1 0 1 0 0 1 0 0 1 0 1 1 0 2 0 1 1 0 0 1 11.3 30.0 9.73.117.515.35.3
11.33.63.11.7027.04.85.6 7.5 0 2
AK-7813 0 2 0 1 0 0 0 0 0 1 1 1 2 0 3 0 3 1 0 0 1 18.3 38.021.31.820.014.44.7
13.13.63.61.8232.65.95.511.0 1 2
AK-7814 0 2 0 1 0 0 0 0 0 1 1 1 2 0 3 0 3 1 0 0 1 15.7 45.024.61.825.515.05.2
10.52.64.02.8028.84.17.016.0 1 2
AK-7817 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 14.0 30.115.02.019.014.04.8
9.93.33.01.8028.46.04.712.5 0 2
AK-7820 0 2 0 1 0 0 0 0 0 1 1 1 1 0 2 0 1 1 0 0 1 17.0 47.017.52.716.512.54.4
11.74.32.71.5019.76.03.3 9.0 0 2
AK-7821 0 1 0 1 0 0 0 0 0 1 1 1 1 0 2 0 1 1 0 0 1 19.3 55.015.53.521.314.34.3
12.13.83.21.7022.33.85.910.0 0 2
AK-8371 0 1 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 19.8 38.312.73.021.013.03.9
10.12.93.50.7721.33.65.911.5 1 2
AK-19113 0 2 0 1 0 0 0 0 0 1 0 1 1 0 2 0 1 1 0 0 1 7.3 23.510.02.415.7 9.74.5
10.03.13.22.6019.25.93.310.0 1 2
AK-20384 0 1 0 1 0 0 0 1 0 1 1 1 1 0 1 0 1 1 0 0 1 8.5 21.7 8.02.712.3 8.7-9
10.33.03.4-9 -9 -9 -9 8.0 1 2
AK-26069 0 2 0 1 0 0 1 0 0 1 0 1 2 0 1 0 3 1 0 0 1 10.0 30.5 8.73.520.015.04.7
9.33.03.11.2025.74.95.210.0 0 2
AK-52992 0 1 0 1 0 0 0 0 0 1 0 1 1 0 2 0 2 0 0 0 1 15.5 48.315.03.220.515.05.6
11.52.54.60.8026.54.65.8 9.5 1 2
AK-54238 0 2 0 1 0 0 0 0 0 1 0 1 2 0 2 0 1 1 0 0 1 19.5 36.013.32.720.312.74.5
11.02.83.91.6027.74.95.710.0 0 2
AK-75132 0 1 0 1 0 0 1 0 0 1 1 1 0 0 0 0 1 1 0 0 1 12.0 39.0 9.54.118.511.84.1
10.12.83.60.5021.75.44.010.5 0 2
AK-77409 0 1 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 40.0 85.527.53.119.013.05.0
13.34.13.21.8630.35.55.510.0 -9 2
UR-89929 0 1 0 1 0 0 0 0 0 1 0 1 1 0 1 0 2 1 0 0 1 24.7 40.011.73.416.313.05.6
11.53.03.80.4328.35.84.9 9.0 0 2
UR-89932 0 1 0 1 0 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 12.0 35.011.73.012.5 9.54.5
8.83.12.81.2024.05.64.3 8.5 0 2
UR-89937 0 2 0 1 0 0 1 0 0 1 0 1 1 0 1 0 2 1 0 0 1 14.0 32.311.02.917.310.74.6

9.52.93.31.7027.75.45.110.0 0 2
UR-89938 0 2 0 1 0 0 1 0 0 1 0 1 2 0 1 0 2 0 0 0 1 12.0 27.5 7.53.713.510.54.0
8.92.33.91.0028.06.44.4 8.5 0 2
UR-89939 0 2 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 1 0 0 1 14.7 31.710.03.214.0 9.74.4
10.62.93.70.40 -9 -9 -9 9.0 0 2
UR-89940 0 1 0 1 0 0 1 0 0 1 0 1 1 0 1 0 2 1 0 0 1 23.0 73.519.53.815.013.04.6
9.52.73.52.9021.74.94.4 8.0 0 2
UR-89941 0 1 0 1 0 0 1 0 0 1 0 1 1 0 1 0 2 1 0 0 1 13.7 45.012.33.716.012.34.4
10.03.33.00.4026.35.84.5 8.5 0 2

ANALYSIS 2. *ARNICA FULGENS* AND *A. SORORIA*

(2A4,21F2.0,1X,2F3.1,2F4.1,F3.1,3F4.1,F3.1,F4.1,3F3.1,F4.1,2F3.1, F4.1,2F3.1)
A-554 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.05.041.0 9.01.6 5.626.016.0
4.912.42.25.60.925.74.45.810.08.94.5
A-555 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.05.024.5 7.51.1 6.821.015.0
4.511.72.54.70.721.04.54.711.07.53.1
A-559 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.522.8 8.01.2 6.720.513.5
4.411.02.83.90.421.55.24.113.07.33.9
A-562 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.019.0 6.01.4 4.321.514.5
4.812.12.84.30.521.25.14.211.57.13.8
A-563 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.519.0 4.50.9 5.022.313.0
4.311.92.45.00.623.34.35.411.06.53.5
A-564 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.519.8 5.50.9 6.121.014.3
4.111.43.13.70.619.74.74.210.07.13.2
A-565 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.521.7 5.71.0 5.721.313.0
4.311.42.05.70.622.03.85.811.57.03.5
A-566 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.518.5 5.11.1 4.618.712.7
4.211.32.34.90.620.83.55.910.57.33.6
A-571F 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.020.7 5.61.2 4.723.013.0
4.212.12.54.80.821.94.25.214.57.43.5
WY-697 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.025.5 7.80.9 8.724.514.5
5.411.83.23.70.722.75.34.310.57.94.0
WY-698 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.039.0 8.01.3 6.230.016.0
5.012.03.04.00.925.04.55.612.08.13.5
WY-699 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.529.5 8.41.3 6.525.513.5
5.112.92.74.81.324.44.55.413.07.53.0
WY-700 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.05.027.0 6.51.3 5.026.015.0
5.615.13.54.31.531.87.24.4 8.07.93.7
WA-109 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.024.3 9.21.2 7.724.013.0
3.911.32.44.70.9 -9 2.9-9 10.07.32.9
MO-310 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.05.032.3 9.31.3 7.221.013.5
6.613.62.65.20.423.04.25.511.58.03.7
MO-1497 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.535.813.91.013.921.3
15.0 4.312.22.45.10.520.03.45.910.07.33.3
ND-95776 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.03.526.5 6.31.5 4.224.0
15.0 4.212.02.74.41.222.56.33.613.56.82.7
ID-1939 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.069.517.51.412.525.0
14.0 5.012.52.25.70.425.25.34.810.07.23.6
A-11648 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.029.5 8.81.5 5.922.5 12.0
3.911.92.05.70.922.24.25.315.07.22.6
A-16927 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.022.5 4.90.9 5.417.0
12.0 4.213.02.65.00.720.74.34.811.06.62.9
A-16903 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.524.5 7.81.5 5.222.0 15.0
5.110.62.24.80.522.34.25.313.57.43.4
BC-1841 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.04.037.5 8.31.3 6.423.0 13.0
4.611.63.73.10.422.55.73.9 8.0-9 -9
CO-1463 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1.05.027.3 8.11.0 8.123.7 14.0

4.412.42.74.61.322.66.33.615.08.02.9
CO-4382 0 2 1 0 1 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.05.069.018.31.413.125.0
15.0 3.7 -9 -9 -9 1.524.76.93.614.07.02.6
OR-744 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.03.011.5 4.11.0 4.115.0 11.0
3.710.91.95.70.517.84.44.010.07.13.1
S-4312 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.03.034.8 6.91.3 5.318.3 11.7
3.910.12.93.50.723.54.45.312.07.22.8
BC-530 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.04.040.012.81.5 8.522.8 14.0
3.711.92.94.11.222.26.53.414.36.62.9
M-11040 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.04.053.018.71.117.021.0
16.0 4.5 9.72.14.60.519.23.75.210.57.93.6
A-11866 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.04.052.514.02.1 6.729.5
16.0 4.914.92.75.51.324.46.93.512.58.43.5
A-2749 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.04.330.0 9.11.6 5.723.3 14.4
4.512.23.04.10.421.85.63.910.08.13.6
A-1174 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 1 1 1 1 1 1.04.522.0 9.41.2 7.820.2 12.2
4.212.42.84.40.518.56.32.911.08.13.3
A-557 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1 1.04.015.8 6.13.5 1.717.3 10.7
3.411.02.15.20.321.33.75.811.07.73.8
A-558 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.025.4 6.90.8 8.622.0 11.3
3.3 9.91.95.20.817.74.04.412.77.73.5
A-568 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 3.04.523.0 5.21.1 4.723.0 12.7
4.212.12.45.01.224.14.65.213.09.04.2
A-569 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.526.0 8.21.1 7.524.0 13.7
3.811.42.15.40.823.05.04.614.38.74.6
A-570 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.022.6 7.20.8 9.021.8 12.3
3.511.52.25.20.521.35.04.313.57.53.7
A-571S 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.524.7 7.71.1 7.023.3 12.7
3.711.22.25.10.420.73.36.314.08.33.9
A-572 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 5.05.038.3 8.62.1 4.121.5 12.5
3.610.93.03.60.425.06.24.012.07.63.3
A-573 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.042.011.81.3 9.127.0 15.0
3.311.82.54.70.930.37.14.314.07.93.2
A-574 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.04.523.7 5.00.8 6.320.7 13.3
4.411.02.44.60.322.04.94.511.59.14.7
UT-588 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.026.0 6.51.4 4.620.0 11.3
3.411.12.84.00.923.84.45.413.08.43.4
UT-13815 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.03.535.011.41.9 6.021.5
15.5 4.211.32.34.90.724.74.85.111.09.73.9
NE-13460 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.04.526.3 7.90.9 8.815.0
12.0 3.5 9.91.95.20.820.74.05.210.07.23.4
ID-717 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.035.0 8.41.2 7.024.0 13.5
3.813.92.55.60.222.74.35.311.09.34.2
ID-4765 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.03.523.7 9.11.8 5.123.0 12.3
3.811.72.44.91.124.15.34.513.77.63.4
ID-3293 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.546.510.81.5 7.222.0 13.0
4.210.22.05.10.426.34.46.015.08.03.7
ID-26659 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.532.3 9.31.0 9.324.0
14.5 4.111.62.54.60.728.25.15.512.58.93.6
CA-866 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 3.04.019.0 6.90.9 7.724.0 11.0
3.6 9.72.44.00.415.33.54.4 9.07.53.5
CA-1788 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.022.3 6.51.2 5.420.5 11.3
3.911.92.35.21.121.05.04.212.07.73.8
WY-58727 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.03.525.0 6.31.1 5.718.5
12.5 3.811.01.95.81.224.54.55.413.08.13.6
OR-1929 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.04.039.3 9.71.3 7.523.3 12.7
3.711.61.86.41.222.74.64.910.77.53.5
OR-2381 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.04.529.5 6.81.4 4.921.0 11.3
4.313.72.16.51.127.54.36.414.59.24.3
MO-4743 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.030.2 5.80.9 6.419.0
13.0 3.610.11.95.30.722.04.25.210.38.75.1
MO-4510 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.04.531.3 7.01.4 5.020.5

11.0 3.610.62.15.01.423.55.94.012.08.75.0
MO-11499 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.529.8~~7~~.90.8 9.819.0
12.0 3.611.91.86.60.222.04.74.711.08.63.7
WA-4461 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.039.5 7.31.3 5.618.3
13.8 4.010.22.34.40.426.36.04.412.07.53.7
WA-551 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.55.536.0 8.01.0 8.021.0 12.5
3.510.72.24.90.420.84.25.012.57.83.5
OR-7360 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 3.05.038.310.01.6 6.323.7
12.5 4.012.82.84.60.527.35.55.010.58.33.9
WA-8064 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.034.7 9.61.5 6.412.3
10.7 3.612.21.48.70.518.03.65.010.07.33.7
A-15768 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 3.05.042.513.50.915.019.5
14.0 3.3 9.82.73.61.424.75.74.310.58.13.7
A-16893 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.05.021.06.01.3 4.622.7 11.7
3.311.32.54.50.419.34.74.113.08.13.7
BC-8157 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.526.7 7.31.3 5.620.0 12.5
3.510.32.14.90.224.95.34.713.37.53.7
BC-9552 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 1.04.031.0 6.31.0 6.321.3 11.2
3.711.61.67.30.322.35.44.113.08.43.7
BC-9519 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 3.05.044.310.41.6 6.521.4
11.2 3.411.51.57.70.825.56.04.315.08.63.5
BC-11565 0 2 1 0 1 1 1 0 0 1 1 2 0 2 0 1 2 0 1 0 1 2.05.031.3 7.41.1 6.722.5
11.0 3.410.52.24.80.216.74.43.815.58.63.5
NWT-3416 0 1 0 2 1 1 2 0 0 1 1 2 0 2 0 1 2 2 0 0 2 3.04.037.5 9.10.811.412.5
9.0 4.610.02.14.80.622.74.45.2 8.05.92.7
A-14723 0 1 0 2 1 1 2 0 0 1 1 2 0 2 0 1 2 2 0 0 2 3.04.040.0 8.31.7 4.911.5 10.0
3.3 8.42.23.80.413.53.73.6 8.05.42.0
NWT-7081 0 1 0 2 1 1 2 0 0 1 1 2 0 2 0 1 2 2 0 0 2 7.07.042.0 9.82.4 4.114.3
10.0 4.3 9.02.53.60.320.65.33.9 7.57.52.7
A-426 0 1 1 0 1 1 1 0 0 2 1 2 0 2 2 1 2 2 0 0 1 1.54.013.8 5.61.3 4.314.3 10.7
4.410.52.34.60.719.14.44.3 8.57.83.4
NWT-140 0 1 0 0 1 1 1 0 0 2 1 2 0 2 0 1 2 2 0 0 1 1.04.523.7 6.71.1 6.122.7
12.3 4.510.12.24.60.824.37.23.414.57.63.5
BC-7015 0 1 1 0 1 1 1 0 0 2 1 2 0 2 0 1 2 2 0 0 1 1.03.016.4 8.31.1 7.521.0 12.0
4.311.73.63.34.124.36.83.6 8.37.23.1

ANALYSIS 3. *ARNICA ANGUSTIFOLIA*

AF01 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 22.80
8.20 1.30 19.30 15.00 4.90 11.40 2.70 3.50 24.70 5.30 12.00 ~~7.70 3.50~~
AO01 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 17.80
4.70 0.70 15.70 11.30 3.60 10.00 2.10 2.90 16.80 4.60 11.70 6.00 2.20
AO02 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 4.00 1.00 1.00 1.00 3.00 12.50
4.50 1.00 20.00 12.00 4.40 10.20 2.30 3.50 17.00 5.00 14.00 6.90 2.70
AO03 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 13.70
4.20 0.90 15.00 11.00 4.40 9.70 2.10 4.20 20.30 5.40 11.00 6.90 2.70
AO04 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 2.30 12.80
4.60 0.80 17.00 11.30 3.90 10.40 2.20 4.00 17.50 4.90 12.00 5.80 2.20
AO05 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 2.50 10.50
3.70 0.70 17.00 10.50 4.40 9.20 2.70 1.70 14.30 3.70 11.50 6.90 2.70
AO06 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 27.50
7.30 0.90 17.50 14.00 4.40 9.70 2.30 2.60 18.80 5.20 10.00 7.30 2.90
AO07 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 4.00 1.00 2.00 1.00 2.00 9.50
3.50 0.80 17.50 12.50 4.00 7.40 2.60 1.90 18.00 4.90 9.50 6.10 2.50
AS01 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 27.20
8.40 1.30 20.70 16.30 4.30 10.20 2.60 2.00 22.30 4.70 11.00 7.30 3.00
AS02 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 4.00 17.00
6.40 0.80 16.00 11.00 4.50 10.60 2.00 2.60 21.00 4.60 7.00 6.90 2.70

AS03 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 4.00 1.00 2.00 1.00 3.00 21.80
5.80 1.10 17.70 15.00 4.50 10.70 3.20 2.70 20.80 6.00 8.50 6.80 2.60
AV01 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 2.50 10.30
3.30 0.50 17.00 11.00 4.00 9.30 2.90 0.90 10.50 3.60 11.00 6.90 2.70
AV02 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 2.50 12.00
4.00 0.60 16.70 12.00 3.80 9.90 2.50 1.30 15.70 4.50 10.00 6.30 2.30
AV03 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 2.50 10.70
2.50 0.70 16.70 11.30 4.00 10.30 3.20 1.20 13.60 4.40 9.50 6.90 2.70
AV04 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 11.70
5.60 1.00 21.00 11.50 4.00 11.20 2.50 1.00 15.40 4.40 10.50 6.90 2.70
AV05 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 1.00 3.00 17.10
5.60 0.70 21.70 14.30 4.30 11.30 2.50 1.20 19.80 4.20 9.50 6.90 2.70
TA01 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 3.50 14.50
4.90 0.90 21.00 13.10 5.00 11.00 3.30 1.50 16.10 5.10 8.50 7.70 3.50
TA02 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.50 22.00
6.70 0.80 20.70 15.70 7.30 11.70 2.90 1.40 20.00 6.60 8.50 8.20 3.20
TA03 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.00 13.00
5.20 0.90 18.30 13.80 4.60 11.40 2.90 1.70 27.80 7.70 8.30 7.20 3.5
TA04 1.00 3.00 1.00 2.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 3.50 13.00
5.00 0.80 20.00 15.50 5.00 12.90 3.00 2.90 25.70 5.90 9.00 7.80 3.60
TA05 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.00 12.80
5.50 0.50 20.00 14.50 6.30 10.70 2.70 1.60 17.30 4.80 10.00 8.30 3.30
TA06 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 3.00 14.20
5.20 0.70 18.30 14.70 6.70 10.90 2.80 1.40 15.10 4.90 8.00 7.30 3.00
TA07 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.00 12.00
4.30 0.80 19.00 13.00 5.00 11.70 2.60 1.00 15.80 4.70 7.50 6.20 2.60
TA08 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 3.50 12.60
4.60 1.10 17.20 11.50 5.00 9.80 2.60 1.60 15.70 5.30 9.00 6.50 3.00
TA10 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.00 11.00
4.30 0.60 15.50 12.50 4.60 10.20 2.80 1.20 18.80 4.90 9.50 6.80 3.00
TB01 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.00 15.70
5.60 0.80 18.00 15.00 6.30 10.10 2.40 0.70 15.30 7.60 7.50 7.50 3.00
TB02 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 3.00 15.30
6.30 0.90 18.30 12.70 4.60 11.20 3.30 0.60 15.20 5.90 9.50 7.00 3.10
TX01 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 4.00 1.00 2.00 1.00 4.50 8.30
4.80 0.40 17.70 13.00 5.30 10.90 2.60 2.40 20.00 4.90 11.00 6.00 2.90
TN01 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 3.00 2.00 2.00 1.00 3.50 14.00
6.80 1.10 22.50 16.50 5.10 13.50 3.70 1.60 24.20 8.00 9.00 8.40 3.10
TN02 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 3.00 2.00 2.00 1.00 4.00 18.00
6.50 0.80 21.70 15.80 6.10 12.70 4.00 2.20 24.00 9.00 8.30 8.80 3.60
TN03 1.00 3.00 1.00 3.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 4.00 15.00
6.50 0.70 17.50 13.50 4.90 10.80 3.10 0.90 16.60 4.70 9.00 7.50 3.20
PL01 1.00 1.00 1.00 1.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 1.00 3.00 16.50
6.90 1.10 15.30 11.30 4.30 8.50 2.40 1.20 18.00 5.30 9.00 6.20 2.90
SL01 1.00 2.00 1.00 1.00 1.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 21.00
5.60 0.70 17.70 16.00 5.30 12.60 2.50 1.20 28.50 6.00 10.00 8.50 3.30
SL02 1.00 2.00 2.00 1.00 1.00 1.00 2.00 2.00 2.00 1.00 2.00 1.00 3.50 21.00
6.20 0.80 22.50 17.00 4.80 12.00 2.40 1.00 29.30 5.60 9.50 7.70 3.70
SL03 1.00 2.00 1.00 2.00 2.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 3.50 24.50
7.90 0.60 16.00 12.30 4.10 10.50 2.40 1.70 27.60 6.20 9.00 7.20 3.00
SL04 1.00 2.00 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 11.50
5.80 0.30 18.30 14.70 4.10 10.50 2.40 1.10 22.80 5.00 9.50 7.60 3.10
SL05 1.00 2.00 1.00 1.00 2.00 1.00 2.00 2.00 2.00 1.00 2.00 1.00 4.00 23.70
8.20 0.60 19.00 14.30 5.40 12.50 2.50 1.20 22.80 5.30 12.30 8.50 3.90
SN06 1.00 2.00 1.00 1.00 1.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 22.50
6.70 0.80 22.00 15.50 5.40 10.80 3.00 1.40 32.50 5.90 9.70 8.30 3.50
SN07 2.00 2.00 1.00 2.00 2.00 1.00 1.00 2.00 3.00 1.00 2.00 1.50 3.40 26.00
11.30 1.40 21.30 18.70 6.50 13.30 2.80 1.60 20.30 5.00 11.00 8.70 3.80
SN08 1.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 22.00
5.70 0.80 20.00 17.00 4.70 12.80 2.30 3.00 24.60 6.80 9.00 7.20 3.20
SN09 1.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 21.00
6.30 1.00 22.50 13.50 4.90 13.00 2.90 1.80 23.50 7.00 12.00 7.70 3.20

SN10 1.00 2.00 1.00 1.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 1.00 5.00 37.00
10.90 1.80 21.50 13.50 4.80 12.30 2.60 0.80 21.00 4.20 10.00 8.20 3.30
SQ01 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.50 3.00 15.50
7.20 1.20 21.30 16.30 5.20 11.50 2.50 0.70 19.50 5.70 12.00 7.70 3.20
SQ02 1.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 1.00 4.00 14.00
7.10 1.40 22.80 14.00 4.50 11.70 2.90 1.30 23.80 7.30 12.70 7.20 3.10
SQ03 1.00 2.00 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 23.30
6.60 0.70 24.00 16.50 5.10 12.60 2.20 1.60 25.70 5.30 10.00 8.70 3.70
SQ04 2.00 2.00 2.00 2.00 2.00 1.00 2.00 2.00 2.00 1.00 2.00 2.00 3.00 28.00
8.70 0.70 22.30 17.70 5.10 12.30 2.60 1.20 24.60 5.40 11.50 8.40 3.50
SQ05 2.00 2.00 2.00 1.00 2.00 1.00 2.00 2.00 2.00 1.00 2.00 3.00 4.00 30.00
8.80 1.10 20.00 16.70 4.50 12.90 2.70 1.20 25.30 5.70 8.50 8.30 3.50
SQ06 2.00 2.00 1.00 2.00 2.00 1.00 2.00 2.00 3.00 1.00 2.00 1.50 4.00 11.70
6.20 0.90 19.70 12.70 4.80 10.60 2.40 0.80 25.30 6.00 12.30 6.50 3.10
NG01 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 2.50 14.40
4.80 0.60 13.30 11.00 4.00 9.80 1.90 1.20 16.20 5.20 9.00 6.30 2.50
NG02 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.30 3.30 26.30
5.80 0.80 19.30 14.70 3.90 9.60 2.40 0.80 15.20 4.40 10.70 6.80 3.10
NG03 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 2.50 16.50
5.80 0.70 20.00 10.50 3.90 9.70 2.30 1.00 15.30 4.20 11.50 6.20 2.10
NG04 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 2.00 1.00 2.00 1.00 2.70 9.00
3.40 0.50 16.30 10.00 3.60 9.30 2.50 1.20 15.00 4.60 9.50 7.10 3.50
NG05 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 8.70
4.20 1.00 18.00 12.70 3.90 10.30 2.60 0.90 17.60 5.10 9.50 6.70 2.90
NG06 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 2.00 19.50
5.30 0.90 16.00 13.50 3.80 9.20 2.40 0.90 16.60 3.80 10.00 5.40 2.70
NG07 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 3.00 21.20
5.50 0.60 17.00 14.70 4.70 10.30 2.80 1.00 22.60 6.00 8.70 7.00 2.90
NG08 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 2.50 13.50
3.90 0.70 15.50 10.00 3.40 8.00 2.40 0.40 15.40 4.10 8.50 6.40 2.40
NG09 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 2.00 10.00
4.00 0.60 17.00 11.00 3.90 9.20 2.60 0.40 14.80 5.20 10.00 6.20 2.40
NG10 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 22.00
7.00 0.50 14.30 14.70 5.20 11.00 2.70 1.40 25.70 6.80 9.30 7.50 3.00
NG11 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 2.50 14.00
5.20 0.80 15.00 11.00 3.70 10.00 2.50 1.20 16.20 4.80 10.00 6.40 2.40
NG12 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 3.00 12.50
4.80 0.90 17.30 14.70 4.20 10.50 2.80 1.10 20.60 5.50 8.50 7.00 2.80
NG13 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 2.00 16.50
5.50 0.90 14.70 12.00 4.00 10.00 2.20 1.10 19.50 5.60 10.30 6.50 2.50
NG14 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 3.00 20.80
6.30 1.00 17.00 12.80 3.40 9.20 1.90 0.80 15.10 4.90 10.00 6.10 2.50
NG15 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 10.00
4.20 0.50 17.50 14.50 4.40 10.80 2.10 1.00 18.50 4.20 9.50 7.60 2.90
NG16 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 2.80 15.30
4.70 0.80 15.00 11.70 4.00 8.90 2.20 1.40 17.30 5.10 10.00 7.00 2.60
NG17 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 9.00
5.40 1.00 14.00 12.60 4.40 10.30 2.30 1.10 20.00 6.00 11.70 6.70 2.80
NG18 2.00 2.00 1.00 2.00 2.00 1.00 2.00 2.00 3.00 1.00 2.00 1.50 3.70 16.60
7.30 0.70 16.30 15.00 4.80 11.90 2.80 1.10 20.20 5.30 11.00 7.90 3.30
NA01 2.00 2.00 1.00 1.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.50 3.50 13.50
5.80 1.20 16.70 11.30 4.30 10.90 2.30 1.20 16.80 4.20 8.70 7.00 2.30
NA02 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.70 13.20
6.50 0.80 15.00 14.30 4.90 10.70 1.90 1.30 14.30 5.50 9.70 7.40 2.90
NB03 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 2.80 12.30
5.70 0.60 20.70 11.30 4.20 10.40 1.90 1.80 21.30 4.30 12.50 6.10 2.40
NN04 1.00 2.00 1.00 2.00 2.00 2.00 3.00 2.00 3.00 1.00 2.00 1.00 3.00 21.30
5.10 0.70 19.70 12.00 3.80 10.90 2.10 1.30 18.30 4.40 11.30 6.70 2.50
NN05 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 21.30
6.30 1.00 20.30 14.50 4.10 9.50 2.10 1.50 25.00 7.10 13.70 7.10 2.50
NN06 2.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 2.30 3.00 20.80
6.40 0.90 19.50 19.00 5.10 11.30 2.60 1.30 24.00 6.80 8.70 7.50 2.10

NN07 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 1.00 3.00 23.00
7.50 0.90 17.00 14.00 4.80 10.50 3.20 2.60 22.30 6.70 9.30 7.20 2.70
NN08 1.00 2.00 1.00 1.00 2.00 2.00 3.00 1.00 2.00 1.00 2.00 1.00 2.30 9.30
3.80 0.80 18.70 11.00 3.60 10.30 3.10 1.00 16.30 4.30 9.00 7.20 2.60
NY09 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 23.30
5.50 0.50 20.70 14.00 4.50 13.00 2.40 2.50 25.80 7.20 8.00 8.00 3.10
NY10 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 4.00 1.00 2.00 1.00 3.00 20.30
5.50 0.50 20.70 12.70 5.20 11.40 2.70 1.50 21.80 4.80 9.50 6.30 2.50
NY11 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 17.00
6.30 0.90 20.00 16.70 4.30 9.90 3.00 1.80 25.00 7.20 9.00 7.50 2.70
NY12 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 26.70
7.00 1.00 18.30 14.00 4.70 13.20 2.80 3.00 29.10 7.00 11.00 7.50 2.60
NA13 1.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.00 3.00 13.00
3.90 0.90 15.70 11.30 4.60 10.60 2.10 1.00 20.00 4.80 10.00 6.30 2.60
NA14 2.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.70 3.00 21.50
7.50 1.10 16.70 14.30 4.30 11.30 2.30 1.20 24.00 5.40 8.70 7.70 2.90
NA15 2.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 2.00 1.70 3.00 30.70
5.70 1.30 17.70 14.00 4.30 11.50 2.30 4.00 27.00 6.40 9.70 7.00 3.00
BM01 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 2.00 4.50 32.50
13.70 1.10 23.50 17.50 5.30 11.70 3.10 1.20 24.70 5.80 11.50 7.30 2.80
BM02 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 3.00 4.00 39.50
7.30 0.60 20.00 15.70 5.30 12.80 3.20 1.30 26.70 5.50 9.50 9.10 3.00
BN03 2.00 2.00 1.00 2.00 2.00 2.00 2.00 1.00 3.00 1.00 2.00 1.70 3.00 30.00
7.30 1.10 24.00 17.50 5.00 10.70 2.50 1.10 23.90 5.40 11.00 9.10 3.60
BO04 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.00 4.00 29.00
6.00 0.70 22.50 14.50 5.10 10.00 3.20 1.10 24.50 8.00 11.50 7.40 3.00
BO05 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.00 3.40 27.50
8.70 1.00 15.00 12.50 4.20 10.00 2.70 1.70 12.50 4.40 6.00 6.80 3.00
BY06 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 3.00 3.50 38.80
8.00 1.40 16.50 13.50 5.10 8.80 2.80 0.80 21.20 5.50 12.50 8.70 2.80
BY07 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 3.00 4.00 30.00
8.80 1.70 19.00 15.00 4.10 7.70 2.70 1.50 13.00 5.00 8.00 6.80 2.70
BA08 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 3.00 4.00 54.00
10.50 1.70 25.00 12.00 4.10 9.80 2.00 1.00 24.70 6.60 12.00 7.00 2.50
BA09 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.00 3.30 27.50
9.30 1.20 23.30 17.70 5.10 12.70 2.00 1.70 22.30 4.90 9.00 7.50 2.90
IU01 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 27.70
8.30 1.10 18.00 11.30 4.10 9.10 1.90 2.30 23.00 6.40 9.30 6.00 2.40
IU02 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 2.00 3.00 30.50
8.00 1.20 21.00 15.00 4.70 10.00 2.50 1.30 22.20 6.50 11.00 7.50 2.50
IU03 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 15.70
4.30 0.50 18.30 12.30 4.00 9.50 2.10 1.30 18.30 5.20 8.30 6.50 2.50
IU04 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 4.00 17.00
6.20 0.70 19.00 14.00 4.20 10.80 2.50 2.30 22.30 6.90 13.00 7.50 2.90
IU05 1.00 2.00 1.00 1.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 2.00 17.00
3.10 0.60 17.00 13.00 4.20 7.30 2.50 1.30 15.80 6.40 10.00 6.50 2.50
IU06 2.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 2.00 1.50 3.00 34.50
8.50 0.90 17.00 14.30 4.70 10.10 2.40 2.10 24.70 6.40 8.50 7.50 2.90
IU07 1.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 3.00 1.00 2.00 1.00 3.00 13.50
4.50 0.60 17.50 11.00 4.30 8.00 2.50 0.80 14.30 5.70 11.00 6.10 2.50
IU08 2.00 2.00 1.00 2.00 2.00 2.00 3.00 1.00 3.00 1.00 1.00 2.50 3.00 13.50
5.20 0.70 21.50 12.00 5.10 11.00 2.40 1.30 16.40 3.10 15.50 7.70 3.00
IU09 1.00 2.00 2.00 1.00 2.00 2.00 2.00 2.00 2.00 1.00 2.00 1.00 3.00 24.70
5.80 1.20 17.00 14.70 4.90 10.80 2.80 2.00 24.30 6.30 7.70 8.00 2.70

ANALYSIS 4. *ARNICA* SUBGENUS *ARCTICA*

(2A4,23F2.0,1X,2F3.1,2F4.1,F3.1,3F4.1,F3.1,F4.1,3F3.1,F4.1,2F3.1,F4.1,3F3.1)
A-65519 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 9.3 3.50.9 3.913.5
11.53.810.02.54.00.614.03.84.2 6.7-9 -9 3.0
A-56257 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 5.5 2.30.7 3.514.7
10.73.7 9.52.43.90.413.02.84.7 6.5-9 -9 3.0
A-1067 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 11.0 3.80.9 4.411.3
11.34.6 8.62.04.30.716.13.54.7 9.7-9 -9 3.0
A-544 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 8.0 4.41.2 3.713.4
10.63.810.72.44.40.714.73.24.5 6.3-9 -9 3.0
A-449 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 10.3 4.31.3 3.414.3
10.73.9 9.72.44.10.615.72.85.5 5.7-9 -9 3.0
A-450 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 11.0 4.21.1 4.015.0
11.04.0 9.62.04.90.615.83.64.3 6.0-9 -9 3.0
A-17457 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 9.0 4.31.3 3.516.8
14.34.210.02.54.00.613.32.65.2 7.5-9 -9 3.0
A-1607 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 7.0 4.51.5 3.019.0
16.04.011.62.84.1-9 -9 -9 -9 -9 -9 -9 3.0
A-438 0 2 1 1 0 1 0 0 5 1 1 1 1 0 1 0 0 1 1 1 0 0 1 1.0-9 7.0 2.91.0 2.915.5
10.5-9 11.12.64.30.514.73.93.8 5.5-9 -9 3.0
N-2139 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 11.4 4.51.3 3.418.7
15.23.810.93.53.10.817.53.84.6 7.4-9 -9 3.0
N-2140 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 14.0 5.14.1 3.619.7
15.04.212.43.43.71.019.84.44.5 9.6-9 -9 3.0
N-2141 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.4 6.12.1 3.021.2
13.83.611.33.33.50.818.84.54.2 9.0-9 -9 3.0
N-2142 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 14.6 4.91.4 3.620.6
17.44.011.93.63.30.817.65.13.5 9.2-9 -9 3.0
N-2143 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 10.2 4.01.5 2.817.8
13.03.410.33.92.71.218.04.14.5 8.0-9 -9 3.0
Q-26082 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.3 4.11.4 3.018.7
12.32.810.62.73.90.915.94.03.9 9.5-9 -9 3.0
Q-26083 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.8 3.50.8 4.017.5
15.04.110.82.83.90.816.63.25.2 9.0-9 -9 3.0
Q-26084 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 16.3 4.71.0 5.018.5
13.03.910.13.43.00.516.23.44.8 8.6-9 -9 3.0
N-29216 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.9 4.21.1 3.[illegible].5
15.34.012.03.53.51.116.04.04.0 9.0-9 -9 3.0
N-74031 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 8.5 4.91.4 3.519.0
12.3-9 11.43.63.2-9 -9 -9 -9 -9 -9 -9 3.0
Q-49028 0 1 0 1 0 0 0 0 5 0 0 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.0 4.41.1 3.916.3
13.73.811.03.23.50.9 -9 -9 -9 -9 -9 -9 3.0
BC-7827 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 9.0 2.21.0 2.314.0
10.53.510.43.53.01.116.02.85.710.0-9 -9 3.0
BC-10507 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 10.6 2.91.0 3.118.0
10.5-9 10.13.33.10.321.84.05.5 8.5-9 -9 3.0
BC-60645 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 7.2 1.70.9 1.814.7
10.34.0 8.84.12.10.614.72.75.4 9.0-9 -9 3.0
BC-78430 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 11.0 5.31.1 4.719.0
11.0-9 10.43.43.10.314.73.04.910.0-9 -9 3.0
YT-33 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 16.5 3.40.9 3.817.0
13.04.711.33.53.21.228.83.77.810.0-9 -9 3.0
YT-3767 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 24.0 4.11.3 3.114.3
14.74.111.93.04.02.025.04.26.0 8.5-9 -9 3.0
YT-10080 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 10.3 2.41.0 2.414.5
11.04.410.63.82.80.819.33.85.110.0-9 -9 3.0
NWT-83 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 13.2 4.40.9 4.820.0
11.03.310.92.83.91.817.54.73.710.0-9 -9 3.0
NWT-6647 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 15.5 5.0.1.4

3.618.0 13.04.013.03.14.21.630.83.88.1 9.0-9 -9 3.0
AK-46 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 11.5 1.70.9 1.816.5
10.53.8 9.03.52.61.417.55.13.4 8.5-9 -9 3.0
AK-163 1 1 0 1 0 1 0 0 4 0 1 1 0 0 1 1 0 0 1 1 0 0 1 3.0-9 13.6 3.21.1 3.020.0
11.74.8 9.02.14.3-9 19.43.85.110.0-9 -9 3.0
AK-367 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 10.5 3.11.1 2.817.5
10.03.810.22.93.50.421.04.05.3 9.0-9 -9 3.0
AK-685 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 17.8 3.91.0 3.914.3
12.75.010.33.33.11.423.34.25.5 9.0-9 -9 3.0
AK-77409 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 40.0 8.62.8 3.119.0
13.05.013.34.13.21.830.35.55.510.0-9 -9 3.0
UR-89932 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 12.0 3.51.2 3.012.5
9.54.5 8.83.12.81.224.05.64.3 8.5-9 -9 3.0
UR-89939 0 1 0 1 0 0 0 0 5 0 1 1 0 0 0 1 1 0 1 1 0 0 1 1.0-9 14.7 3.21.0 3.214.0
9.74.410.62.93.70.40-9 -9 -9 9.0-9 -9 3.0
SD-178 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 3.03.030.0 9.32.6 3.610.0
10.74.3 8.81.75.21.015.34.03.8 9.06.62.65.0
SD-243 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 6.04.532.0 9.02.1 4.3 9.5
11.04.0 8.71.65.40.915.73.84.1 7.57.52.97.0
SD-1638 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 6.54.041.0 9.02.4 3.810.3
10.74.6 8.21.55.50.716.03.34.8 -9 7.32.75.0
SD-31790 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 4.02.033.010.82.6
4.213.0 11.04.4 8.31.55.50.615.03.24.7 7.07.32.85.0
SD-16212 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 3.54.022.0 6.01.4 4.3 9.0
10.33.7 7.71.45.50.715.13.93.9 8.06.82.65.0
N-2132 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.03.721.1 8.61.7 5.115.7
21.04.9 9.32.04.70.916.05.62.9 8.57.53.25.0
N-2133 1 1 1 3 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.53.725.3 7.31.4 5.216.5
12.34.7 9.92.05.01.618.25.23.5 9.07.32.03.0
N-2134 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.73.020.3 6.81.4 4.916.7
13.74.110.52.34.60.914.56.22.3 9.57.22.55.0
N-2135 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.33.535.010.42.0 5.219.0
12.85.010.22.54.11.215.55.13.0 8.57.32.75.0
N-2989 1 1 1 3 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.63.723.1 6.01.1 5.513.3
13.05.1 9.92.44.10.818.55.23.6 8.58.33.65.0
NB-72 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.03.532.0 7.01.0 7.012.0
11.04.5 9.82.04.9-9 -9 -9 -9 -9 7.02.95.0
Q-2476 1 1 1 2 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.04.018.5 6.91.7 4.114.0
12.04.4 8.62.43.61.219.75.13.9 8.76.83.05.0
Q-17524 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.04.025.8 7.61.8 4.416.3
12.74.8 8.52.23.91.016.54.83.4 9.57.43.15.0
Q-25337 0 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.04.030.5 5.40.9 6.0 -9 -9
5.7 9.12.43.8-9 -9 -9 -9 -9 8.03.35.0
Q-27547 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.73.327.0 6.21.3 4.814.3
13.75.0 9.42.04.70.817.86.32.8 9.07.33.05.0
A-265 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.54.735.0 8.81.2 7.311.8
10.84.2 9.82.44.10.821.04.05.3 7.07.02.55.0
A-6658 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.03.520.0 4.61.2 3.812.5
11.54.9 8.92.33.90.921.05.93.6 9.07.43.03.0
BC-71642 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.03.529.5 8.61.3 6.613.7
12.04.7 8.32.53.3-9 -9 -9 -9 6.08.02.83.0
M-3429 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 1.53.733.3 9.00.8 9.911.0
13.34.9 8.21.94.30.520.34.84.3 7.07.03.33.0
NT-85 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.33.731.2 7.81.1 7.111.7
13.34.7 8.22.43.40.717.84.54.0 7.57.23.03.0
NT-8524 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.03.328.2 5.30.7 7.613.0
13.04.6 8.92.33.90.621.74.05.4 8.08.03.03.0
NT-3416 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.04.037.5 9.10.8 9.912.5
9.04.610.02.14.80.622.74.45.2 8.05.92.7-9
O-816 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.53.035.5 8.01.1 7.312.7
13.34.3 8.72.24.00.416.24.23.9 8.06.32.83.0
S-16263 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 2.04.037.5 7.21.1 6.514.0

14.34.6 8.02.43.31.119.26.53.011.07.62.73.0
Y-7463 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.04.030.0 6.71.3 5.212.5
13.04.3 8.72.24.00.415.64.73.3 9.08.03.03.0
A-2714 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 1.53.0 9.5 2.90.7 4.1 8.3
10.36.1 8.92.14.2-9 15.64.83.3 7.06.72.63.0
A-22626 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 1.53.014.0 3.21.1 2.913.0
11.05.1 9.22.24.2-9 19.85.73.5 8.76.22.83.0
BC-4 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 1.53.517.2 5.90.9 6.613.7
11.05.2 10.22.14.90.118.05.43.3 7.57.83.03.0
BC-50092 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 2.02.011.0 4.21.0 4.214.3
10.04.4 10.51.85.80.119.35.03.9 8.57.53.23.0
ID-12552 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 3.73.016.4 5.41.3 4.211.7
10.04.8 10.12.14.81.219.05.13.7 8.07.13.13.0
MO-9098 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 1.53.011.5 2.90.9 3.212.3
9.34.3 7.71.84.30.116.55.33.1 8.06.72.63.0
MO-12867 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 1.53.012.3 4.31.0
4.313.0 10.34.911.11.66.9-9 22.44.94.6 7.56.83.43.0
UT-14771 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 2.03.0 8.5 3.30.6 5.513.5
10.04.3 8.52.23.9-9 20.25.53.7 7.07.12.63.0
WA-1496 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 3.03.012.3 4.51.0 4.510.2
10.04.4 8.52.14.00.115.54.23.7 9.06.42.63.0
WY-998 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 3.03.012.7 3.31.0 3.313.8
10.85.1 9.82.44.1-9 18.55.23.6 8.57.33.03.0
A-563 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.03.519.0 4.50.9 5.022.3
13.04.3 11.92.45.00.623.34.35.411.06.53.53.0
A-565 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.04.521.7 5.71.0 5.721.3
13.04.3 11.42.05.70.622.03.85.811.57.03.53.0
A-566 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.03.518.5 5.11.1 4.618.7
12.74.2 11.32.34.90.620.83.55.910.57.33.63.0
A-571F 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.04.020.7 5.61.2 4.723.0
13.04.2 12.12.54.80.821.94.25.214.57.43.53.0
WY-699 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.04.529.5 8.41.3 6.525.5
13.55.1 12.92.74.81.324.44.55.413.07.53.03.0
ND-95776 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.03.526.5 6.31.5 4.224.0
15.04.2 12.02.74.41.222.56.33.613.56.82.73.0
A-11648 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.04.029.5 8.81.5 5.922.5
12.03.9 11.32.05.70.922.24.25.315.07.22.63.0
A-161927 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.04.022.5 4.90.9 5.417.0
12.04.2 13.02.65.00.720.74.34.811.06.62.93.0
CO-1463 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.05.027.3 8.11.0 8.123.7
14.04.4 12.42.74.61.322.66.33.615.08.02.93.0
A-569 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.04.526.0 8.21.1 7.524.0
13.73.8 11.42.15.40.823.05.04.614.38.74.63.0
A-570 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.04.022.6 7.20.8 9.021.8
12.33.5 11.52.25.20.521.35.04.313.57.53.73.0
A-571S 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.04.524.7 7.71.1 7.023.3
12.73.7 11.22.25.10.420.73.36.314.08.33.93.0
UT-588 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.04.026.0 6.51.4 4.620.0
11.33.4 11.12.84.00.923.84.45.413.08.43.43.0
ID-4765 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.03.523.7 9.11.8 5.123.0
12.33.8 11.72.44.91.124.15.34.513.77.63.43.0
WY-58727 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.03.525.0 6.31.1
5.718.5 12.53.811.01.95.81.224.54.55.413.08.13.63.0
WA-4461 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.05.039.5 7.31.3 5.618.3
13.84.0 10.22.34.40.426.36.04.412.07.53.73.0
A-16893 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.05.021.0 6.01.3 4.622.7
11.73.3 11.32.54.50.419.34.74.113.08.13.73.0
BC-8157 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 1.04.526.7 7.31.3 5.620.0
12.53.5 10.32.14.90.224.95.34.713.37.53.73.0
A-7504 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.04.012.8 5.50.511.020.0
14.56.3 10.72.74.01.617.34.83.610.08.33.33.0
A-10328 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.014.2 5.20.7 7.418.3

14.76.710.92.83.91.415.14.93.1 8.07.33.03.0
A-13668 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.04.012.0 4.30.8 5.419.0
13.05.011.72.64.51.015.84 73.4 7.56.22.63.0
A-14244 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.013.3 3.70.7 5.317.0
15.07.9 9.62.83.4-9 -9 -9 -9 -9 8.23.43.0
A-16703 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.512.6 4.61.1 4.217.2
11.5-9 9.82.63.81.615.75.33.0 9.06.53.03.0
A-19313 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.511.3 5.50.8 6.921.0
13.75.310.92.93.80.914.75.62.6 9.06.92.83.0
A-96014 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.04.011.0 4.30.6 7.215.5
12.5-9 10.22.83.61.218.84.93.8 9.56.83.03.0
BC-69739 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.04.015.7 5.60.8 7.018.0
15.06.310.12.44.20.715.37.62.0 7.57.53.03.0
MO-4436 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.5 9.2 5.30.7 7.620.0
13.0-9 11.42.74.2-9 -9 -9 -9 -9 -9 -9 3.0
MO-12965 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.04.5 8.3
4.80.412.017.7 13.05.310.92.64.22.420.04.94.111.06.02.93.0
G-2 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.02.514.4 4.80.6 8.013.3
11.04.0 9.81.95.21.216.25.23.1 9.06.32.55.0
G-24 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.02.516.5 5.80.7 8.320.0
10.53.9 9.72.34.21.015.34.23.611.56.22.15.0
G-150 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.03.021.2 5.50.6 9.217.0
14.74.710.32.83.71.022.66.03.8 8.77.02.95.0
G-413 0 1 1 0 1 1 1 0 1 0 0 1 1 2 0 2 0 1 1 1 0 0 1 1.02.514.0 5.20.8 6.515.0
11.03.710.02.54.01.216.24.83.410.06.42.45.0
G-724 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.03.012.5 4.80.9 5.317.3
14.74.210.52.83.81.120.65.53.7 8.57.02.85.0
G-1220 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.02.016.5 5.50.9 6.114.7
12.04.010.02.24.51.119.55.63.510.36.52.55.0
G-1305 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.03.020.8 6.31.0 6.317.0
12.83.4 9.21.94.80.815.14.93.110.06.12.55.0
G-1701 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.02.815.3 4.70.8 5.915.0
11.74.0 8.92.24.01.417.35.13.410.07.02.65.0
G-6276 0 1 1 0 1 1 1 0 1 0 0 1 1 2 0 2 0 1 1 1 0 0 1 1.03.0 9.0 5.41.0 5.414.0
12.64.410.32.34.51.120.06.03.311.76.72.85.0
G-13067 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.02.010.0 3.00.8 3.813.0
10.0-9 8.52.43.51.012.94.13.111.0-9 -9 5.0
G-TYPE 0 1 1 0 1 1 1 0 1 0 0 2 1 2 0 2 0 1 1 1 0 0 1 1.04.017.0 7.00.8 8.820.0
15.0-9 11.02.05.50.620.85.83.6 9.5-9 -9 3.0
L-157 0 1 1 0 0 1 1 0 0 0 0 1 1 2 0 2 0 1 1 2 0 0 1 1.03.023.0 6.50.513.020.0
13.0-9 12.31.86.80.420.54.05.110.0-9 -9 3.0
L-TYPE 0 0 1 0 0 1 1 0 1 0 0-9-9 2 0-9 2-9 1 2 0 0 1 1.04.017.0 3.81.0 3.8 -9 -9
3.7 9.52.24.31.415.05.12.910.07.52.85.0
BC-64979 1 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 9.06.052.0 9.81.8 5.418.7
11.3-9 12.52.84.50.724.56.24.0 8.0-9 -9 5.0
BC-64987 1 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 0 1 0 1 2.03.037.0 7.31.0 7.317.3
14.0-9 10.32.34.50.518.04.83.8 9.0-9 -9 3.0
FULTYPE 0 2 1 0 1 1 1 1 3 0 0 1 1 2 0 2 0 1 1 1 1 1 1 1.05.030.010.30.911.419.0
13.0-9 11.51.96.10.7 -9 -9 -9 9.0-9 -9 3.0
N-10874 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 2 0 1 1 2 0 0 1 1.03.513.0 3.50.5 7.016.0
15.06.611.43.13.72.315.25.22.9 7.0-9 -9 3.0
A-11606 0 2 1 0 2 1 1 0 1 0 0 2 1 2 0 3 0 1 1 2 0 0 1 1.03.513.5 4.20.7 6.015.7
14.7-9 9.52.04.81.321.06.03.510.5-9 -9 3.0
MO-891 1 0 1 1 0 1 0 0 4 0 0 1 1 2 0 0 0 1 0 2 1 0 2 2.73.824.3 6.61.8 3.712.7
12.0-9 9.31.75.50.218.05.03.6 8.5-9 -9 3.0
A-72719 1 0 1 2 0 1 0 1 4 0 0 1 1 2 0 1 0 1 0 2 1 0 2 3.03.024.5 6.62.4 2.813.5
14.55.410.71.95.60.118.85.93.2 8.57.02.55.0
Q-1881 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1 2 0 0 1 3.04.036.0 9.81.6 6.118.0
14.75.3 9.72.34.20.716.54.33.8 6.07.53.35.0
Q-1904 0 1 1 2 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1-9-9 0 2 1.03.323.5 8.01.9 4.216.0
12.0-9 8.72.04.41.517.04.93.511.5-9 -9 5.0
N-10875 1 1 1 3 1 1 2 0 2 0 0 1 1 2 0 2 0 1 1-9-9 0 2 1.83.023.3 7.21.0 7.215.7

13.3-9 9.42.04.71.516.85.82.9 9.0-9 -9 5.0
AK-29 0 2 0 1 1 0 0 0 5 0 1 2 0 0 0 2 1 0 1-9-9 0 1 1.03.010.0 3.81.1 3.520.5
16.0-9 10.32.05.22.826.05.84.5 9.5-9 -9 3.0
A-19647 1 1 1 2 1 1 2 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 2 3.03.529.0 6.50.7 9.310.0
11.0-9 9.22.04.60.315.34.53.4 7.0-9 -9 3.0
SD-232 1 0 1 2 0 1 2 0 2 0 0 0 1 2 0 0 0 1 1 1 0 0 2 2.04.034.310.82.9 3.714.0
11.5-9 8.51.84.70.820.05.23.8 9.0-9 -9 7.0
Y-1025 1 1 1 0 1 1 1 0 1 0 0 1 1 2 0 2 0 1 1 1 0 0 1 2.03.520.0 8.70.810.923.5
13.5-9 11.02.74.11.224.05.54.410.0-9 -9 5.0
UR-199 0 1 1 0 1 1 1 0 1 0 0 1 1 2 0 2 0 1 1 2 0 0 1 1.04.030.0 7.41.2 6.217.0
12.0-9 8.31.94.41.320.05.33.810.0-9 -9 3.0
NY-4 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 2 0 0 1 1 0 0 1 1.03.017.8 4.70.7 6.715.7
11.33.610.02.14.82.916.84.63.711.76.02.25.0
NY-1908A 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 3 0 1 1 1 0 0 1 1.03.012.2 4.40.7 6.318.0
10.7-9 -9 -9 -9 3.017.84.34.111.7-9 -9 5.0
NY-1908B 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 2 0 0 1 1 0 0 1 1.03.013.7 4.20.9 4.715.0
11.0-9 9.72.14.64.220.35.43.811.0-9 -9 5.0
NY-1913 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 2 0 0 1 1 0 0 1 1.02.312.8 4.60.8 5.817.0
11.33.910.42.24.74.017.54.93.612.05.82.25.0
NY-1973 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 2 0 1 1 1 0 0 1 1.02.510.5 3.70.7 5.317.0
10.5-9 9.22.73.41.714.33.73.911.5-9 -9 3.0
NY-20387 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 3 0 1 1 1 0 0 1 1.02.0 9.5 3.50.8 4.417.5
12.54.0 7.42.62.81.918.04.93.7 9.56.12.55.0
SN-1555 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 3 0 1 1 1 0 0 1 1.03.021.8 5.81.1 5.317.7
15.04.510.73.23.32.720.86.03.5 8.56.82.65.0
SV-7 0 1 1 0 0 1 1 0 1 0 0 2 0 2 0 2 0 1 1 1 0 0 1 1.02.510.3 3.30.5 6.617.0
11.0-9 9.32.93.20.910.53.62.911.0-9 -9 5.0
SV-12 0 1 1 0 1 1 1 0 1 0 0 2 0 2 0 2 0 0 1 1 0 0 1 1.02.512.0 4.00.6 6.716.7
12.03.8 9.92.54.01.315.74.53.510.06.32.35.0

Appendix 4. Pollen viability

Arnica louiseana
Canada, Alberta: Porsild & Breitung 16067 (CAN) 1%; Farr s.n. (PH) 2%; Breitung 17457 (ALTA) 3%; Macoun 65520 (CAN) 0%; Breitung 17454 (NY) 1%; Lee s.n. (ALTA) 0%; Weber 2446 (GH) 0%; Dumais 6274C (ALTA) 1%; Porsild 22666 (CAN) 1%; Scoggan 16440 (CAN) 1%; Porsild & Breitung 16280 (CAN) 0%; Calder 37189 (DAO) 0%; Straley 1607 (DAO) 0%; Norris 72 (DAO) 1%; Laing 371 (CAN) 0%; Breitung 17457 (ALTA) 1%; Mortimer 438 (ALTA) 1%; Brown 665 (GH) 0%; Scotter 9797 (DAO) 0%; Porsild & Breitung 16164 (CAN) 0%; Kuchar 511 (ALTA) 0%.

Arnica frigida subsp. frigida
Canada, British Columbia: Beamish, Krause & Luitjens 681811 (CAN) 0%; Raup & Correll 10507 (CAN) 0%; Taylor, Szczawinski & Bell 916 (CAN) 0%; Taylor, Szczawinski & Bell 1103 (CAN) 1%. **Northwest Territories:** Youngman & Tessier 83 (CAN) 0%; Welsh & Rigby 12060A (CAN) 0%; Cody & Johansson 12878 (DAO) 0%; Scotter 22746 (DAO) 0%; Scotter 12353 (DAO) 0%; Cody & Spicer 17721 (DAO) 0%; Scotter & Zoltai 25751 (DAO) 0%; Cody & Scotter 19193 (DAO) 0%; Cody & Brigham 21009 (DAO) 0%; Cody & Brigham 20938 (DAO) 0%; Cody 17253 (DAO) 0%; Calder 34252 (DAO) 6%; Calder 33964 (DAO) 0%; Cody & Ferguson 10057 (DAO) 0%; Lambert s.n. (DAO) 1%; Spicer 1615A (DAO) 0%; Findlay 129 (DAO) 0%. **Yukon:** Youngman & Tessier 600 (CAN) 2%; McEwen 208 (CAN) 0%; Schofield & Crum 8271 (CAN) 2%; Raup, Drury & Raup 13590 (CAN) 1%; Raup, Drury & Raup 13465 (GH) 4%; Porsild & Breitung 9948 (ALTA) 1%; Porsild & Breitung 10047 (CAN) 10%; Porsild & Breitung 10080 (CAN) 2%; Murray 1776 (CAN) 5%; Cooper 33C (NY) 0%; Porsild & Breitung 10467 (CAN) 1%; Porsild & Breitung 11054 (CAN) 2%; Campbell 469 (CAN) 12%; McNeish s.n. (CAN) 1%; Raup & Raup 12514 (CAN) 0%; Beamish, Krause & Luitjens 681725 (CAN) 15%; Freedman 291 (CAN) 0%; Raup & Correll 11214 (GH) 4%; Clarke 292 (CAN) 8%; Douglas 6345 (DAO) 6%; Scotter 21169A (DAO) 0%.
U.S.A., Alaska: Ward 1478 (CAN) 0%; Norberg s.n. (GH) 95%; Shetler & Stone 3162 (CAN) 3%; Spetzman 4262 (CAN) 3%; Spetzman 1891 (CAN) 5%; Hettinger 367 (CAN) 0%; Hettinger 51 (CAN) 2%; Spetzman 835 (CAN) 0%; Schweger 56-116 (ALTA) 0%; Harris 1208 (ALTA) 95%; Harris 1366 (ALTA) 99%; Harris 1302 (ALTA) 91%; Harris 1192 (ALTA) 6%; Packer 2654 (ALTA) 0%; Welsh 4434 (NY) 2%; Nelson & Nelson 3492 (GH) 3%; Scamman 6265 (GH) 0%; Scamman 3770 (GH) 91%; Scamman 3942 (GH) 94%; Scamman 1674 (GH) 5%; Scamman 679 (GH) 25%; Scamman 1911A (GH) 98%; Scamman 5108 (GH) 18%; Harms 2954 (GH) 98%; Staender 31 (ALA) 1%; Brophy et al. (ALA) 99%; Ebersole & Bowman (ALA) 0%; Ward & Rothe 45 (ALA) 0%; Helmstetter 80-208 (ALA) 13%; Helmstetter 123-79 (ALA) 4%; Murray & Johnson 6687 (ALA) 0%; Springer s.n. (ALA) 0%; Becker 23 (ALA) 85%; Jorgensen T-191 (ALA) 3%; Drury 1768 (CAN) 91%; Drury 1903 (GH) 97%; Donaldson 184A (ALA) 60%; Brockman s.n. (ALA) 0%; Shaughnessy 72-114 (ALA) 98%; Parker RM-75 (ALA) 7%; Racine 99 (ALA) 8%; Robertson 184 (ALA) 97%; Thomas N-11-52 (ALA) 97%; Harms 4317 (GH) 97%; Smith 2610 (ALA) 98%; Richey s.n. (ALA) 96%; Hulten s.n. (GH) 0%; Koranda & Shanks 22939 (NY) 0%; Calder 5621 (DAO) 4%; Porsild & Porsild 243 (CAN) 2%; Laing 203A (CAN) 25%; Porsild & Porsild 95 (CAN) 98%; Wood & Wood 459 (CAN) 85%; Porsild & Porsild 807 (CAN) 95%; Porsild & Porsild 1166 (CAN) 97%; Spetzman 5166 (CAN) 0%; Murray 2015 (CAN) 5%; Drury 1501 (CAN) 98%; Gjaerevoll 19 (CAN) 95%; Raup 66 (CAN) 99%; Welsh 4217 (NY) 0%; Taylor & Taylor 19113 (NY) 93%; Drury 4104 (GH) 95%; Schofield 2129 (DAO) 98%; Norberg s.n. (GH) 96%; Wiggins 13813 (GH) 4%; Schofield 1850 (DAO) 3%; Porsild & Porsild 150 (CAN) 0%; Richey s.n. (ALA) 85%; Williams 3593 (ALA) 95%; Cooper CV-685 (DAO) 41%; Pegau 273 (ALA) 97%; Staender & Staender 27 (ALA) 0%; Chapman 51 (ALA) 0%; Densmore 253B (ALA) 96%; Racine 167 (ALA) 1%; Murray & Johnson 5067 (ALA) 96%; Parker 235 (ALA) 75%; Kassler 61 (ALA) 95%; Kelso 82-48 (ALA) 97%; Parker 196 (ALA) 2%; Murray & Johnson 6101 (ALA) 1%; Alf et al. (ALA) 7%; Batten 496 (ALA) 0%; Batten & Batten 75-185 (ALA) 0%; Batten & Batten 75-369 (ALA) 0%; Parker 274 (ALA) 97%; Cantlon & Gillis 57-452 (US) 0%; Yokel 41 (ALA) 3%; Geist s.n. (ALA) 0%; Lipkin 80-135 (ALA) 15%; Viereck 5009 (ALA) 95%; Komarkova, Hansell & Seabert 379 (ALA) 0%; Frohne 54-238 (ALA) 40%; Alt 5 (ALA) 0%; Frohne 54-314 (ALA)

99%.
U.S.S.R.: Petrovsky s.n. (ALTA) 16%; Nechayer, Plieva & Yurtsev s.n. (ALTA) 0%; Sekretareva, Sytin & Yurtsev s.n. (ALTA) 0%; Sekretareva, Sytin & Yurtsev (ALTA) 9%; Shamurin & Yurtsev s.n. (ALTA) 0%; Korobkov s.n. (ALTA) 0%; Katenin et al. (ALTA) 0%; Karenin & Petrovsky s.n. (ALTA) 0%; Korobkov s.n. (ALTA) 0%; Korobkov s.n. (ALTA) 1%; Korobkov s.n. (ALTA) 0%; Yurtsev s.n. (ALTA) 0%; Afonina s.n. (ALTA) 0%; Zimarskaya at al. s.n. (ALTA) 0%; Nechayev, Plieva & Yurtsev s.n. (ALTA) 0%.

Arnica frigida subsp. griscomii
Canada, Newfoundland: Fernald, Long & Fogg 2139 (DAO) 1%; Fernald, Long & Fogg 2140 (GH) 1%; Fernald, Long & Fogg 2141 (DAO) 4%; Fernald, Long & Fogg 2142 (GH) 1%; Fernald, Long & Fogg 2143 (GH) 3%; Fernald et al. 29216 (GH) 0%; Tuomikoski 343 (CAN) 1%; Hay & Bouchard 74031 (CAN) 4%. **Québec:** Fernald & Smith 26085 (NY) 0%; Fernald & Smith 26083 (MT) 0%; Marie-Victorin et al. 49028 (DAO) 0%.

Arnica rydbergii
Canada, Alberta: Porsild & Breitung 12786 (CAN) 0%; Ringius 1148 (ALTA) 0%; Dudynsky 7840 (ALTA) 0%; Breitung 14027 (ALTA) 2%; Breitung 16674 (NY) 0%; Breitung 17514 (NY) 0%; Krajina s.n. (UBC) 0%; Ringius 1165 (ALTA) 6%; Kuchar 517 (ALTA) 1%; Packer 1969-473 (ALTA) 0%; Kuchar 2714 (ALTA) 0%; Packer 1969-424b (ALTA) 0%; Pegg 1719 (ALTA) 0%; Lee s.n. (ALTA) 0%; Kondla (ALTA) 0%; Porsild & Breitung 16117 (CAN) 0%; Porsild & Breitung 16162 (CAN) 0%; Porsild & Breitung 13211 (CAN) 1%; Porsild & Breitung 13448 (CAN) 0%; Porsild 22626 (CAN) 0%; Macoun 65521 (CAN) 0%; Porsild & Breitung 15517 (CAN) 0%. **British Columbia:** Vrugtman 620050 (UBC) 0%; Taylor & Szczawinski 774 (UBC) 0%; Morrison s.n. (UBC) 0%; Beamish & Vrugtman 610601 (UBC) 0%; Calder & Saville 10527 (UBC) 0%; Verbeek 95 (UBC) 0%; Hainault 7696B (ALTA) 0%; Beamish & Vrugtman 60702 (UBC) 0%; Weber 2284 (UBC) 55%; Fodor 512 (UBC) 0%; Krause 682020 (UBC) 0%; Williams & Luitjens 4 (UBC) 0%; McCalla 2886 (ALTA) 0%; Porsild 18377 (CAN) 0%; Macoun 96036 (CAN) 12%; Macoun 26934 (CAN) 1%; Beamish et al. 750092 (UBC) 0%; Straley 1574 (UBC) 0%; Thompson & Thompson 406 (NY) 0%; Chaney 3 (UBC) 0%; Selby 744 (UBC) 0%; Johns 554 (UBC) 0%; Straley 1660 (UBC) 0%.
U.S.A., Colorado: Clokey 4383 (NY) 1%; Goodding 1838 (NY) 4%; Goodding 1698 (NY) 5%; Rollins 1351 (NY) 62%; Mackenzie 310 (NY) 48%. **Idaho:** Christ & Ward 14548 (NY) 0%; Christ & Ward 14865 (NY) 3%; Hitchcock & Muhlick 10934 (NY) 7%; Christ 12552 (NY) 9%. **Montana:** Lackschewitz 9098 (NY) 22%; Hitchcock & Muhlick 12867 (NY) 1%; Hitchcock 16826 (NY) 5%; Lackschewitz 4591 (NY) 9%; Lackschewitz 5208 (NY) 0%; Hitchcock 18594 (NY) 0%. **Utah:** Goodrich 14771 (NY) 3%; Goodman & Hitchcock 1538 (NY) 0%; Payson & Payson 5082 (NY) 2%. **Washington:** Douglas & Douglas 3990 (ALTA) 0%; Thompson 15035 (ALTA) 0%; Straley 1677 (UBC) 21%; Straley 1496 (UBC) 0%; Allen 229 (NY) 1%; Meyer 1562 (NY) 3%. **Wyoming:** Rollins 998 (NY) 6%; Hitchcock 16380 (NY) 0%; Hitchcock 16688 (NY) 0%; Evert 6193 (NY) 6%; Evert 2315 (NY) 1%; Smith 1158 (NY) 3%.

Arnica fulgens
Canada, Alberta: Shaw 2462 (ALTA) 88%; Boivin & Perron 12374 (ALTA) 84%; Bradley s.n. (ALTA) 82%; Moss 9791 (ALTA) 97%; Breitung 16047 (ALTA) 85%; McCalla 11648 (ALTA) 99%; McCalla 11663 (ALTA) 98%; McCalla 11866 (ALTA) 91%; Dumais & Young 1552 (ALTA) 96%; McCalla 11664 (ALTA) 98%; Moss 9831 (ALTA) 50%; Boivin, Hubbard & Alex 9548 (ALTA) 84%; Boivin & Alex 9381 (ALTA) 91%; Rusconi s.n. (ALTA) 81%; Scott 1300 (ALTA) 96%; Cormack 363 (ALTA) 91%; Cormack 175 (ALTA) 87%; Moss 8090 (ALTA) 62%; Moss 954 (ALTA) 93%; Sexsmith 239 (ALTA) 26%; Brinkman 1634 (ALTA) 98%; Klar 472 (ALTA) 81%; Klar 1174 (ALTA) 96%; Brinkman 2068B (ALTA) 95%; Survey 725 (ALTA) 67%; Moss 1075 (ALTA) 94%; Moss 3247 (ALTA) 96%; Nagy & Blais 985 (UBC) 86%; Straley 2749 (UBC) 87%; Brink s.n. (UBC) 90%; Aikenhead s.n. (ALTA) 91%; Kvisle s.n. (ALTA) 95%; Brinkman 2144 (ALTA) 96%. **British Columbia:** Johns 530 (UBC) 82%; Moss 8170 (ALTA) 78%; **Manitoba:** Macoun 12725 (MT) 98%. **Saskatchewan:** Boivin & Perron 11917 (ALTA) 88%; Boivin & Perron 12088 (ALTA) 85%; Breitung 4312 (ALTA) 92%; Tripp s.n. (ALTA) 80%.
U.S.A., Colorado: Goodding 1492 (PH) 95%; Clokey 3959 (PH) 97%; Bethel & Clokey 4382 (PH) 98%; Coulter s.n. (PH) 39%; Straley 1463 (UBC) 17%. **Idaho:** Maguire 17163 (PH) 98%. **Montana:** Hitchcock & Muhlick 12307 (PH) 88%; Hitchcock 16043 (UC) 93%;

Straley 1497 (UBC) 72%; Blankinship 310 (MT) 96%. **North Dakota:** Lunell s.n. (PH) 95%. **Oregon:** Hansen 744 (NY) 85%. **Washington:** Sandberg & Leiberg 103 (PH) 97%; Beattie & Lawrence 2334 (PH) 97%; Thompson 8344 (PH) 73%; Downen 109 (ALTA) 93%; Suksdorf s.n. (MT) 50%. **Wyoming:** Nelson 148 (PH) 92%; Williams 2363 (UC) 96%; Straley 1841 (UBC) 88%.

Arnica sororia
Canada, Alberta: Klar 1210 (ALTA) 95%; Scott 1268 (ALTA) 98%; Scoggan 16720 (CAN) 95%; Breiting 15768 (ALTA) 95%; Lewis s.n. (CAN) 96%; Sanson s.n. (CAN) 58%; Porsild & Breitung 16395 (CAN) 95%; Cormack s.n. (ALTA) 95%; Boivin & Alex 9672 (ALTA) 98%; Cormack 106B (ALTA) 97%; Dore & Breitung 11702 (ALTA) 86%; Goulden & Goulden s.n. (ALTA) 94%; Willing s.n. (ALTA) 61%; McCalla 6714 (ALTA) 96%; Brinkman 5413 (ALTA) 87%; Suis s.n. (ALTA) 98%; McCalla 3693 (ALTA) 94%; McCalla 8748 (ALTA) 86%; Brinkman 960 (ALTA) 84%; Stringer s.n. (ALTA) 90%; Moss 1172 (ALTA) 82%; Kuchar 2537 (ALTA) 96%; Hermann 12800 (ALTA) 97%; McCalla 2012 (ALTA) 99%; Bradley s.n. (ALTA) 84%; Brinkman 2280 (ALTA) 87%; Survey 918 (ALTA) 71%; Soper s.n. (CAN) 96%. **British Columbia:** Eastham 11565 (CAN) 91%; Macoun 14712 (CAN) 91%; Macoun 14713 (CAN) 99%; Macoun 14710 (CAN) 98%; McCalla 8157 (ALTA) 93%; McCalla 9552 (ALTA) 62%; McCalla 9519 (ALTA) 96%; Hardy 15009 (UBC) 98%; Vrugtman & Campbell 610402 (CAN) 90%; McCabe 6427 (UC) 97%; McCabe 6392 (UC) 70%; McCabe 2337 (UC) 97%; McCabe 1301 (UC) 86%; Macoun 69321 (CAN) 93%; Calder et al. 18193 (UC) 77%; Calder & Saville 8037 (UC) 89%; Wilson 195 1/2 (UBC) 84%; Krajina 65062414 (UBC) 55%; Calder et al. 17345 (UBC) 88%; Rose 7926 (UBC) 93%.
U.S.A., California: Baker & Nutting s.n. (UC) 97%; Babcock & Stebbins 1822 (UC) 56%; Babcock & Stebbins 1788 (UC) 95%; Austin s.n. (US) 97%; Applegate 866 (US) 98%. **Idaho:** McCalla 4765 (ALTA) 95%; Davis 1151 (UC) 91%; Davis 3787 (UC) 92%; Davis 438 (UC) 59%; Abrams 717 (UC) 87%; Holmgren & Holmgren 7963 (UC) 98%; Maguire & Holmgren 26659 (UC) 94%; Maguire & Holmgren 26325 (UC) 99%; Hitchcock & Muhlick 13927 (UC) 96%; Nelson & Macbride 1256 (US) 97%. **Montana:** McCalla 4743 (ALTA) 81%; McCalla 4510 (ALTA) 94%; Barkley & Rose 2450 (UC) 97%; MacDougal 134 (US) 50%; Moore s.n. (UC) 89%; Kirkwood 1338 (UC) 97%; Hitchcock & Muhlick 11499 (UC) 82%; Hitchcock 17983 (UC) 96%; Hitchcock 17768 (UC) 81%; Hitchcock 17902 (UC) 98%. **Nevada:** Nichols & Lund 239 (UC) 94%; Shipley s.n. (US) 60%; Raven & Solbrig 13460 (NY) 68%. **Oregon:** Maguire & Holmgren 26430 (UC) 97%; Cronquist 7360 (UC) 94%; Cusick 1929 (UC) 93%; Leiberg 2387 (UC) 87%. **Utah:** Maguire et al. 13815 (UC) 91%. **Washington:** McCalla 4461 (ALTA) 81%; Beattie & Chapman 2264 (UC) 96%; Beattie & Lawrence 2461 (UC) 97%; Rogers 505 (UC) 94%; Gaines & Scheffer 550 (UC) 98%; John & Pickett 6204 (UC) 99%; Suksdorf 8759 (UC) 41%; Rogers 551 (UC) 91%; Hitchcock 17412 (UC) 97%; Constance & Beetle 2744 (US) 86%. **Wyoming:** Anderson 322 (UC) 92%; Uttal 5069 (PH) 60%.

Arnica angustifolia subsp. angustifolia
Canada, Alberta: Pegg 1714 (ALTA) 0%; Mortimer 415 (ALTA) 43%; Moss 4923 (ALTA) 17%; Moss 12682 (ALTA) 0%; Kuchar 508 (ALTA) 0%; Boivin & Gillett (ALTA) 8%; Downie 541B (ALTA) 0%; Downie 544 (ALTA) 1%; Mortimer 426 (ALTA) 0%; Mortimer 483 (ALTA) 15%. **British Columbia:** McCalla 7015 (ALTA) 49%; Taylor et al. 121 (UBC) 0%; Beamish et al. 730354 (UBC) 4%; Rose 78464 (UBC) 0%; Buttrick 688 (UBC) 26%; Beamish et al. 730343 (UBC) 2%; Taylor et al. 1366 (UBC) 21%. **Manitoba:** Scoggan 6382 (MT) 0%; Scoggan 5896 (MT) 17%; Porsild 5506 (MT) 46%; Gillett 2011 (MT) 0%; Gillett 2462 (MT) 0%; Wolf s.n. (ALTA) 0%; Wolf s.n. (ALTA) 0%. **Newfoundland:** Forbes s.n. (GH) 0%; Fernald & Long 29207 (GH) 5%; Fernald & Long 29215 (GH) 3%; Fernald, Pease & Long 29208 (GH) 22%; Fernald, Long & Fogg 2124 (MT) 0%; Loken 9 (MT) 1%; Fernald, Long & Fogg 2125 (MT) 2%; Wynne-Edwards 7111 (CAN) 0%; Wynne-Edwards 7136 (CAN) 0%; Abbe 572 (GH) 0%; Woodworth 432 (GH) 0%; Woodworth 428 (GH) 0%; Viereck 639 (ALA) 0%; Woodworth 431 (GH) 0%; Abbe & Hogg 568 (GH) 0%; Palmer s.n. (PH) 3%; Abbe & Odell 569 (CAN) 4%; Ives 12 (CAN) 0%; Wynne-Edwards 7502 (CAN) 4%; Gardner 315 (GH) 0%. **Northwest Territories:** Welsh & Rigby 12021 (ALTA) 11%; Cody & McCanse 2207 (MT) 0%; Porsild 5602 (MT) 0%; Younkin 106 (ALTA) 0%; Hernandez 202 (ALTA) 59%; Kershaw 803 (ALTA) 0%; Wilk 11 (ALTA) 32%; Wolf s.n. (ALTA) 0%; Hernandez 244 (ALTA) 6%; Cody & McCanse 2328 (US) 0%; Lambert et al. 65081304 (UBC) 10%; Perret & Kelsall 10 (UBC) 24%; Porsild & Porsild 1973 (O) 5%;

Simmons 2585 (O) 0%; Lindstrom s.n. (O) 15%; Lindstrom s.n. (O) 23%; Hainault 4027 (O) 0%; Hainault 3847 (O) 0%; Kershaw 798 (ALTA) 3%; Reid 420 (ALTA) 68%; Findlay 40 (ALTA) 2%; Porsild & Porsild 2947 (ALTA) 57%; Porsild 6865 (ALTA) 26%; Porsild 17072 (ALTA) 17%; Harington 400 (ALTA) 46%; Bliss s.n. (ALTA) 23%; Savile 4567 (ALTA) 52%; Ross 3 (ALTA) 15%; Haag 140 (ALTA) 59%; Owen & Hickman s.n. (ALTA) 6%; Raup & Soper 9384 (ALTA) 69%; Porsild & Porsild 2530 (MT) 41%; Senn & Calder 3803 (MT) 7%; Calder 2153 (MT) 30%; Choque s.n. (MT) 6%; Bruggemann 632 (MT) 39%; Sims 6248B (UBC) 0%; Matthews s.n. (UBC) 0%; Oldenburg 46-2108 (UBC) 3%; Oldenburg 54-207 (UBC) 5%; Bruggemann 797 (UBC) 8%. **Ontario:** Moir 2082 (MT) 0%; Scott s.n. (UBC) 0%; Baldwin 7898 (CAN) 5%; Baldwin 7678 (CAN) 0%. **Québec:** Legault 6791 (MT) 0%; Lemieux s.n. (MT) 6%; MacInnes 5174 (MT) 0%; Ouellet s.n. (CAN) 0%; Abbe, Abbe & Marr 3549 (CAN) 0%; Malte 126984 (CAN) 0%; Polunin 192 (CAN) 0%; Porsild 21885 (CAN) 0%; Malte 120206 (CAN) 0%; Abbe & Abbe 3805 (GH) 0%; Dutilly & Lepage 13262 (GH) 0%; Abbe & Abbe 3254 (ALA) 0%; Hedberg 67-371 (O) 0%; Spreadborough 14385 (NY) 0%. **Yukon:** Noel s.n. (UBC) 15%; Raup, Drury & Raup 13148 (UBC) 10%; Beamish s.n. (UBC) 17%; Langenheim 4130 (UBC) 98%; Dudynsky 7801 (ALTA) 99%; Dudynsky 7806 (ALTA) 99%; Dudynsky 7826 (ALTA) 95%; Dudynsky 7802 (ALTA) 99%; Dudynsky 7822 (ALTA) 23%; Dudynsky 7823 (ALTA) 10%; Dudynsky 7829 (ALTA) 17%; Mitchell 53 (MT) 43%; Hettinger 227 (ALTA) 99%; Packer 1458 (ALTA) 23%; Raup & Raup 12366 (US) 42%; Collier 29 (US) 95%; Eastwood 235 (US) 99%; Neilson 691 (US) 28%; Raup & Raup 12886 (UBC) 1%; Beamish et al. 681223 (UBC) 16%; Beamish et al. 681265 (UBC) 0%; Noel 26 (UBC) 20%; Porsild & Breitung 9756 (O) 0%; Murray & Murray (ALA) 0%; Murray 1616 (ALA) 38%; Murray & Murray 776 (ALA) 10%; Porsild & Breitung 9756 (ALTA) 5%; Greene 295 (ALTA) 75%; Greene 226 (ALTA) 54%; Lambert & Morrison 65071602 (UBC) 0%; Beamish et al. 681443 (UBC) 44%; Beamish et al. 681350 (UBC) 0%; Raup & Correll 11212 (UBC) 21%; Parmelee 2855 (UBC) 16%; Downie 499 (ALTA) 77%; Dudynsky 7805 (ALTA) 0%; Dudynsky 7803 (ALTA) 70%; Dudynsky 7804 (ALTA) 75%; Peterson 2 (ALTA) 84%; Peterson 3 (ALTA) 99%.
U.S.A., Alaska: Nelson & Nelson 3677 (US) 95%; Mendenhall s.n. (US) 99%; Mertie s.n. (US) 95%; Anderson & Gasser 7218 (ALA) 97%; Mendenhall s.n. (US) 98%; Schrader s.n. (US) 99%; Scamman 1667 (US) 99%; Harms 2703 (C) 96%; Harms 2761 (C) 98%; Dudynsky 7808 (ALTA) 96%; Dudynsky 7807 (ALTA) 99%; Cantlon & Malcolm 58-0150 (US) 0%; Murie 35 (US) 5%; Schrader & Hartman 51 (US) 6%; Dudynsky 7811 (ALTA) 8%; Dudynsky 7810 (ALTA) 2%; Murray 6838 (ALA) 42%; Shetler 1058 (ALA) 99%; Murray 3324 (ALA) 50%; Lipkin 80-121 (ALA) 6%; Geist s.n. (ALA) 10%; Geist s.n. (ALA) 48%; Packer 2113 (ALA) 62%; Hettinger 456 (ALTA) 0%; Thompson 1925956 (US) 15%; Holmen s.n. (C) 0%; Dean 42 (ALA) 99%.
Greenland: Laegaard 1328 (C) 0%; Bay & Fredskild 413 (C) 10%; Brink s.n. (C) 24%; Fredskild 6276 (C) 5%; Andersen & Hanfgarn 557 (O) 0%; Vaage s.n. (O) 0%; Astrup & Kliim-Nielsen 724 (C) 0%; Raup, Raup & Washburn 385 (C) 0%; Marris 9 (C) 0%; Moore PM15 (C) 3%; Behrndt s.n. (C) 0%; Tulinius 7 (C) 0%; Gelting 31 (C) 0%; Sorensen 3026 (C) 0%; Andersen & Hanfgarn 2 (C) 0%; Andersen & Hanfgarn 268 (C) 0%; Argent & Argent 24/18774 (C) 0%; Elkington s.n. (C) 0%; Spearing et al. 141 (C) 0%; Bartlett 45 (C) 0%; Povelsen s.n. (C) 0%; Schiotz s.n. (C) 0%; Gelting s.n. (C) 0%; Bennike s.n. (C) 0%; Ollgard 68-1333 (C) 10%; Hansen & Holt 383 (C) 27%; Kruuse 1119 (C) 32%; Holt 1651 (C) 25%; Alstrup 69266 (C) 21%; Ollgard 68-252 (C) 2%; Bay 78-1701 (C) 0%; Holt 1220 (C) 0%; Holt 1305 (C) 6%; Bocher 573 (C) 3%; Holmen s.n. (C) 0%; Harris 1748 (ALTA) 3%; Porsild s.n. (MT) 0%; Porsild s.n. (MT) 6%; Porsild & Porsild (MT) 51%.
Norway: Lundmark 19 (O) 5%; Fries s.n. (O) 6%; Lundmark s.n. (O) 2%; Nyland s.n. (O) 13%; Engelskjon s.n. (O) 3%; Lundmark s.n. (O) 2%; Resvoll-Holmsen s.n. (O) 1%; Lundmark s.n. (O) 5%; Bleyt s.n. (O) 3%; Lundmark s.n. (O) 1%; Lundmark s.n. (O) 2%; Engelskjon s.n. (O) 6%; Engelskjon s.n. (O) 2%; Fridtz 20389 (O) 4%; Fridtz 20387 (O) 2%; Fridtz 20390 (O) 7%; Fridtz 20393 (O) 3%; Noto s.n. (O) 1%; Sivertsen E6 (O) 5%; Senum s.n. (C) 0%.
Spitsbergen: Lid s.n. (C) 0%; Neilson 1015 (C) 0%; Hadoc s.n. (O) 0%; Lynge s.n. (O) 0%; Mikaelsen s.n. (O) 0%; Spicer s.n. (O) 0%; Halliday H540 (O) 0%; Resvoll-Dieset s.n. (O) 0%.
Sweden: Alm 1555 (O) 2%; Nordstrom s.n. (ICEL) 0%; Bjorkman s.n. (ICEL) 3%; Alm & Tengwall s.n. (C) 0%; Einarsson s.n. (ICEL) 5%.

Arnica angustifolia* subsp. *tomentosa
Canada, Alberta: S.F.F. 176 (ALTA) 2%; Pegg 1725 (ALTA) 0%; Macoun 96013 (CAN)

27%; Lambart 372 (CAN) 35%; Malte & Watson 2306A (CAN) 0%; Kuchar 2802 (ALTA) 10%; Ringius 1382 (ALTA) 2%; Raup & Abbe 3939 (ALTA) 49%; Porsild & Breitung 15968 (CAN) 3%; Porsild 22625 (CAN) 14%; Moss 10328 (ALTA) 46%; Porsild & Breitung 16261 (CAN) 0%; Malte & Watson 607 (CAN) 0%; Malte & Watson 1486 (CAN) 0%; Kindle 93493 (CAN) 42%; Macoun 96015 (CAN) 0%; Porsild & Lid 19313 (CAN) 5%; Porsild & Lid 19393 (CAN) 4%; Porsild 20787 (CAN) 4%; Packer 4187A (ALTA) 11%; Packer & Silber (ALTA) 0%; Mortimer 597 (ALTA) 1%; Dumais 7504 (ALTA) 3%; Lee & Peterson 56147 (ALTA) 26%; Carroll 497 (ALTA) 56%; Kondla 1840 (ALTA) 30%; Packer 3063 (ALTA) 46%; Porsild & Breitung 14244 (ALTA) 10%; Dudynsky 7844 (ALTA) 8%; Downie 541A (ALTA) 43%; Downie 535 (ALTA) 1%; Downie 536 (ALTA) 0%; Dudynsky 7852 (ALTA) 44%; Forbes 77/100 (ALTA) 5%; Dudynsky 7842 (ALTA) 44%; Forbes 77/133A (ALTA) 39%; Dudynsky 7728 (ALTA) 38%; Dudynsky 7836 (ALTA) 34%. **British Columbia:** Beil 160686 (UBC) 0%; Selby 199 (UBC) 10%; Beamish et al. 681107 (CAN) 0%; Macoun 96011 (CAN) 0%. **Newfoundland:** Fernald, Long & Fogg 2128 (MT) 8%; Fernald, Long & Fogg 2127 (MT) 5%; Hay & Bouchard 74032 (MT) 1%; Fernald, Long & Fogg 2129 (MT) 1%. **Northwest Territories:** Crickmay 113 (CAN) 0%; Raup & Soper 9730 (CAN) 0%. **Yukon:** Porsild & Breitung 11053 (CAN) 0%.
U.S.A., Montana: Lackschewitz 4436 (NY) 0%; Hitchcock & Muhlick 12965 (NY) 0%.

Arnica lonchophylla subsp. lonchophylla
Canada, Alberta: Porsild & Breitung 16163 (CAN) 8%; Porsild 22367 (CAN) 19%; Porsild & Breitung 16281 (CAN) 57%; Porsild 20719 (CAN) 40%; Macoun 14723 (CAN) 12%; Porsild & Breitung (CAN) 15%; Porsild & Breitung (CAN) 20%; Macoun 96064 (CAN) 9%; Macoun 96074 (CAN) 19%; Malte & Watson 1542 (CAN) 31%; Malte & Watson 1290 (CAN) 15%; Moss 10330 (CAN) 14%; Porsild & Lid 19395 (CAN) 12%; McCalla 10533 (UBC) 15%; McCalla 12276 (ALTA) 17%; Doherty 265 (ALTA) 34%; Russell s.n. (ALTA) 14%; McCalla 10396 (ALTA) 22%; Brethour s.n. (ALTA) 41%; Cormack 722 (ALTA) 16%; Porsild & Breitung 12378 (CAN) 21%. **British Columbia:** Luckhurst s.n. (UBC) 48%; Jackson 1854 (UBC) 16%; Rose 78465 (UBC) 17%. **Manitoba:** Scoggan 3429 (ALTA) 16%; Baldwin 2275 (GH) 18%. **Newfoundland:** Fernald, Long & Fogg 2133 (GH) 38%; Fernald, Long & Fogg 2136 (GH) 49%; Fernald, Long & Fogg 2135 (GH) 47%; Fernald, Long & Fogg 2132 (GH) 34%; Fernald, Long & Fogg 2137 (GH) 14%; Mackenzie & Griscom 11030 (GH) 13%; Fernald, Long & Fogg 2138 (GH) 10%; Fernald, Long & Fogg 2130 (GH) 22%; Rouleau 2989 (NY) 18%; Rouleau 177 (MT) 8%; Rouleau 8225 (MT) 9%; Rouleau 3546 (MT) 16%; Hay & Bouchard 74026 (MT) 59%; Hay & Bouchard 74027 (MT) 33%. **Northwest Territories:** Raup 3376 (GH) 17%; Raup 3374 (GH) 12%; Bedford 1925 (CAN) 5%; Harper 2344 (CAN) 16%; Scotter 3182 (CAN) 38%; Shacklette 2960 (CAN) 24%; Henderson 30A (CAN) 45%; Hume(?) s.n. (CAN) 20%; Crickmay 112 (CAN) 14%; Thieret & Reich 4873 (CAN) 46%; Thieret & Reich 6933 (NY) 42%; Cody & Spicer 11376 (UBC) 35%; Morrison 85 (ALTA) 29%; Lewis 570 (ALTA) 7%; Wilk 12 (ALTA) 28%; Talbot 2246 (ALTA) 8%; Thieret & Reich 7081 (NY) 59%. **Nova Scotia:** Smith et al. 6474 (MT) 2%. **Ontario:** Moir 816 (GH) 20%; Garton 1410 (NY) 16%; Britton s.n. (UBC) 23%; Garton 15032 (UBC) 14%. **Québec:** Pease 20175 (GH) 20%; Marie-Victorin & Rolland-Germain 27547 (GH) 12%; Fernald & Collins 1201 (GH) 14%; Marie-Victorin & Rolland-Germain 49412 (GH) 9%; Clausen 3188 (NY) 6%; Fernald & Weatherby 2476 (GH) 14%; Stebbins 825 (GH) 7%; Rousseau 52213 (MT) 19%; Rousseau 52119 (MT) 12%; Grandtner et al. 8106 (DAO) 17%. **Saskatchewan:** Argus 162-63 (GH) 11%; Raup 6222 (GH) 3%; Argus 998-62 (NY) 23%; Raup 6260 (NY) 34%. **Yukon:** Raup & Correll 11191 (GH) 12%; Douglas & Douglas 5825 (CAN) 11%; Williams s.n. (UBC) 27%; Schofield & Crum 7463 (UBC) 46%.
U.S.A., Alaska: Taylor et al. 19294 (NY) 64%. **Minnesota:** Butters & Abbe 93 (GH) 14%; Lakela 3095 (GH) 10%;

Arnica lonchophylla subsp. arnoglossa
U.S.A., South Dakota: Stephens & Brooks 31790 (NY) 91%; Stephens & Brooks 40471 (GH) 75%; Over 1638 (US) 40%; Over 16212 (US) 94%; Rydberg 823 (US) 86%; Johnson 243 (NY) 85%; Johnson 178 (NY) 85%; Pratt 130 (NY) 36%; Rusty s.n. (NY) 65%.

Appendix 5. Collections used in flavonoid analyses

A. frigida subsp. frigida
Canada, British Columbia: Summit Lake, Stone Mtn. Prov. Park *Downie 452*; Summit Lake, Stone Mtn. Prov. Park *Downie 525*. **Yukon:** Km 32.5 Hwy. 9 *Downie 469*; Km 34.5 Hwy. 9 *Downie 470*; Km 38.5 Hwy. 9 *Downie 471*; Km 73.5 Dempster Hwy. *Downie 474*; Km 75 Dempster Hwy. *Downie 476*; Km 76 Dempster Hwy. *Downie 478*; Km 80 Dempster Hwy. *Downie 477*; Km 1717.5 Alaska Hwy., Kluane Park *Downie 628*; Km 1912 Alaska Hwy., SSE Beaver Creek *Downie 674*.
U.S.A., Alaska: Mile 258 Richardson Hwy., 12 km. S. Delta Junction *Downie 503*; Mile 250 Richardson Hwy. *Downie 504*; Mile 254 Richardson Hwy. *Downie 662*; Donnelly Dome *Downie 519*; Mile 259 Richardson Hwy. *Downie 660*; Mile 231 Richardson Hwy., Darling Creek Crossing *Downie 663*; Mile 193 Richardson Hwy. *Downie 666*; Mile 84.8 Steese Hwy. *Downie 505*; Mile 89 Steese Hwy. *Downie 650*; Mile 99.5 Steese Hwy., Fish Creek Crossing *Downie 657*; Mile 106 Steese Hwy., Eagle Summit *Downie 506*; Mile 115 Steese Hwy. *Downie 656*; Mile 39 Elliott Hwy., 30 miles SE Livengood *Downie 508*; Mile 39.3 Elliott Hwy. *Downie 508A*; Healy *Downie 509*; Hwy. 3, 1 km N Denali Park entrance *Downie 642*; Mile 246 Hwy. 3, S Healy *Downie 644*; Mile 256 Hwy. 3 *Downie 645*; Mile 13 Hwy. 8 (Denali Hwy.) *Downie 515*; Mile 22 Hwy. 8, Tangle Lakes Campground *Downie 516*; Mile 11 Hwy. 8 *Downie 517*; Mile 106.5 Glenn Hwy., Caribou Creek *Downie 514*; Mile 1412 Alaska Hwy., SE Delta Junction *Downie 668*; Hwy. 1, 12 miles S Tok *Downie 638*; Mile 102.5 Hwy. 1 *Downie 639*; Mile 67.5 Hwy. 1, Carlson Creek *Downie 640*; Mile 40 Taylor Hwy. *Downie 475*.

A. frigida subsp. griscomii
Canada, Québec: Mt. Saint-Alban, Forillon Natl. Park *Downie 531*. **Newfoundland:** SW Port Au Choix *Downie 533*; Pointe Riche *Downie 534*.

A. louiseana
Canada, Alberta: Moraine Lake, Banff Natl. Park *Downie 449*; Peyto Lake, Banff Natl. Park *Downie 450*; Columbia Icefields, Jasper Natl. Park *Downie 544*; Bald Hills, Jasper Natl. Park *Downie 546*; Bald Hills, Jasper Natl. Park *Downie 547*.

A. fulgens
Canada, Alberta: S. junction Hwys. 36 and 9 near Hanna *Downie 554*; S. junction Hwys. 1 and 41 near Medicine Hat *Downie 559*; S. Cypress Hills *Downie 562*; 0.5 km N. Bare Creek, Hwy. 41 *Downie 563*; Bare Creek Reservoir *Downie 565*; Hwy. 880, N. Aden *Downie 571F*.
U.S.A., Montana: Toole County, 15 km W. Sweetgrass *Downie 710*; Liberty County, near Port of Whitlash border crossing *Downie 712*; Pondera County, S.W. Conrad on Hwy. 219 *Downie 713*; Judith Basin County, junction Hwys. 80 and 87 *Downie 714*. **Wyoming:** Big Horn County, E. Medicine Wheel Archeological Site Rd., Big Horn Natl. Forest *Downie 698*; Johnson County, S.W. Buffalo *Downie 699*.

A. sororia
Canada, Alberta: Hwy. 1, 2 km E. Suffield *Downie 557*; Hwy. 41, E. Medicine Hat *Downie 558*; Manyberries *Downie 568*; Pendant Orielle *Downie 569*; W. Pendant Orielle *Downie 570*; Hwy. 880, N. Aden *Downie 571S*; W. McNab, N.W. Warner *Downie 572*; S. side Milk River Ridge Reservoir *Downie 573*. **British Columbia:** Wasa, N. Cranbrook *Downie 703*; S. Kamloops on Hwy. 5 *Downie 707*; Near Tranquille, N.W. Kamloops *Downie 708*.
U.S.A., Montana: Wheatland County, 12 miles W. Harlowton, Hwy. 12 *Downie 716*; Wheatland County, 0.5 miles E. Shawmut, Hwy. 12 *Downie 717*.

A. rydbergii
Canada, Alberta: Jasper Natl. Park, Bald Hills *Downie 723*; Banff Natl. Park, Wah-wah Ridge, vic. Sunshine Ski Lodge *Downie 731*; Waterton Lakes Natl. Park, Upper Lake Carthew on Carthew-Allison Trail *Downie 732*; Waterton Lakes Natl. Park, Carthew summit *Downie 733*.
U.S.A., Wyoming: Hwy. 30 at Nash Fork Campground *Downie 691*; Medicine Bow Natl. Forest, Rd. to Medicine Bow Peak *Downie 693*; Medicine Bow Natl. Forest, 3 km W.

Mirror Lake *Downie 695*; Medicine Bow Natl. Forest, 2 km W. Mirror Lake *Downie 696*.

A. angustifolia subsp. angustifolia
Canada, Alberta: Jasper National Park, Columbia Icefields *Downie 544*; Jasper National Park, Mt. Edith Cavell *Downie 721*; Jasper National Park, Bald Hills *Downie 722*; Cardinal Divide *Downie 725*; 1 km E. Klewi Wayside, Wood Buffalo Natl. Park *Downie 580*; 5 km S. Pine Lake Campground *Downie 583*. **British Columbia:** Muncho Lake Provincial Park *Downie 454*; Muncho Lake Provincial Park *Downie 619*; S. Muncho Lake Provincial Park *Downie 618*; Km 750 Alaska Hwy. *Downie 621*; Km 895 Alaska Hwy. *Downie 623*; Km 906 Alaska Hwy. *Downie 624*; Km 625 Alaska Hwy. *Downie 625*; Muncho Lake Provincial Park *Downie 622*. **Northwest Territories:** Km 174 Hwy. 3 *Downie 602A*; Km 160 Hwy. 3 *Downie 604*; Km 327 Hwy. 3 *Downie 596*; Km 308 Hwy. 3 *Downie 597*; Km 282 Hwy. 3 *Downie 598*; Km 180 Hwy. 3 *Downie 601*; 5 km E. Hay River, Hwy. 2 *Downie 575*; Km 76 Hwy. 5 *Downie 578*; Km 133 Hwy. 5 *Downie 579*; Km 68 Hwy. 5, 8 km S. junction Hwy. 6 *Downie 577*; 1 km N. Blue Fish Creek, Hwy. 3 *Downie 591*; Fort Providence *Downie 606*; Km 233 Hwy. 1 *Downie 608*; Km 299 Hwy. 1 *Downie 610*; 1 km E. junction Hwy. 7 and Hwy. 1 *Downie 612*; Km 168 Hwy. 1 *Downie 590*; Km 379 Hwy. 1 *Downie 611*; 56 km N. Fort Liard, Hwy. 7 *Downie 615*; Km 222 Hwy. 3 *Downie 599*; Km 174 Hwy. 3 *Downie 602B*; Km 142 Hwy. 3 *Downie 605*; Km 262 Hwy. 1 *Downie 609*. **Quebec:** Fort Chimo *Hedberg 1959* (Botanic Garden, U. of Copenhagen); No locality information. *Böcher 10050* (Botanic Garden, U. of Copenhagen); No locality information. *Böcher 13666* (Botanic Garden, U. of Copenhagen). **Yukon:** Km 1074 Alaska Hwy. *Downie 456*; Km 1790 Alaska Hwy. *Downie 678*; Km 354 Klondike Hwy. *Downie 684*; Km 1193 Alaska Hwy. *Downie 459*; Km 1341 Alaska Hwy. *Downie 461*; 16 km S. Haines Junction *Downie 480*; 88 km S. Haines Junction *Downie 481*; Km 134 Klondike Hwy. *Downie 484*; Km 218 Canol Road *Downie 489*; Km 174 Canol Road *Downie 491*; Km 13 Canol Road *Downie 522*; Km 2 Canol Road *Downie 521*; Km 380 Campbell Hwy. *Downie 496*; Km 1618 Alaska Hwy. *Downie 497*; Beaver Creek *Downie 672*; Km 1878 Alaska Hwy.; Koidern *Downie 676*; Km 156.5 Canol Rd. *Downie 494*; Km 272 Klondike Hwy. *Downie 686*; Km 36 Hwy. 8, S.W. Tagish *Downie 687*; Km 471 Klondike Hwy., N. Pelly Crossing *Downie 466*; Km 610.5 Klondike Hwy., N.W. McQuesten. *Downie 467*; Km 5 Dawson Boundary Rd. No. 9. *Downie 472*; Km 12 Dempster Hwy. *Downie 473*; Km 646 Klondike Hwy. *Downie 479*; Km 547 Campbell Hwy. *Downie 487*; Km 1912 Alaska Hwy. *Downie 675*; Km 1192.5 Alaska Hwy. *Downie 523*; Kluane National Park; *Downie 629*.
U.S.A., ALASKA: Mile 1359 Alaska Hwy. *Downie 520*; Mile 1309 Alaska Hwy., between Tetlin and Tok Junction *Downie 636*; Mile 1239 Alaska Hwy. *Downie 631*; Mile 1264 Alaska Hwy., Northway *Downie 633*; 2 miles S. Tetlin ~~Junction Downie 635; Mile~~ 263 Richardson Hwy., S. Delta Junction *Downie 659*; Mile 1372 Alaska Hwy. *Downie 669*; Mile 1324 Alaska Hwy. *Downie 671*; 60 km E.S.E. Tok Junction *Downie 501*; Mile 1396 Alaska Hwy. *Downie 502*; Mile 314 Parks Hwy., N. Nenana *Downie 649*; Circle Hot Springs Rd. *Downie 655*; Mile 275 Parks Hwy. *Downie 647*.
Greenland: Holsteinborg *Böcher 4749*; Sdr. Stromfjord *Böcher 12080*; Sdr. Stromfjord, Sandflugtdalen *Böcher 13354*; Lyell's Land, Polhemsdal *Böcher 6059*; Disko, Godhavn *Böcher 8158*; Disko, Brededal *Böcher 8895*; Nugssuaq peninsula, Marrait *Böcher 1*; Scoresby Sund, Nordvestfjord *Böcher 10796*.
Sweden: Torne lappmark, Jukkasjarvi, Loupakkte *Nilsson s.n.* (Botanical Garden, U. of Uppsala).
Norway: Troms, Tromso, Mt. Flojfjell. *Nilsson s.n.* (Botanical Garden, U. of Uppsala).
U.S.S.R.: Gydan Peninsula, Sibiria (V.L. Komarov Botanical Institute, Leningrad); No locality information, Coll. No. 2965. (Main Botanic Garden, Moscow); No locality information, Coll. No. 632. (Main Botanic Garden, Moscow).

A. angustifolia subsp. tomentosa
Canada, Alberta: Ram Mountain *Downie 535,536*; Jasper National Park, Signal Mtn. *Downie 724*; Cardinal Divide *Downie 728,729*; Mile 92 Hwy. 4, N. Coleman *Downie 734*; Ram Mountain *Downie 535A*; Cardinal Divide *Downie 541A*; **British Columbia:** Muncho Lake Provincial Park *Downie 620*. **Northwest Territories:** Hwy. 7 near Liard River *Downie 746*.

A. lonchophylla subsp. lonchophylla
Canada, Alberta: Wood Buffalo National Park, Km 26 Hwy. 5 *Downie 581*; Wood

Buffalo Natl. Park, 2 km N. Pine Lake Campground *Downie 582;* Wood Buffalo Natl. Park, S. Pine Lake *Downie 584;* Wood Buffalo Natl. Park, 20 km S. Pine Lake *Downie 585.* **British Columbia:** Km 935 Alaska Hwy. *Downie 455.* **Northwest Territories:** 13 km E. Hay River, Hwy. 2 *Downie 576;* 11 km N.W. Enterprise, Hwy. 1 *Downie 586;* 43 km N. Fort Providence, Hwy. 3 *Downie 592;* 60 km N. Fort Providence, Hwy. 3 *Downie 593;* Km 92 Hwy. 3 *Downie 594;* Km 167 Hwy. 3 *Downie 603;* Km 192 Hwy. 1, W. Hwy. 3 junction *Downie 607;* Km 212 Hwy. 7 *Downie 613.* **Québec:** St. Joachim-de-Tourelle *Downie 530.* **Yukon:** Km 245 Klondike Hwy., Fox Lake *Downie 463;* Km 378 Campbell Hwy., 15 km S. Ross River *Downie 488.*