

University of New Mexico

## UNM Digital Repository

---

Biology ETDs

Electronic Theses and Dissertations

---

4-7-1967

### A Study Of The Genus Phacelia In New Mexico

Helen M. Bobisud

Follow this and additional works at: [https://digitalrepository.unm.edu/biol\\_etds](https://digitalrepository.unm.edu/biol_etds)



Part of the [Biology Commons](#)

---

# UNIVERSITY OF NEW MEXICO LIBRARY

## MANUSCRIPT THESES

Unpublished theses submitted for the Master's and Doctor's degrees and deposited in the University of New Mexico Library are open for inspection, but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publication of the thesis in whole or in part requires also the consent of the Dean of the Graduate School of the University of New Mexico.

This thesis by Helen M. Bobisud  
has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its patrons is expected to secure the signature of each user.

NAME AND ADDRESS

DATE

*Roger B. Petersen St John's College, Santa Fe* 22 May 1972

*Rezzie H. H. Webb U.N.M.* 1 Feb 1976

*Carolyn Dodson U.N.M.*

11 February 1974



A STUDY OF THE GENUS PHACELIA

IN NEW MEXICO

By

Helen M. Bobisud

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Biology

The University of New Mexico

1967



LD  
3781  
NS63B631  
cop.2

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

**A STUDY OF THE GENUS PHACELIA**

**TITLE**

**IN NEW MEXICO**

**Helen M. Bobisud**

**CANDIDATE**

**BIOLOGY**

**DEPARTMENT**

*Al Sege*

**DEAN**

*4-7-67*

**DATE**

**COMMITTEE**

*William C. Martin*

**CHAIRMAN**

*C. Clayton Hoff*

*Howard J. Dittmer*

0425375







## ACKNOWLEDGMENTS

I wish to thank Dr. William C. Martin for suggesting the problem and for his encouragement and guidance throughout the course of the work. Thanks also are due my husband, who suffered several cases of Phacelia dermatitis during the collecting and who typed the manuscript.



## TABLE OF CONTENTS

Acknowledgments . . . . .	ii
List of Maps . . . . .	v
List of Tables . . . . .	vi
Introduction and Historical Survey . . . . .	1
Range of the Genus . . . . .	4
Materials and Methods . . . . .	6
Description of the Genus <u>Phacelia</u> in New Mexico . . . . .	7
Characteristics Used in Species Diagnoses . . . . .	8
General Observations on the Genus . . . . .	11
Key to the New Mexican Species of <u>Phacelia</u> . . . . .	13
Descriptions and Discussions of the Species . . . . .	15
<u>P. sericea</u> . . . . .	15
<u>P. ivesiana</u> . . . . .	17
<u>P. heterophylla</u> . . . . .	20
<u>P. integrifolia</u> . . . . .	31
<u>P. congesta</u> . . . . .	36
<u>P. popei</u> . . . . .	39
<u>P. neomexicana</u> . . . . .	43
<u>P. coerulea</u> . . . . .	47
<u>P. crenulata</u> . . . . .	50
<u>P. intermedia</u> . . . . .	54



Summary . . . . .	58
Appendix: Citation of Specimens . . . . .	59
Literature Cited . . . . .	65



## LIST OF MAPS

Map 1. Distribution of <u>P. sericea</u> and <u>P. ivesiana</u> . . . . .	18
Map 2. Ranges and Intergrades of <u>P. heterophylla heterophylla</u> and <u>P. hastata hastata</u> . . . . .	28
Map 3. Distribution of <u>P. integrifolia</u> . . . . .	35
Map 4. Distribution of <u>P. congesta</u> . . . . .	38
Map 5. Distribution of <u>P. popei</u> . . . . .	42
Map 6. Distribution of <u>P. neomexicana</u> . . . . .	46
Map 7. Distribution of <u>P. coerulea</u> . . . . .	49
Map 8. Distribution of <u>P. crenulata</u> . . . . .	53
Map 9. Distribution of <u>P. intermedia</u> . . . . .	56



## LIST OF TABLES

Table 1. Hybrid Index Values for the Variability Range of	
Each of Four Characteristics . . . . .	24
Table 2. Hybrid Index Values for New Mexico <u>P. heterophylla</u> . .	26



## INTRODUCTION AND HISTORICAL SURVEY

Phacelia, the largest genus in the family Hydrophyllaceae, consists of some 150 to 200 species. The genus is heterogeneous and has undergone several revisions of both infrageneric organization and species classification. The type species is P. secunda J. F. Gmelin, Syst. 2:330. 1791.

In 1789 Jussieu assigned the genus to what is now the family Boraginaceae. Brown (see Edwards, 1817) assigned Phacelia to the order Hydrophyllaeae. In 1875 Asa Gray united the order Hydrophyllaeae with the family Hydroleae and formed the family Hydrophyllaceae. He divided the genus Phacelia into seven subgenera based on characteristics of ovules, seeds, and corolla appendages. The subgenera included Euphacelia, Eutoca (formerly a separate genus), Microgenetes, Whitlavia, Gymnobythus, Cosmanthus, and Cosmanthoides. In 1890 Phacelia was once more put in the Boraginaceae by Baillon, who did not recognize the family Hydrophyllaceae. In 1913, however, Brand restored the Hydrophyllaceae to family status and wrote the only existing monograph dealing with the entire genus Phacelia. He divided the genus into six sections, four of which were very small. The small sections were Whitlavia, Gymnobythus, Microgenetes, and Cosmanthus; the two large ones were Eutoca and Euphacelia. Partial revisions of the genus by several authors followed.

In 1944 Howell created the section Miltitzia, composed of nine desert species, from the genus Miltitzia. He considered the new section more closely related to section Microgenetes than to any other



section. In 1946 he revised the section *Microgenetes*, which he now called *Euglypta* by right of the latter being the prior name. This section is composed of 11 North American species of desert inhabitants and one South American montane species. Section *Euglypta*, together with section *Miltitzia*, he thought to be derived from section *Eutoca*. Constance (1949) revised the section *Cosmanthus*, which he considered a subgenus because of its distinctive morphology, cytology, and geographical range. This subgenus, composed of 14 species, is confined to eastern North America. In 1955 Gillett revised the sections *Whitlavia*, with five species, and *Gymnobythus*, with two species.

Neither section *Phacelia* (the name now preferred to *Euphacelia*) nor section *Eutoca* have been revised in their entirety. Voss revised the *Phacelia crenulata* group of section *Phacelia* in 1937, and Heckard revised the *Phacelia magellanica* group of the same section in 1960. Gillett revised the *Phacelia franklinii* group of section *Eutoca* in 1960.

Extensive investigations of the chromosome numbers of the Hydrophyllaceae have been undertaken by Cave and Constance (1942, 1944, 1947, 1950, and 1959). In a paper summarizing the results of these investigations, Constance (1963) proposes a new infrageneric organization for *Phacelia* based in part on these results. He suggests dividing the genus into three subgenera: *Cosmanthus* (basic haploid number 9), *Howellanthus* ( $n = 8$ ), and *Phacelia* (basic haploid number 11). Subgenus *Cosmanthus* consists of 14



species, including one perennial, one biennial, and seven annuals with  $n = 9$ , two annuals with  $n = 5$ , one annual with  $n = 8$ , and one annual with  $n = 14$  (Cave and Constance, 1950). Subgenus Howellanthus contains only one species, a perennial with  $n = 8$ . Subgenus Phacelia is a large and heterogeneous group of perennials, biennials, and annuals and is divided into several species groups. The basic haploid number in this subgenus is 11, but haploid numbers of 8-13, 22-24, and 33 have been found. Constance suggests that the perennial species of these three subgenera represent three evolutionary stocks which, in the cases of subgenera Cosmanthus and Phacelia, have given rise to numerous annual species with varying chromosome numbers. He states that a reduction in ovule number appears to have arisen independently in several groups.

The present study is an attempt to determine which species of Phacelia occur in New Mexico and to simplify species determination of New Mexico specimens.



## RANGE OF THE GENUS

The genus Phacelia is native only in the Western Hemisphere, where it ranges from near the Arctic Circle in western North America to Guatemala and from Peru to the tip of South America. In the United States the genus is found everywhere except in New England and Florida, with the main concentration of species west of the Rocky Mountains.

There are about 15 species in South America, representing three groups, all of which have their centers of distribution in North America (Heckard, 1963); this suggests that migration has been from north to south. The Phacelia crenulata group has, according to Heckard, probably fewer than 10 South American species, most of which are found in high montane areas, suggesting that the migrating species could have been montane. Section Euglypta has one species, P. cumingii, in South America. This species seems very similar to the North American P. affinis. Heckard proposes that the migration of plants of this group has been fairly recent and that Axelrod's (1952) theory that the best time for the dispersal of warm desert species was in the Recent geological epoch may have some application here. The third group having some members in South America is the P. magellanica complex; Heckard's studies indicate that there are at least four species of this group in South America. The plants of the northern Andes most closely resemble those of the mountains of southern Mexico and are similar to those of Arizona, New Mexico, and Colorado. Heckard suggests



that only one species of this group was involved in the migration to the south and that the other South American species, including the only annual in the complex, have all been derived from this migrating species. The 16 chromosome counts done on the South American species have all revealed a haploid number of 11. Further study of the little known Colorado, New Mexico, Arizona, and Mexico plants may provide more insight into the southward migration of certain members of this genus.



## MATERIALS AND METHODS

Fifty-six collections of Phacelia were made in central, southeastern, and northwestern New Mexico during 1965 and 1966. The number of plants collected at one place varied from one to about 30, depending on the size of the population. An attempt was made to select both the largest and smallest plants from each population. In the case of some of the larger specimens only a portion sufficient to indicate the size of the plant was taken. Other collections were taken mostly at random but with some attempt to include plants with ripe seeds, fully developed corollas, or rosette leaves. In some cases collections were made at the same place at different times to obtain several stages of plant development.

The plants studied included approximately 300 specimens from both my own collections and those in the University of New Mexico Herbarium.

The hybrid index used in connection with P. heterophylla is a rapid method devised by Anderson (1949) for determining which individuals of a group of plants are probably hybrids and if these putative hybrids are  $F_1$ ,  $F_2$ , or backcrosses to one of the parents. Several characters which differ between two taxa believed to be involved in hybridization are chosen, and the range of variability of each character is divided into three or more sections. A value is assigned to each section, the lowest value to the section typical of one taxon, the highest to the section typical of the other taxon. Each plant is then scored for each character and these values totaled to give the hybrid index of that plant. A hybrid index equal to that of either parental taxon indicates that the plant is not a hybrid; an intermediate value indicates that it is a hybrid.



DESCRIPTION OF THE GENUS PHACELIA IN NEW MEXICO

Phacelia Juss., Gen. 129. 1789.

Annual, biennial, or perennial herbs with 1 to several main stems, puberulent to hispid to sericeous, often with glandular hairs. Rosette leaves often not persistent, entire to pinnatifid; cauline leaves smaller, entire to pinnatifid. Inflorescence a panicle or thyrse of scorpioid racemes with 2 rows of flowers; racemes sometimes very short and obscurely scorpioid, straightening in fruit. Sepals 5, linear to ovate, elongating in fruit, usually somewhat heteromorphic with the outermost sepal the widest. Corolla tubular or campanulate, white to blue or violet, often pubescent externally; corolla lobes imbricate in the bud; five pairs of scalelike appendages usually present in the throat of the corolla, oblong to lunate, entire to erose, sometimes united to the filaments at the base. Stamens 5, inserted on the corolla at the same level, alternate, glabrous to villous; anthers versatile. Style cleft about  $1/4$  to  $2/3$  its length. Ovary 1-celled, but appearing almost 2-celled by involution of the placentas. Placentation parietal, 4 to about 20 ovules per ovary. Fruit a loculicidal capsule with 2 lines of dehiscence, globose to ovate to slightly obovate, acute to obtuse at the apex, usually sparsely hirsute. Seeds 1 to about 20 per capsule, elliptic to fusiform, sometimes partly or wholly corrugated, often with one side excavated and with a prominent ridge.



## CHARACTERISTICS USED IN SPECIES DIAGNOSES

Although each species or variety of Phacelia has a typical growth form, there is a great deal of variation, even within one population, because this form is much influenced by the age and size of the plant. In species or varieties in which the mature plant shows branching at the base, a young plant often has only one stem. Likewise, in those taxa wherein one main stem is the usual growth form, a plant with a broken-out top will produce several branches from the base.

The leaves are also variable from plant to plant. The shape, especially that of the basal leaves, is not at all reliable as a diagnostic characteristic, being variable and often difficult to determine because of the numerous divisions and the tendency to become wrinkled in drying. The amount of dissection of the leaves and their lobes is diagnostically more useful. Whereas there is much intraspecific variation, it is possible to use leaf dissection as a basis for segregating New Mexico phacelias into three groups.

Phacelia ivesiana and P. heterophylla have leaves that are no more than once pinnatifid with entire lobes; P. popei and P. neomexicana have leaves at least twice pinnatifid; the other species have leaves that are no more than once pinnatifid with lobes at least serrate.

Pubescence consists of four main types of trichomes, two of which are glandular. The glandless trichomes are unicellular, one being fine, short, and sometimes wavy, the other being hollow, long, straight, and stiff. One of the glandular trichomes is a long,



stiff, hollow, unicellular hair enlarged at the base, which is surrounded by several apparently glandular cells. The lumen of the trichome shaft is often filled with a yellowish or brownish sticky fluid. In the descriptions this kind of trichome is denoted "gland-based." The other glandular trichome, that which is indicated by the word "glandular" in the descriptions, is composed of a stalk of about two or three cells topped by a cuplike glandular structure which varies greatly in size, ranging from barely visible under 20X magnification in P. heterophylla to easily visible with the naked eye in P. coerulea and related species. The proportions of these four kinds of trichomes varies from species to species and somewhat from plant to plant. This is a fairly good diagnostic character, but the subjectiveness of terms makes accurate description difficult. The pubescence characteristics used in the descriptions below were determined under a magnification of 20X.

Corolla length and stamen exertion are to some extent useful characteristics, although both show considerable intraspecific variation. Because corolla appendages are so variable from plant to plant and so difficult to describe accurately, they are not useful in distinguishing species.

Seeds are the most useful structures diagnostically. The size shows little variation within a population, and even within a species. The shape also is useful, especially in separating major groups. Presence or absence of corrugations and their distribution is the most constant character except in a few cases (see P. integrifolia).



The presence or absence of a light marginal band on the seed is not very meaningful, because this sometimes varies within a species.



## GENERAL OBSERVATIONS ON THE GENUS

The New Mexico phacelias (with the possible exception of P. intermedia and P. ivesiana, which I did not collect) tend to be inhabitants of areas more or less disturbed either by man or by nature. Common habitats are road cuts, arroyo bottoms, talus slopes, and open forest areas. The desert and plains species do not seem to be able to compete well in heavily grassed areas; the plants may grow in abundance on a road cut or in an arroyo bottom but not at all in an adjacent grassy area. The montane species, P. sericea, P. heterophylla, and P. neomexicana, do, however, grow in grassy areas, but often not in such numbers and with such robustness as those growing on adjacent road cuts or other disturbed areas. It is very likely that man's road building has played an important part in the recent history of this genus. The combination of numerous disturbed habitats and the weedy nature of Phacelia is especially favorable for the phenomenon of introgression (Stebbins, 1950).

On hot days the leaves of P. integrifolia and related species are found with the edges curled under so that the abaxial side is scarcely visible. This may be a mechanism to reduce excessive evaporation from the leaves.

Observations indicate that all the species of Phacelia that I collected (with the possible exception of P. sericea) are insect pollinated. Small bees seem to be the most frequent visitors, but bumblebees are found on the flowers of P. integrifolia, P. heterophylla,



and P. neomexicana. Small butterflies were commonly observed on the flowers of P. congesta var. rupestris collected at Sitting Bull Falls.



KEY TO THE NEW MEXICAN SPECIES OF PHACELIA

1. Ovules more than 4 (usually 15-20) per capsule . . . . . 2
1. Ovules 4 or fewer per capsule . . . . . 3
2. Sericeous perennial; stamens exserted . . . . . P. sericea
2. Hirsute and pubescent annual; stamens included . . . P. ivesiana
3. Leaves entire or pinnatifid with entire lobes . . P. heterophylla
3. Leaves not entire, and if pinnatifid, then lobes not entire . 4
4. Anthers blue-black . . . . . 5
4. Anthers yellow . . . . . 6
5. Corolla with infoldings between the lobes; cauline leaves  
not cleft more than halfway to the midrib; herbage not  
villous-hirsute . . . . . P. integrifolia
5. Corolla without infoldings between the lobes; at least  
some cauline leaves cleft more than halfway to midrib;  
herbage villous-hirsute . . . . . P. congesta var. rupestris
6. Seeds not corrugated on the excavated side . . . . . 7
6. Seeds corrugated on the excavated side . . . . . 9
7. Leaves once pinnate or once pinnatifid, lobes elliptic,  
constricted at the base . . . . . P. congesta var. congesta
7. Leaves more than once pinnate or more than once pinnatifid,  
ultimate lobes linear, not constricted at the base . . . . . 8
8. Seeds 1.1-2.1 mm long; corolla lobes subentire to  
crenulate . . . . . P. popei
8. Seeds 2.3-3.3 mm long; corolla lobes fimbriate . . . P. neomexicana



9. Corollas 3-4 mm long; stamens exerted no more  
than 0.3 mm . . . . . P. coerulea
9. Corollas more than 4 mm long; stamens exerted 1 mm or more . 10
10. Petioles of the basal leaves 1.2-2 cm long; seeds 2.5-  
3.8 mm long; adaxial side of leaves glabrous to glandular  
pubescent or hirsutulous . . . . . P. crenulata
10. Petioles of the basal leaves 2.3-4.3 cm long; seeds 2-2.5  
mm long; adaxial side of leaves densely pubescent or  
hirsutulous with appressed gland-based trichomes . P. intermedia



# DESCRIPTIONS AND DISCUSSIONS OF THE SPECIES

Phacelia sericea (Graham) A. Gray. Amer. Journ. Sci. II. 34:254. 1862.

Eutoca sericea Graham. Edinburgh N. Phil. Journ. 172. 1830.; Bot.

Mag. 57: pl. 3003. 1830.

Perennial, about 16 cm high. Stems erect, moderately stout, villous. Basal leaves apparently persistent, 8-12 cm long, 1.8-3.5 cm wide, lanceolate, pinnatifid, the lobes narrow, serrate to cleft, acute, sericeous, especially abaxially; petioles 3.5-5.0 cm long, sericeous. Cauline leaves 1.2-8.5 cm long, 0.1-2.2 cm wide, becoming reduced on the flowering stalk, entire to pinnatifid; lobes entire to cleft, acute to attenuate, sericeous, especially abaxially; petioles absent to 3.5 cm long, sericeous. Inflorescence a thyrse of usually 5- to 6-flowered unilateral racemes; pedicels 1-2 mm long, villous. Sepals about 7 mm long at anthesis, linear, acute, villous. Corolla about 5 mm long, campanulate, lobes rounded, subentire, pubescent exteriorly and interiorly on each lobe just above and between the appendages, pinkish-purple, white in the throat. Appendages in corolla triangular, fimbriate, not attached to the stamens, overlapping each other at the center of each lobe of the corolla. Stamen filaments 11 mm long, exserted 6.5 mm beyond the tip of the corolla lobes, purple, glabrous; anthers oval, orange-yellow. Style 14 mm long, cleft 4.6 mm, purple. Ovary densely pilose. Ovules about 15-20, oblong to lanceolate, not excavated on either side. No mature fruits or seeds available for description.

Type: Canadian Rockies. Drummond, 2nd Franklin Expedition.



Range: Alberta to British Columbia, south to northern New Mexico, northern Arizona, Nevada, and California.

The only collections made in New Mexico are from Mt. Wheeler, near Taos, at 11,000 ft elevation.

The Mt. Wheeler population apparently constitutes the southernmost extension of the species on the eastern side of its range. Gillett (1960) apparently did not know of the existence of this population, although it was reported by Wootton and Standley (1915). Gillett describes two subspecies, ssp. sericea and ssp. ciliosa. Subspecies ciliosa apparently is the result of crossing between P. sericea sericea and P. idahoensis and occurs in the area where their ranges overlap (Gillett, 1961). It forms the southernmost extension of the species on the western side of the range near Flagstaff, Arizona. The Mt. Wheeler plants are, however, P. sericea sericea, as would be expected from their position in the range of the species. The population did not appear to be very large; the only specimens seen were the two collected. However, the plants were just beginning to bloom (the flowers on those collected opened after collection) and other plants could have been overlooked easily.

Gillett (1963) reports that P. sericea sericea is a short-day, cold-induced plant. This, he says, is probably a factor limiting the southern extension of its range. Probably equally important, at least at the present time, is the limit imposed by the end of the mountain range. Populations of this species should be looked for in the high mountains between Taos and Santa Fe.



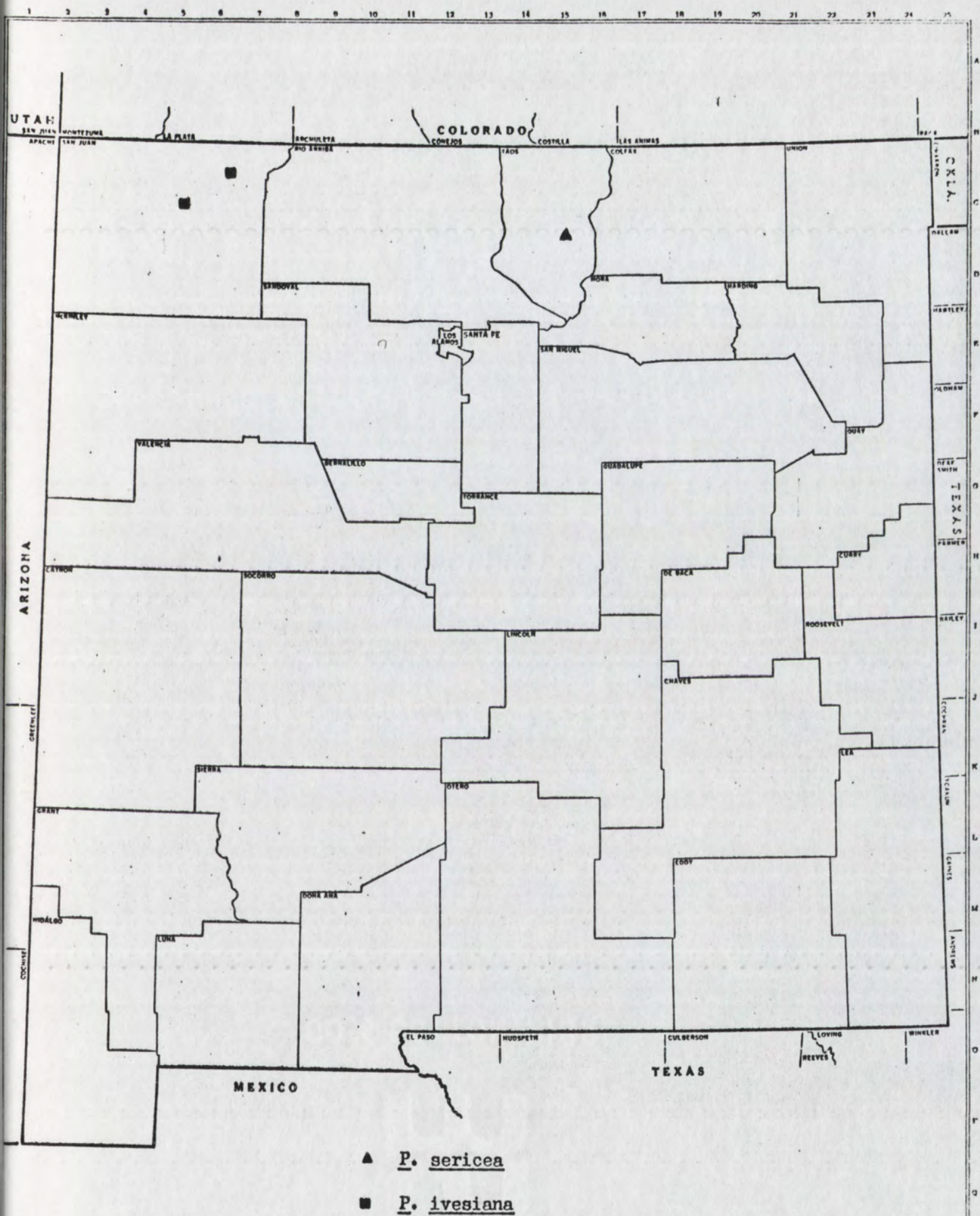
This species is the only member of section *Eutoca* represented in New Mexico. It has no close relatives among the other New Mexican species.

A chromosome number of  $n = 11$  has been reported for *P. sericea* *sericea* (Constance, 1963).

*Phacelia ivesiana* Torr. in Ives, Colo. River Explor. Exped. Bot. 21. 1860.

Annual with one to several branches near the base, erect, 10-17 cm high. Stems weak, hirsute and pubescent, with some glandular pubescence. Rosette leaves either nonexistent or not persistent. Cauline leaves 1.5-4.5 cm long, 0.5-1.4 cm wide, becoming gradually smaller toward the apex of the stem, oblong to ovate, pinnately lobed two-thirds of the way to the midrib, about 4 to 6 lobes on each side; lobes entire or very occasionally toothed, hirsute; petioles 0.4-1.8 cm long, pubescence similar to that of the stem. Inflorescence of very loose scorpioid racemes becoming about 6.5 cm long in fruit. Pedicels 1.5-2.0 mm long, becoming sigmoidly reflexed, hirsute and glandular pubescent. Sepals 7-8 mm long in fruit, linear, obtuse to slightly acute, hirsute and glandular pubescent. Corolla about 4 mm long, tubular, margins subentire, glabrous, white; appendages absent. Staminal filaments included, 2 mm long, yellowish-white when dry, glabrous; anthers yellow. Style about 1.5 mm, cleft 0.5 mm, yellowish when dry. Fruits distant, about 4.2 mm long, 2.1 mm wide, oblong to slightly obovate, obtuse, sparsely hirsute. Seeds about 20 per capsule, 1.5 mm long, 0.5 mm wide, fusiform with no excavation on either side, reticulate and heavily corrugated all around with about







9 corrugations per seed.

Type: Arizona. Newberry, s.n., Ives's Colorado Exped. (NY).

Range: Southern Wyoming and Colorado to Nevada, New Mexico, Arizona, and southeastern California. In New Mexico it is reported from only the northwest corner, 5500-6000 ft elevation.

This species is the only representative of the section *Euglypta* among the plants studied. Howell (1946), however, cites a specimen of *P. affinis* Gray, a member of section *Euglypta*, as being found in the Peloncillo Mountains in Hidalgo County.

Howell (1946) describes two varieties of *P. ivesiana*, var. *typica* (= var. *ivesiana*) and var. *pediculoides*. These vary primarily in the shape and number of corrugations of the seed, var. *ivesiana* having slender seeds with 9 to 12 corrugations and var. *pediculoides* having plump seeds with 5 to 7 corrugations. There also are some indefinite differences in the leaves. Intermediates between the two varieties appear to be nonexistent even in the overlap of the ranges in eastern California, southern Nevada, and western Arizona. The collection from which the original description was made contains plants of both varieties. Chromosome counts (Cave and Constance, 1959) indicate that these two taxa should be considered separate species. Specimens of var. *pediculoides* have a chromosome number of  $n = 23$  while those of var. *ivesiana* have  $n = 11$ . Constance (Cave and Constance, 1959) created the new combination *P. pediculoides* (J. T. Howell) Const. to replace *P. ivesiana* var. *pediculoides*.

Although Howell cites a specimen of *P. ivesiana* var. *ivesiana*



from McKinley County, all the specimens of this taxon in the University of New Mexico Herbarium were collected from San Juan County. Plants of this species are probably more common in the northwest corner of the state than collections indicate because these small plants with inconspicuous flowers are easily overlooked.

Phacelia heterophylla Pursh, Fl. Am. Sept. 1:140. 1814.

P. biennis A. Nels., Bull. Torr. Bot. Club, 1899, 132.

P. circinata Jacq., f. Eclog. Am. 4. 135. t. 91.

Perennial with 1 to several branches at the base, erect to slightly decumbent, 18-82 cm high. Stems weak to stout, sparsely to moderately hirsute to hispid with tomentose pubescence and small glandular trichomes beneath. Rosette leaves not persistent, 6.5-19.5 cm long, 1-5.5 cm wide, entire to pinnate with 3 pairs of lobes, the terminal lobe enlarged; lobes entire, elliptical to elliptic-ovate or elliptic-lanceolate; pubescence of long, stiff, hollow trichomes sometimes containing a brownish-yellow substance, and of an undercovering of fine short trichomes, each type of trichome varying independently from sparse to dense; the long stiff trichomes concentrated on the veins abaxially and between the veins adaxially; petioles 2.5-9.5 cm long, pubescence similar to that of the stem. Cauline leaves 0.7-7.5 cm long, 0.2-6.5 cm wide, becoming gradually smaller toward the stem apex, entire to pinnate with 2 pairs of lobes, the terminal lobe enlarged; lobes entire, elliptic to elliptic-ovate or lanceolate, pubescence similar to that of rosette leaves; petioles absent to 3 cm long, becoming reduced towards stem apex, pubescence similar to that of stem.



Inflorescence a narrow to loose panicle of scorpioid racemes; racemes becoming 0.4-1.5 cm long in fruit, pubescence similar to that of the stem. Sepals somewhat heteromorphic, about 2.5 mm long at anthesis, enlarging to about 8 mm long at seed maturity, 0.8-1.9 mm wide, linear to elliptic-lanceolate, apex acute, hirsute-ciliate with sparse to dense pubescence abaxially. Corolla 3-6 mm long, campanulate, lobes subacute, entire, finely pubescent externally, white to yellowish; appendages lunate, 1.0-1.5 mm long. Stamen filaments 6-10 mm long, exerted 1.0-5.5 mm beyond the tip of the corolla lobes, yellowish brown when dry, sparsely to moderately villous; anthers slightly oblong, yellow-brown when dry with a light strip around the point of attachment. Style 5.3-10.0 mm long, cleft  $1/2-2/3$  the length. Fruit 2.3-3.2 mm long, 2.0-2.1 mm wide, ovate, slightly flattened parallel to the lines of dehiscence, acute apically, hirsute. Capsule and calyx detaching as a unit at maturity. Seeds 1-4 per capsule, 1.9-2.5 mm long, 0.8-1.0 mm wide, ovate, with a slight ridge on one side, favose pitted, light to dark brown.

Type: Idaho. "On dry hills and on the banks of the Kooskoosky" (Clearwater River). M. Lewis, s.n., 6/9/1806. (PH).

Range: Washington to Montana, south into California, New Mexico, and Mexico.

In New Mexico, mountains from Santa Rita and Cloudcroft north, from 7,000 to 11,000 ft. Found primarily in open areas of disturbance, both natural and man-made.

Phacelia heterophylla is a member of section Phacelia, but is



distinctly separate from the other New Mexican members of this section. It is not closely related to either of the two species, P. neomexicana of the same section and P. sericea of section Eutoca, with which it is sometimes found.

Many of the plants studied appear not to be typical P. heterophylla as described by Heckard (1960). These seem to vary in the direction of P. hastata Douglas ex. Lehman, a species which reaches its southern limits in middle Colorado and appears to intergrade with P. heterophylla in many areas of Colorado (Heckard, 1960). In Colorado, however, P. hastata characteristics apparently predominate, whereas in New Mexico P. heterophylla characteristics predominate.

Analysis of Heckard's descriptions of P. heterophylla and P. hastata revealed four major interspecific differences (Table 1). Each plant was scored for these characteristics using the values shown. The results had to be divided into two categories: one with data from plants for which all four characteristics could be determined and the other with data from plants for which three of the characters could be determined, these latter lacking basal leaves. The degree of dissection of the basal leaves often showed the influence of P. hastata with a full rating of two. Thus plants without basal leaves from populations in which most of the plants with basal leaves had ratings of two in this character probably would have higher scores than are indicated. The data for the two groups are shown in Table 2. Collections showing high ratings (hybrid index values of 3 and 4) either in one plant or in many of the plants if several were collected from one population are



TABLE 1. A table of hybrid index values used in evaluating similarity between New Mexico specimens of Phacelia heterophylla and Heckard's descriptions of P. heterophylla and P. hastata. Plants having the characteristic typical of P. heterophylla are assigned hybrid index value 0 and plants having the characteristic typical of P. hastata are assigned hybrid index value 2.



TABLE 1. Hybrid Index Values for the Variability  
Range of Each of Four Characteristics

1. Degree of dissection of basal leaves

Most basal leaves pinnate = 0

A few basal leaves pinnate, and these with no more than one  
pair of leaflets = 1

Basal leaves all entire = 2

2. Color of foliage

Green = 0

Slightly whitish or grayish = 1

Whitish or grayish = 2

3. Density of glandular hairs on upper stems and calyces

Abundant = 0

Sparse = 1

Absent = 2

4. Portion of plant with supra-axillary branches

Not more than upper  $1/3$  of plant = 0

More than upper  $1/3$  but less than upper  $1/2$  of plant = 1

At least upper  $1/2$  of plant = 2



TABLE 2. An analysis of variability in New Mexico Phacelia  
heterophylla using hybrid index value totals.

Section A

Total for typical P. heterophylla = 0

Total for typical P. hastata = 8

Section B

Total for typical P. heterophylla = 0

Total for typical P. hastata = 6.



TABLE 2. Hybrid Index Values for New Mexico P. heterophylla

## A. Plants for which all four characters were determinable:

Hybrid index value	0	1	2	3	4	5	6	7	8	Total
Number of plants	10	7	9	6	4	0	0	0	0	36

## B. Plants for which only three characters were determinable:

Hybrid index value	0	1	2	3	4	5	6	Total
Number of plants	27	9	2	1	0	0	0	39

Number of above plants  
from population where  
most plants had  
pinnate leaves\*

5	2	1	0	0	0	0	8
---	---	---	---	---	---	---	---

---

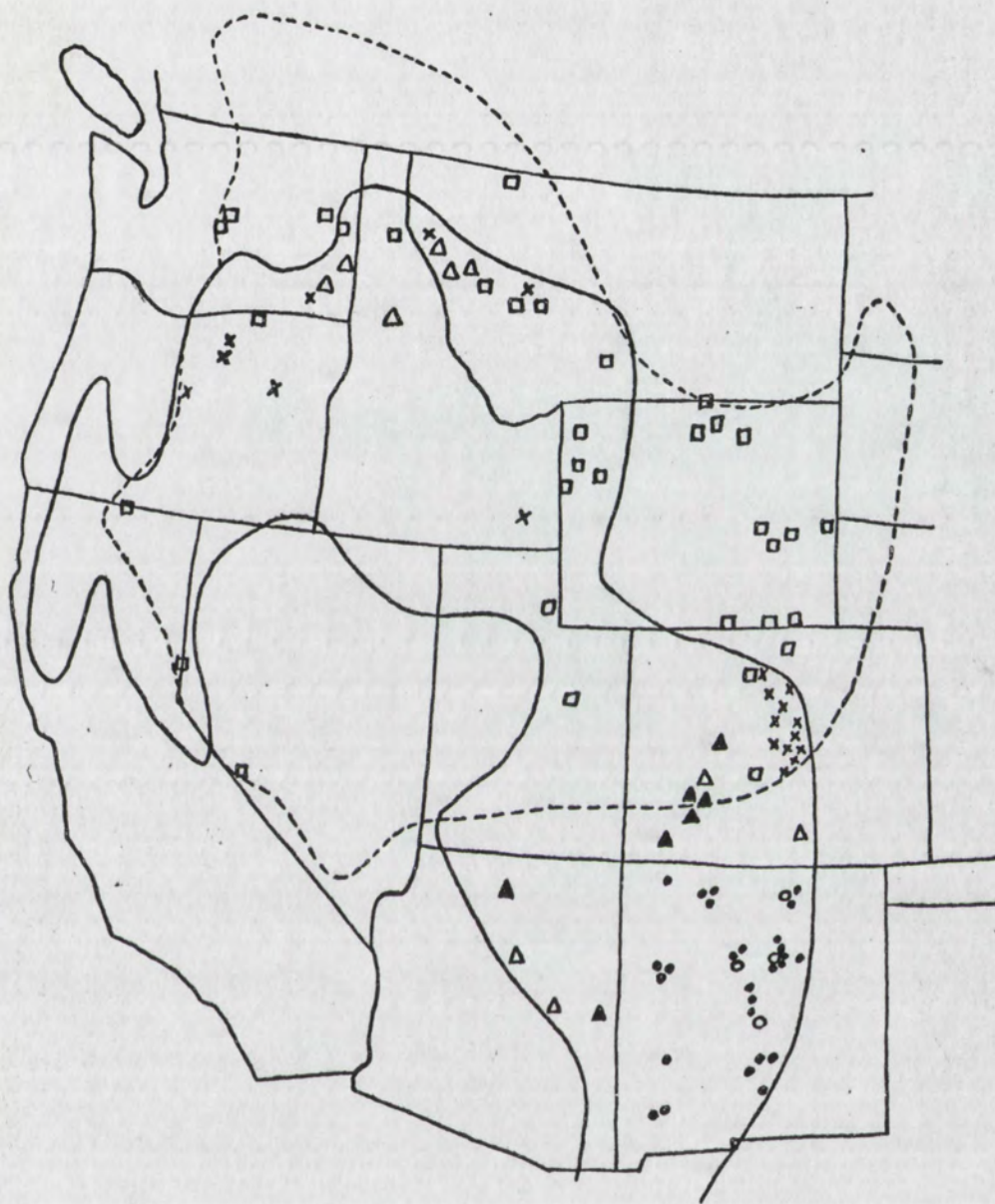
\*Bobisud 128 near Taos and Bobisud 141 near Santa Fe.



Map 2. Ranges and intergrades of P. heterophylla heterophylla and P. hastata hastata, based in part on Heckard (1960).

- Range of P. heterophylla
- ▲ P. heterophylla heterophylla diploid
- △ P. heterophylla heterophylla tetraploid
- Range of P. hastata hastata
- P. hastata hastata tetraploid
- × P. hastata hastata-P. heterophylla heterophylla intergrades, tetraploid
- Collections of P. heterophylla heterophylla in New Mexico
- Collections of P. heterophylla in New Mexico having hybrid index values of 3 and 4





Map 2. Ranges and Intergrades of P. heterophylla heterophylla  
and P. hastata hastata.



indicated on Map 2.

The data presented in Table 2 appear to be evidence of introgressive hybridization as described by Anderson (1949), the introgression being from P. hastata to P. heterophylla in this case. One important question that arises is how the intergrades between these two species occur in northern New Mexico where P. hastata is not present. Two explanations seem plausible. It may be that tetraploid P. hastata occurred in the area some time ago and that hybridization and subsequent backcrossing with tetraploid P. heterophylla took place; then conditions changed, and P. hastata retreated to the north, leaving P. heterophylla and hybrids having genotypes similar to that of P. heterophylla. Or, hybridization and introgression may have occurred in Colorado within the present range of P. hastata and then some of the introgressants which were genotypically similar to P. heterophylla migrated southward. At the moment there is not enough known about either the New Mexico or Colorado plants to propose an answer to this question. Further collections, chromosome counts, and crossing experiments are much needed.

Heckard (1960) has studied the relationship between P. heterophylla and P. hastata to some degree over most of the range of the two species, including Colorado but not New Mexico. He reports that P. heterophylla is composed of two subspecies, ssp. heterophylla and ssp. virgata occurring in the east and west of the range, respectively. He indicates that P. hastata is also composed of two subspecies, ssp. hastata occurring over most of the range and ssp. compacta restricted to a small



area in Nevada. The subspecies involved in the P. hastata X P. heterophylla intergrades in Colorado are P. heterophylla heterophylla and P. hastata hastata. Intergrades between these two subspecies occur also in Oregon, Washington, Idaho, and Montana.

The chromosome counts as reported (Cave and Constance, 1942, 1944, 1947, 1959 and Heckard, 1960) show that P. hastata is a tetraploid with  $n = 22$ , whereas P. heterophylla has both diploid and tetraploid members with  $n = 11$  and  $n = 22$ , respectively. Heckard found that all the P. hastata X P. heterophylla intergrades counted were tetraploid. Map 2, adapted from Heckard, shows the ranges of the two species and specific locations of populations for which chromosome counts are reported.

It can reasonably be presumed that in New Mexico both diploid and tetraploid plants of P. heterophylla are present and that those plants showing evidences of P. hastata introgression are tetraploid. Apparently, the seeds of triploid progeny of the tetraploid-diploid crosses are nonviable. All this, however, needs confirmation.

It has been proposed (Heckard, 1963) that one species of the P. magellanica complex (of which P. heterophylla and P. hastata are members) somehow migrated from North America to South America, where its derivatives now exist isolated from the other members of the complex by the tropics. Some of the history of that migration to the south might be revealed by study of the New Mexico and Colorado members of the complex.



Phacelia integrifolia Torr., Ann. Lyc. New York 2:222, t.3. 1826.

P. arenicola Brandege, Univ. Calif. Pub. Bot. 4:185. 1911.

P. integrifolia Torr. var. arenicola (Brandegee) Brand, Das  
Pflanzenreich IV, 251:82. 1913.

Annual or biennial, usually with one main stem, erect, 7.5-75.0 cm high. Stems slender to stout, glandular pubescent and sometimes also sparsely pilose. Rosette leaves not persistent, 5.0-15.5 cm long, 0.7-3.5 cm wide, deeply serrate to pinnatifid; lobes serrate to dentate, acute to obtuse, glandular puberulent or pubescent, sometimes also sparsely pilose; petioles 1.2-5.0 cm long, pubescence similar to that of the stem. Cauline leaves 0.7-12.5 cm long, 0.3-3.5 cm wide, cleft to serrate or dentate; lobes, when present, serrate or dentate, acute to obtuse, pubescence similar to that of the basal leaves; petioles absent to 2.8 cm long, pubescence similar to that of stem. Inflorescence of groups of scorpioid racemes, these becoming 2.5-15.5 cm long in fruit; pedicels 0.5-2.7 mm long in fruit, pubescence similar to that of the stem. Sepals 4.5-7.5 mm long in fruit, heteromorphic, elliptic to oblanceolate or obovate, acute to subacute, glandular pubescent and sometimes also sparsely pilose or hirsute. Corolla 5.0-6.3 mm long, funnelform or narrowly campanulate, with infoldings between the lobes, medium purple to nearly white; lobes subentire to crenulate, pubescent or puberulent externally; appendages 0.5-1.0 mm long, lunate or ovate, sometimes cupped, margins subentire to crenulate. Stamen filaments 5.5-10.0 mm long, exserted 1.5-4.5 mm, purple, glabrous; anthers blue-black. Style 3.0-10.0 mm long, cleft



2.5-7.5 mm, purple. Capsules 3.0-4.7 mm long, oval to ovate, obtuse to subacute, glandular pubescent. Seeds 4 per capsule, 1.8-4.0 mm long, oblong, excavated on one side with a prominent ridge down the middle, faveolate, usually not corrugate, but sometimes slightly corrugated on the ridge and/or sides, medium to dark brown, often with a light marginal band.

Type: On the Platte. Dr. James, s.n., June 25, 1820, Long's 1st Expedition. (NY).

Range: Kansas, Oklahoma, western Texas, New Mexico, southeastern Utah, Coahuila, and Chihuahua. In New Mexico mostly in the southern three-quarters from Santa Fe County south; 3,000-7,000 ft elevation.

Phacelia integrifolia is a very common and widespread species of Phacelia in the state. It is distinctive in having blue-black anthers and bluish pollen, characteristics which separate it from all the other phacelias in New Mexico except P. congesta var. rupestris. It has a somewhat strong smell which some people consider onionlike and others citruslike. The glandular exudate is somewhat irritating and in some persons causes a dermatitis very similar to that caused by poison ivy.

Voss (1937) describes two varieties of P. integrifolia, distinguishing them primarily on the basis of the length and width of the basal leaves, those of var. integrifolia (= var. typica) being 0.2-7 cm long and 0.7-2 cm wide and those of var. robusta being 3-15 cm long and 3-7 cm



wide. The New Mexico plants have basal leaves 5.0-15.5 cm long and 0.7-3.5 cm wide, and there is no definite break in the size range, large-leaved plants often occurring together in the same population with small-leaved plants. This variation in leaf size is just one aspect of the great variability exhibited by this species.

Other examples of variation in P. integrifolia are those in rosette formation and in dissection of the leaves. The rosettes formed vary from a distinct rosette with the leaves horizontal to an indistinct rosette with leaves tending toward a vertical arrangement. Most plants are of the latter type. Of the populations in which rosette formation was determinable only the populations from Bandelier National Monument and between Bandelier and White Rock in Los Alamos County were characterized by the distinct rosette. Dissection of the basal leaves varies from serrate or dentate to pinnatifid. The latter condition is outside the limits given by Voss (1937), who describes the leaves as being only pinnately cleft. But because rosette leaves are not persistent and are usually gone when plants are collected, this characteristic is easily missed. This characteristic also was observed primarily in the populations between Bandelier and White Rock and in Bandelier. Here the leaves varied from cleft to pinnatifid.

There are intra- and interpopulation variations in the intensity of the color of the corolla. In general there is a ranging from light to dark colors along a north to south cline, but there are several exceptions to this rule.



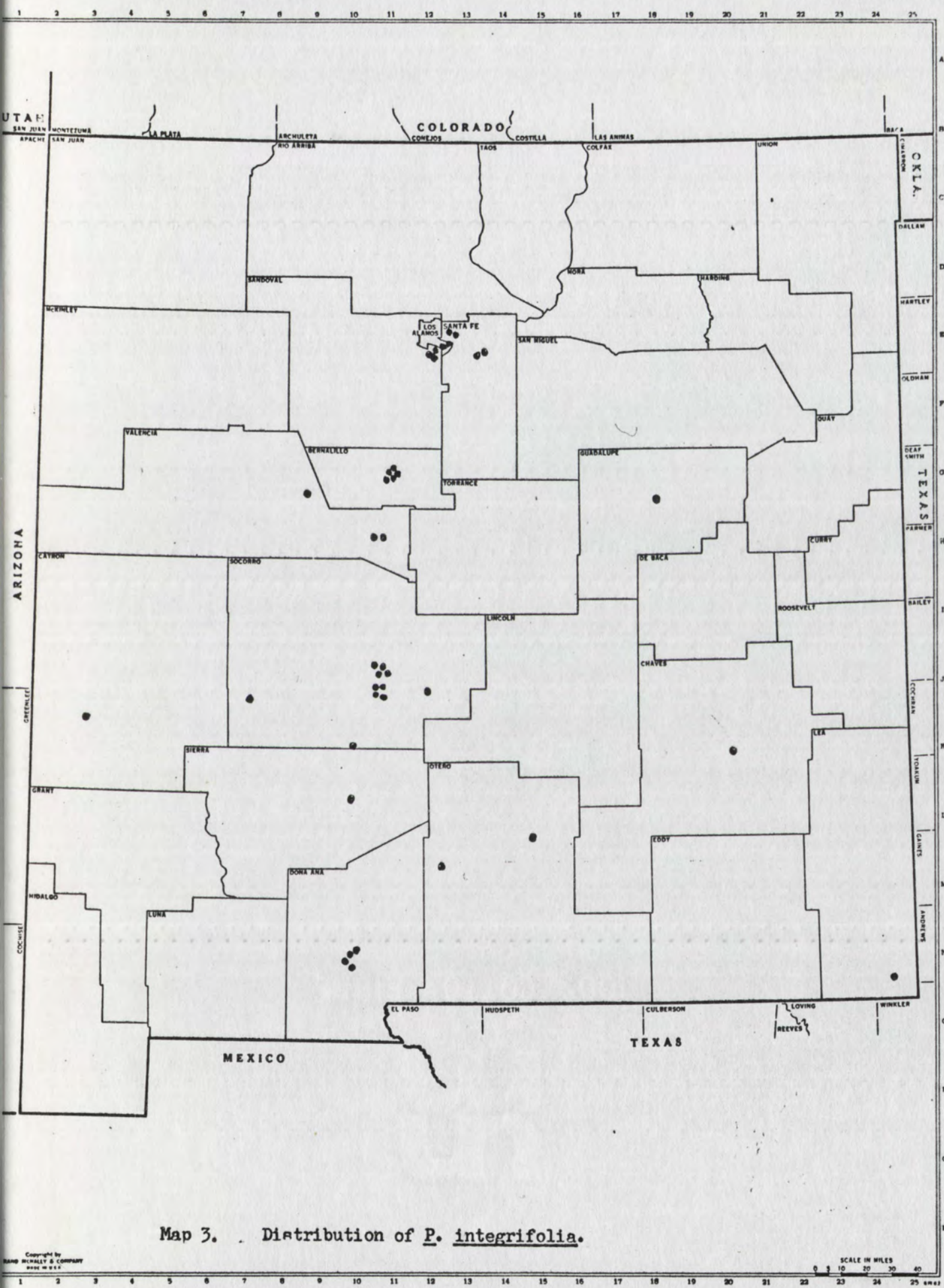
Seeds vary in two main ways, one of which appears to be due to hybridization. The range of length and average length of the seeds differ among the various populations. This does not appear to be at all the result of hybridization, as the seed sizes of all the possible hybridizing species are about the same. In at least some cases the degree of corrugation of the seed does, however, appear to be due to hybridization. Most of the populations of P. integrifolia with high incidences of slight seed corrugation occur also within the range of P. crenulata and P. coerulea. The one notable exception to this is a population near Roswell (Bobisud 110); this situation is peculiar in that no species with corrugated seeds have been found in southeastern New Mexico and adjacent Texas.

Another variation which is apparently connected with hybridization is that in the color of the stain left on newspaper by the herbage of the plant when it is pressed. The usual color is a yellow or yellowish green, but in some cases it is pale orange. This phenomenon is discussed more fully under P. coerulea.

Voss (1937) describes P. integrifolia as having a tubular corolla, a characteristic which he uses in his key. I find this characteristic neither very useful nor very accurate. The corolla actually is campanulate, but the infoldings between the lobes that are characteristic of this species often give the living corolla a more or less funnelform shape. Dried corollas vary from campanulate to funnelform depending on how they have been pressed.

A chromosome number of  $n = 11$  has been reported for P. integrifolia







(Cave and Constance, 1950).

Phacelia congesta Hook, Bot. Mag. LXII:t.3452. 1835.

Annual with one main stem, erect, 2.5-35.0 cm high. Stems somewhat weak, villous-hirsute, gland-tipped trichomes absent to dense. Rosette leaves not persistent, 6.0-11.5 cm long, 2.0-3.5 cm wide, pinnate with the terminal lobe enlarged; lobes widely separated, deeply serrate, acute, hirsute and dark glandular or villous-hirsute; petioles 2.5-6.0 cm long, slightly winged, villous-hirsute, often glandular. Cauline leaves 2.2-14.5 cm long, 1.0-4.5 cm wide, pinnate to pinnately lobed with the terminal lobe enlarged, deeply and often doubly serrate, acute to obtuse, densely hirsute and dark glandular to villous-hirsute, petioles 0.2-7.5 cm long, slightly winged, villous-hirsute, often glandular. Inflorescence of groups of scorpioid racemes, these becoming 1.5-9.0 cm long in fruit; pedicels 1.5-2.0 mm long, hirsute and glandular, or villous-hirsute. Sepals 3.0-3.5 mm long in fruit, somewhat heteromorphic, linear to oblong, acute, hirsute, or hirsute-glandular. Corolla 3-6 mm long, campanulate; lobes slightly to very crenulate, puberulent externally, white drying yellow or blue-violet, whitish or yellowish in the throat; appendages lunate, cupped, margins entire or irregular. Stamen filaments 4.5-7.0 mm long, exserted 1.5-4.0 mm beyond the corolla, purple or white drying yellow, glabrous; anthers yellow or blue-black. Style 5.5-7.5 mm long, cleft 5 mm, purple or white drying yellow. Capsules 2.5-3.5 mm long, oval to globose, acute



to obtuse, hirsute. Seeds 4 per capsule, 2-3 mm long, ovate to fusiform, excavated on one side with a prominent ridge down the middle, reticulate but not corrugated, light brown.

Type: Texas. Drummond 303. (GH).

Range: Central Texas, southern New Mexico and Arizona to central Mexico. In New Mexico found at 4,000-5,000 ft elevation.

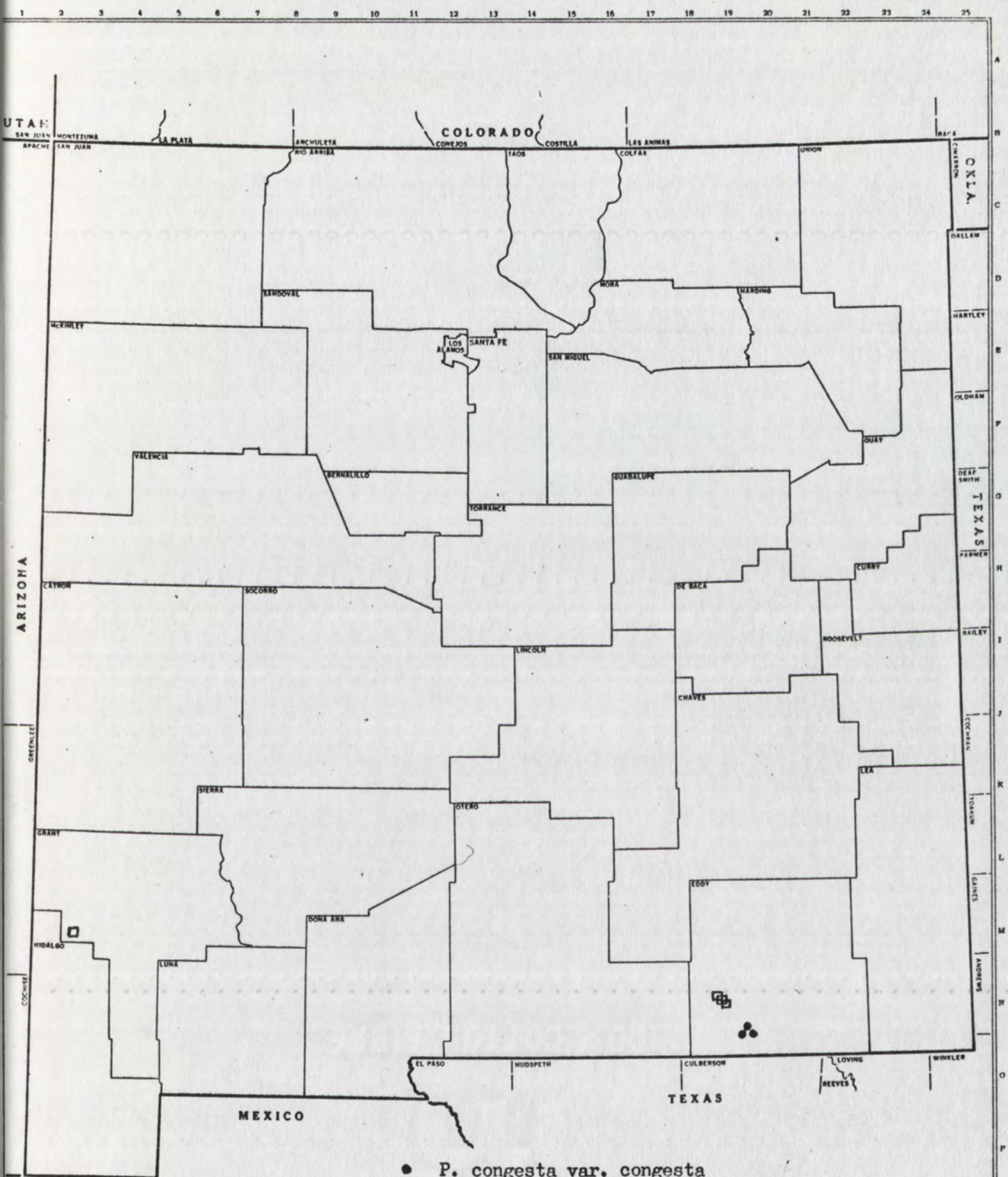
Phacelia congesta is a member of section Phacelia.

Voss (1937) describes three varieties of P. congesta. One of these, var. dissecta, is two-seeded and found only near Dallas, Texas. Of the two four-seeded varieties, he reports var. rupestris in western Texas, New Mexico, Arizona, and Mexico, and var. congesta (= var. typica) in central Texas, northeastern Mexico, and eastward.

According to his key, the character distinguishing these last two varieties is leaf color: var. rupestris is grayish pubescent, whereas var. congesta is green. Clearly, New Mexico plants would be expected to be the grayish var. rupestris. However, the plants studies from the Carlsbad area are very definitely green, and would thus appear to be either var. congesta or, perhaps, an intergrade between the two varieties. Voss reports such intergrades in southern and western Texas.

Phacelia congesta from Red Rock Canyon in Grant County and Sitting Bull Falls in Eddy County are apparently var. rupestris, the former clearly so. The plants from Sitting Bull Falls differ from the Grant County plants and from var. congesta in one very conspicuous respect: the plants from Sitting Bull Falls have white corollas which





Map 4. Distribution of P. congesta.



turn yellow as they dry, whereas all other P. congesta studied have blue corollas. The Sitting Bull Falls population is apparently ecologically isolated and small, being found only within a few hundred yards of Sitting Bull Falls. Thus the theory of genetic drift can readily account for the white corollas of these plants.

The two New Mexico populations of P. congesta var. rupestris differ from the population of var. congesta in anther color (a distinction not noted by Voss), as well as in leaf color: var. rupestris has dark blue anthers whereas the anthers of var. typica are yellow.

Cave and Constance (1944) report the chromosome number  $n = 11$  for P. congesta var. rupestris; the same authors (1947) report the same chromosome number for P. congesta, variety not given.

Phacelia popei Torr. & Gray, Pacif. Rail. Rep. Explor. Mississippi 2:172. 1855.

Annual, 3.5-51.0 cm high. Stems branching at the base, erect to decumbent, slender, hirsute, and glandular pubescent. Basal leaves not persistent, 1.3-12.0 cm long, 0.5-2.5 cm wide, pinnately divided; the lobes narrow, usually pinnatifid, sometimes only serrate, subacute to obtuse, hirsutulous, hirsute on the midrib; petioles 0.6-4.0 cm long, hirsute, and glandular puberulent. Cauline leaves 0.4-6.5 cm long, 0.2-2.5 cm wide, becoming reduced toward the apex of the stem, pinnately divided to pinnatifid; lobes entire to pinnatifid, subacute to obtuse, hirsutulous; the midrib hirsute and glandular pubescent; petioles absent to 0.5 cm long, hirsute, and glandular



puberulent. Inflorescence of groups of 1-4 scorpioid racemes becoming 3.5-10.5 cm long in fruit; pedicels 0.4-1.4 mm long, hirsute, and glandular pubescent. Sepals 2.5-3.9 mm long at anthesis, 2.8-5.3 mm in fruit, oblong to spatulate, heteromorphic, the outermost one widest, hirsutulous, and glandular puberulent. Corolla 3.0-6.3 mm long, campanulate, lobes rounded, subentire to crenulate, glandular pubescent exteriorly, white or blue; blue flowers drying to white with touches of violet on young flowers and buds; appendages about 0.8 mm long, ovate, cupped, subentire. Stamen filaments 5.8-7.0 mm long, exerted 1.0-3.5 mm beyond the tips of the corolla lobes, white, glabrous; anthers oval, yellow. Style 4.0-7.2 mm long, cleft 2.5-6.0 mm, white or blue, glabrous upper two-thirds. Capsules 2.3-3.5 mm long, globose, obtuse, hirsutulous, and glandular puberulent. Seeds 4 per capsule, 1.7-2.1 mm long, 1.0 mm wide, ovate, excavated on one side with a prominent ridge down the middle, heavily reticulate but not corrugated, dark brown.

Type: Llano Estacado, Texas. Captain Pope, s.n. (GH).

Range: Southern Arizona, New Mexico, western Texas, and northern Mexico.

In New Mexico mostly in the southern half, but as far north as Santa Fe and Tucumcari; 4,000-6,500 ft elevation.

This species, a member of section *Phacelia*, seems more closely related to *P. neomexicana* than to any other New Mexico species.

However, the two are morphologically and ecologically distinct.

*Phacelia popei* is a desert and plains plant whereas *P. neomexicana*



is a mountain plant. There are no evidences of hybridization between these two species or between P. popei and any other species in New Mexico.

Three main variations of P. popei occur in New Mexico. Most of the plants are blue flowered and appear to be what Voss (1937) calls var. similis, although the sizes of the corollas in some plants fall outside the range given by him. The other plants are white flowered and fall into two groups which apparently correspond to Voss's two white-flowered varieties, although the corolla sizes again sometimes fall outside the range he gives. The following key to the varieties is adapted from Voss.

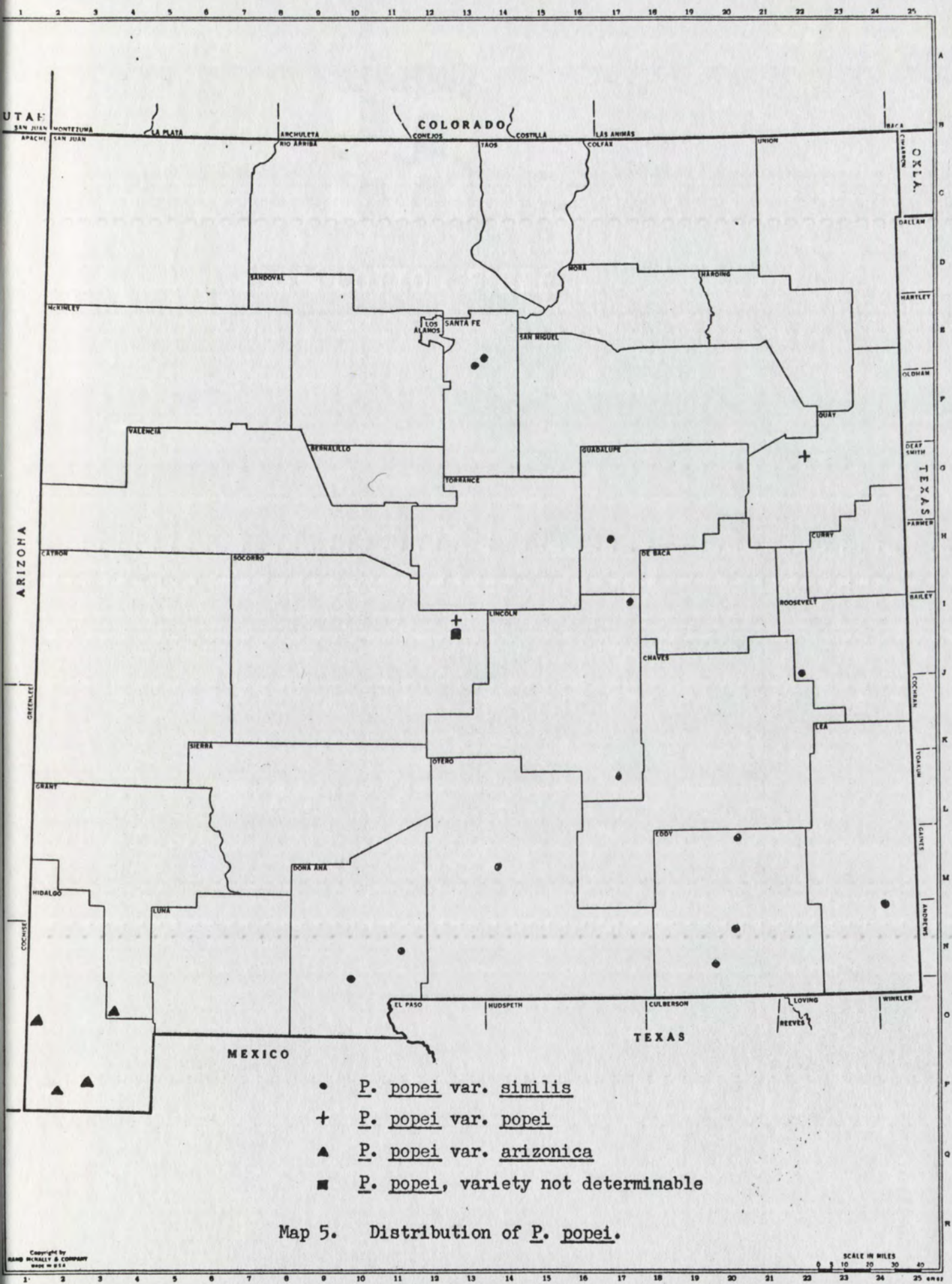
Key to the varieties of P. popei

- 1. Corollas blue . . . . . var. similis
- 1. Corollas white . . . . . 2
- 2. Stems ascending, corolla lobes without distinct light margins when dry . . . . . var. popei (= var. typica)
- 2. Stems decumbent-spreading, corolla lobes with distinct light margins when dry . . . . . var. arizonica

Corolla color is often somewhat difficult to determine in dried specimens because most of the blue color is lost in the drying process. Dried plants which have tinges of violet or blue near the margins of the youngest flowers and oldest buds should be considered blue flowered.

Voss also uses corolla size to distinguish the varieties, but in this study it was found that the variation in one plant from the first







flowers to the last flowers on a raceme and from plant to plant in one population were too great to make this a useful characteristic.

However, in general the corollas of var. similis are longer and broader than those of var. popei and var. arizonica.

The distribution of these varieties is shown on Map 5. In one case the variety was not determinable because of the lack of corollas.

Cave and Constance (1944) report a chromosome number of  $n = 11$  for P. popei (the variety is not given).

Phacelia neomexicana Thurber ex Torr., in Bot. Mex. Bound. Surv., 143. 1859.

Annual, possibly biennial, with one or several main stems, erect, 28-93 cm high. Stems slender to stout, glandular, hirsute to hispid. Rosette leaves not persistent, 13-17 cm long, 4.0-7.5 cm wide, pinnate; lobes cleft to pinnatifid, apices obtuse to acute, hirsute with gland-based trichomes, sometimes also with gland-tipped trichomes; petioles 2.2-4.0 cm long, glandular and hirsute. Cauline leaves 1.2-10.0 cm long, 0.5-4.5 cm wide, pinnate to pinnatifid; lobes cleft to pinnatifid, obtuse to acute, pubescence similar to that of basal leaves; petioles 0.1-4.0 cm long, glandular and hirsute. Inflorescence of groups of scorpioid racemes, these becoming 6.0-13.5 cm long in fruit; pedicels 0.5-1.0 mm in flower, lengthening to 0.8-1.5 mm in fruit, glandular and hirsute. Sepals 3-6 mm long in fruit, heteromorphic, linear to obovate, obtuse to acute, glandular and hirsute. Corolla 3-6 mm long, campanulate, white or blue; lobes fimbriate,



pubescent externally; appendages about 0.8 mm long, lunate, deeply cupped, entire to crenulate margins. Stamen filaments 4.0-7.8 mm long, exserted 1.0-4.8 mm, white or blue; anthers yellow. Style 3.4-9.5 mm long, cleft 2.4-7.0 mm, white or blue. Capsules 3.3-4.5 mm long, oval to ovate, obtuse to subacute, pubescent or hirsute, glandular. Seeds 4 per capsule, 2.3-3.3 mm long, narrowly ovate to oblong, excavated on one side with a prominent ridge down the middle, reticulate, but not corrugated, light to medium brown.

Type: Pine woods near the Copper Mines, Santa Rita, New Mexico. Thurber (No. 1577, Wright). (NY and GH).

Range: Wyoming to Mexico.

In New Mexico in mountain areas in the western two-thirds; 6,000-9,000 ft elevation.

Voss (1937) reports three varieties of P. neomexicana; all three are found in New Mexico. Each of these varieties corresponds to a similar variety in P. popei, which is apparently the closest relative of P. neomexicana. The occurrence of these parallel varieties is a problem which warrants further study. A key to the varieties of P. neomexicana follows.

Key to the varieties of P. neomexicana

1. Corollas blue, stamens exserted 1.5 mm or less . var. neomexicana
1. Corollas white, stamens exserted 2 mm or more . . . . . 2
2. Plants not more than 20 cm high, branching at the base,  
main stem absent . . . . . var. pseudo-arizonica



2. Plants at least 30 cm high, branching at the base  
absent, or if present then lateral branches definitely  
smaller than the main stem . . . . . var. alba

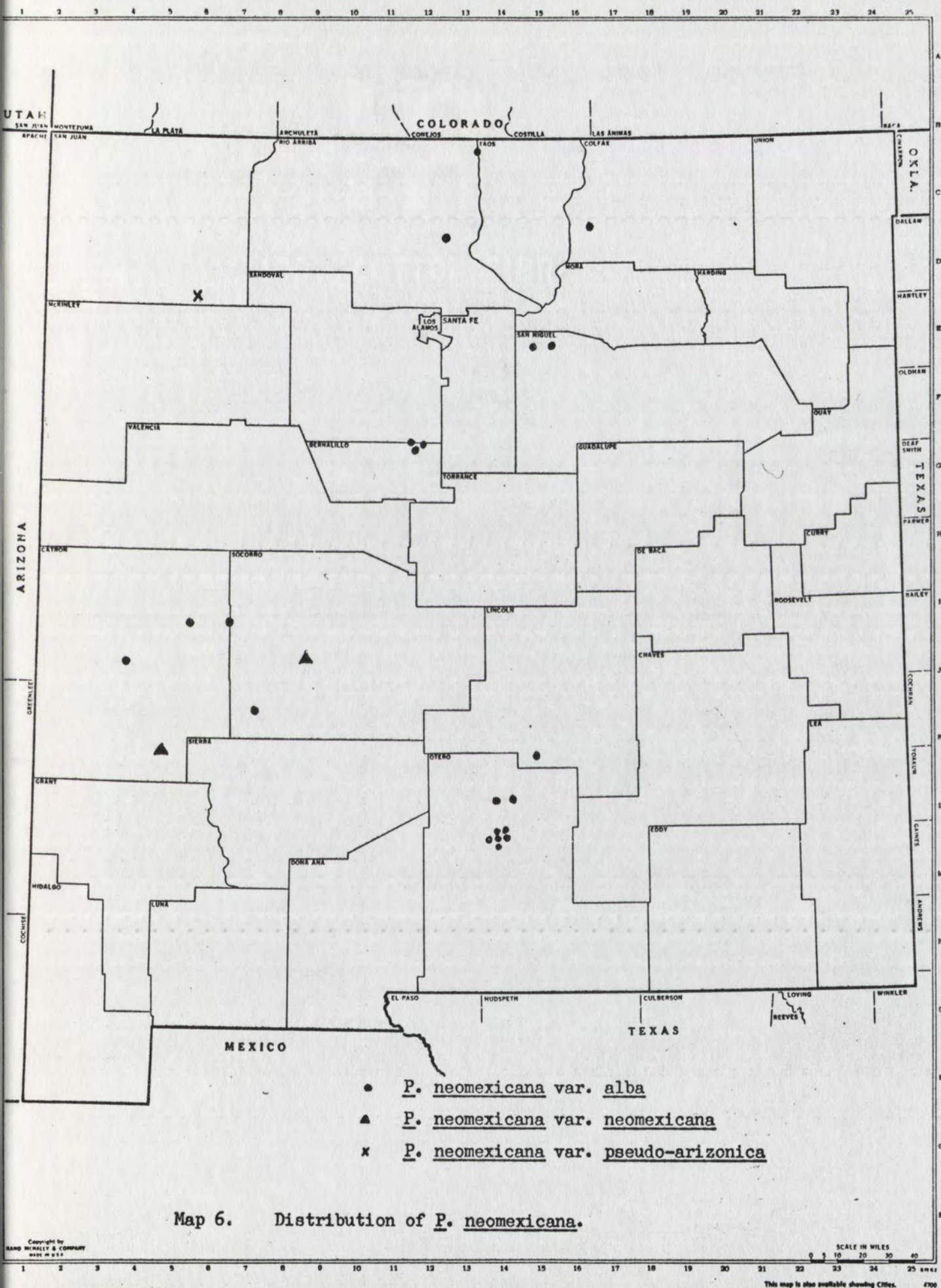
Var. neomexicana is rather restricted in distribution, the only specimens being from the southwestern quarter of the state. Var. alba is also found in this area, and it would be expected that with intensive collecting in this locality intergrades between these two varieties would be found.

Voss reports var. pseudo-arizonica as being found only in northern Arizona and southern Utah, but from the one specimen collected in New Mexico it is evident that the range extends as far as the northwestern corner of this state. This variety appears very similar to the white-flowered varieties of P. popei, especially var. arizonica, but differs from them in the size and shape of the seeds and in habitat and range.

The variety which appears to have the greatest number of individuals and the greatest range in the state is var. alba. It is sympatric with P. heterophylla but shows (and would be expected to show) no evidences of hybridizing with it, the two species not being at all closely related.

A chromosome number of  $n = 11$  has been reported for var. alba (Cave and Constance, 1950) and also for P. neomexicana, variety not stated (Cave and Constance, 1959).







Phacelia coerulea Greene, Bull. Torrey Club 8:122. 1881.

P. invenusta Gray, Proc. Amer. Acad. 20:303. 1885.

Annual, usually branching at the base, erect, 8-32 cm high. Stems slender, glandular pubescent or hirsute. Rosette leaves somewhat persistent, 2.5-9.8 cm long, 0.3-2.0 cm wide, pinnatifid; lobes serrate, acute to obtuse, glandular pubescent abaxially, finely strigose and less glandular adaxially; petioles 2.0-3.8 cm long, glandular pubescent or hirsute. Cauline leaves 0.7-8.1 cm long, 0.2-2.0 cm wide, cleft to pinnatifid; lobes entire to serrate, obtuse to acute, glandular pubescent abaxially, finely strigose and less glandular adaxially; petioles 0.1-3.0 cm long, glandular pubescent or hirsute. Inflorescence of groups of scorpioid racemes; pedicels 0.8-1.3 mm long in fruit, glandular pubescent or hirsute. Sepals 1.7-3.0 mm long, heteromorphic, linear to elliptic, acute to subacute, glandular hirsute. Corolla 3-4 mm long, campanulate, purple lobes, white deep in the throat, lobes slightly crenulate, glabrous to slightly pubescent externally; appendages 0.5-1.0 mm long, obovate, margins entire. Stamen filaments 2-3 mm long, exserted, if at all, less than 0.3 mm, purple, glabrous; anthers yellow. Style 2.1-3.2 mm long, cleft 1-2 mm, purple. Capsules 2.4-3.0 mm long, globose, obtuse, glandular pubescent. Seeds 4 per capsule, 1.9-2.5 mm long, ovate, excavated on one side with a prominent ridge down the middle, reticulate, heavily corrugated on the ridge and margins, dark brown with a light marginal band.

Type: New Mexico, bluffs of the Gila River. Greene, s.n. (GH).

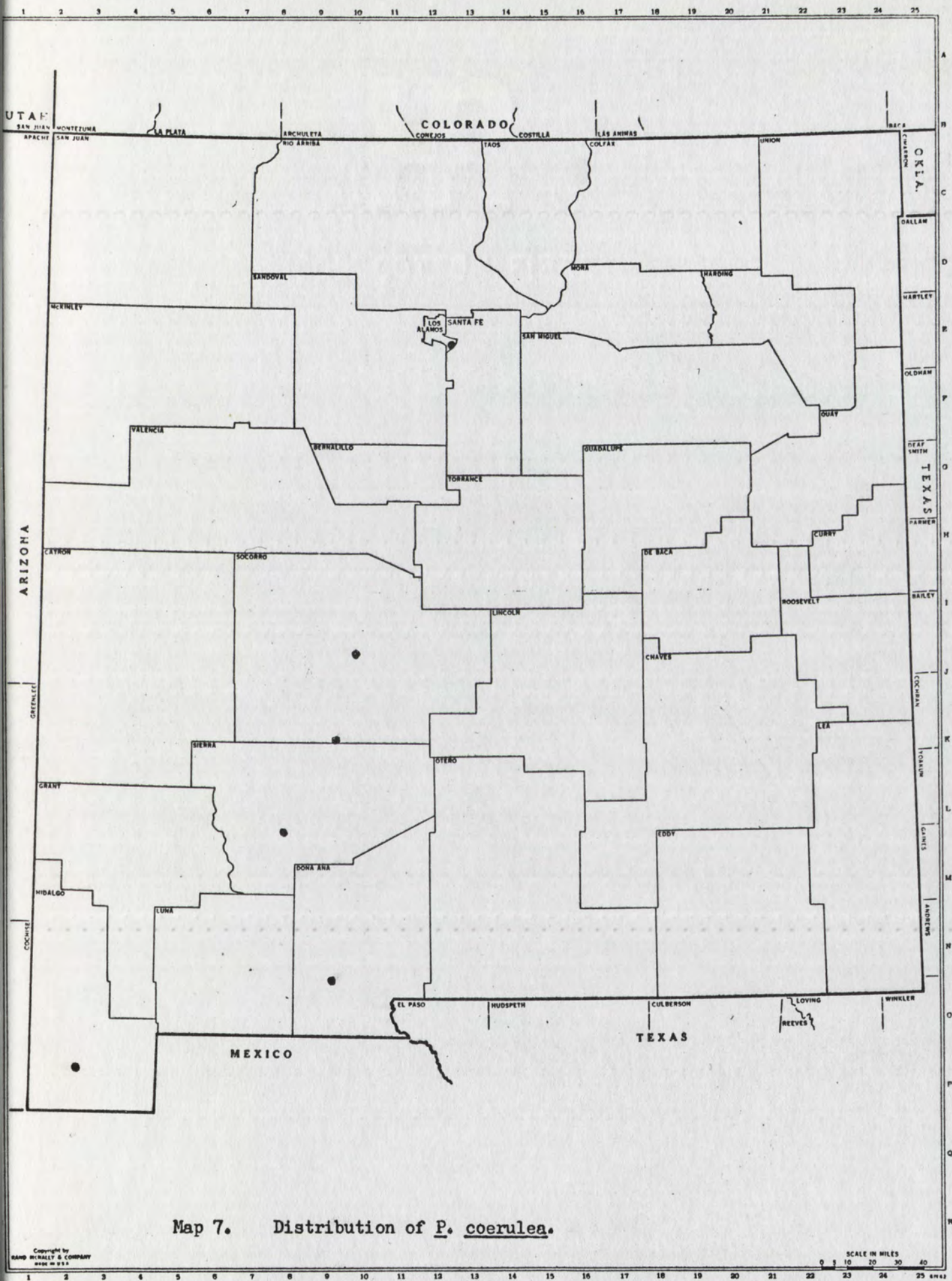


Range: Southern Nevada, Arizona, southwestern New Mexico, Chihuahua, and adjacent Texas; in New Mexico 4,000-6,000 ft elevation.

Phacelia coerulea appears to be closely related to P. integrifolia, P. crenulata, and P. intermedia. The ranges of these four species overlap, so that hybridization can reasonably be expected. Because few specimens of P. intermedia and P. coerulea from the common part of their ranges (in the southwest of the state) were available for study, nothing was determined about the occurrence of crosses between these two species. There are, however, indications of hybridization of P. coerulea with both P. crenulata and P. integrifolia. Most specimens of P. coerulea leave a distinctive bright orange stain on the paper in which they are pressed, whereas specimens of P. crenulata characteristically leave a yellow-green stain. In the spring of 1966 I made collections of P. coerulea, P. crenulata, and P. integrifolia from five locations between Socorro and Hatch (Bobisud 144, 145, 149-153); many of the plants in these collections showed deviations from this characteristic staining. Many specimens of P. crenulata from these populations left a faint orange stain; this appears to indicate hybridization between P. crenulata and P. coerulea in this area. Also supporting this contention are four specimens of P. coerulea (Bobisud 151) which left very little orange stain and which had sepals more rounded and petals more crenulate and pubescent than usual in P. coerulea—characteristics belonging more to P. crenulata.

All the plants of P. integrifolia in these 1966 collections and some in 1965 collections from this area produced light orange stains,







whereas other plants of P. integrifolia (not collected in this area) left only a yellowish stain. This appears to indicate the presence of some hybridization between P. coerulea and P. integrifolia.

None of the putative hybrids among these three species appeared to be  $F_1$  hybrids; all were quite close to one of the parents. Thus introgression appears to be the case. The observations reported above indicate introgression from P. coerulea to P. crenulata, from P. crenulata to P. coerulea, and from P. coerulea to P. integrifolia. The distribution of the three species apparently varies from year to year: in the spring of 1965 only P. integrifolia was found on two trips in this same area. Thus opportunities for crossing among the three species probably occur only occasionally, with backcrossing to one of the parents prevailing between such opportunities. Because there were in 1966 at least four locations where two or more of the three species occurred together,  $F_1$  hybrids will be likely to occur in this area in the spring of 1967. This problem needs further study. Chromatographic analysis, as well as experimental crossing studies and more field observations, seem particularly suitable for this group.

A chromosome number of  $n = 11$  has been reported for P. coerulea (Cave and Constance, 1947, 1950).

Phacelia crenulata Torr., in Wats., Bot. King Exped., 251. 1871.

Annual, with one main stem or branching at the base, erect, 13-35 cm high. Stems slender to medium, partially glabrous to glandular pubescent. Rosette leaves somewhat persistent, about 3.0-8.5 cm



long, 0.7-2.5 cm wide, pinnatifid; lobes serrate, acute to obtuse, glabrous to glandular pubescent or hirsutulous; petioles 1.2-2.0 cm long, glabrous to glandular pubescent. Cauline leaves 0.5-8.3 cm long, 0.2-2.2 cm wide, small and sparse on the upper part of the stem, serrate to pinnatifid; lobes entire to serrate or dentate, obtuse to acute, glabrous to glandular pubescent or hirsutulous; petioles absent to 2 cm long, glabrous to glandular pubescent. Inflorescence of groups of scorpioid racemes becoming 6-15 cm long in fruit; pedicels 0.8-2.0 mm long in fruit, heteromorphic, linear to oblanceolate or obovate, acute to obtuse, glandular puberulent and usually also ciliate-hirsute. Corolla 4.5-8.0 mm long, campanulate, lobes blue or purple, white deep in the throat; lobes slightly crenulate to crenulate, glabrous to pubescent externally; appendages 0.7-1.2 mm long, broadly lunate, more or less cupped, attached to the filament, margins subentire. Stamen filaments 5-9 mm long, exerted 1.2-4.5 mm, purple, glabrous; anthers yellow. Style 5-11 mm long, cleft 3.8-7.5 mm, purple. Capsules 2.8-4.3 mm long, ovate to oblong, subacute to obtuse, glandular pubescent. Seeds 4 per capsule, 2.5-3.8 mm long, elliptic to oblong, excavated on one side with a prominent ridge down the middle, finely reticulate, heavily corrugated on the ridge and margins, medium brown, often with a light marginal band.

Type: Nevada. Trinity Mountains. Watson 873. (NY and GH).

Range: Southern California, southern Nevada, southern Utah, western Colorado, Arizona, and New Mexico; in New Mexico 4,000-5,500



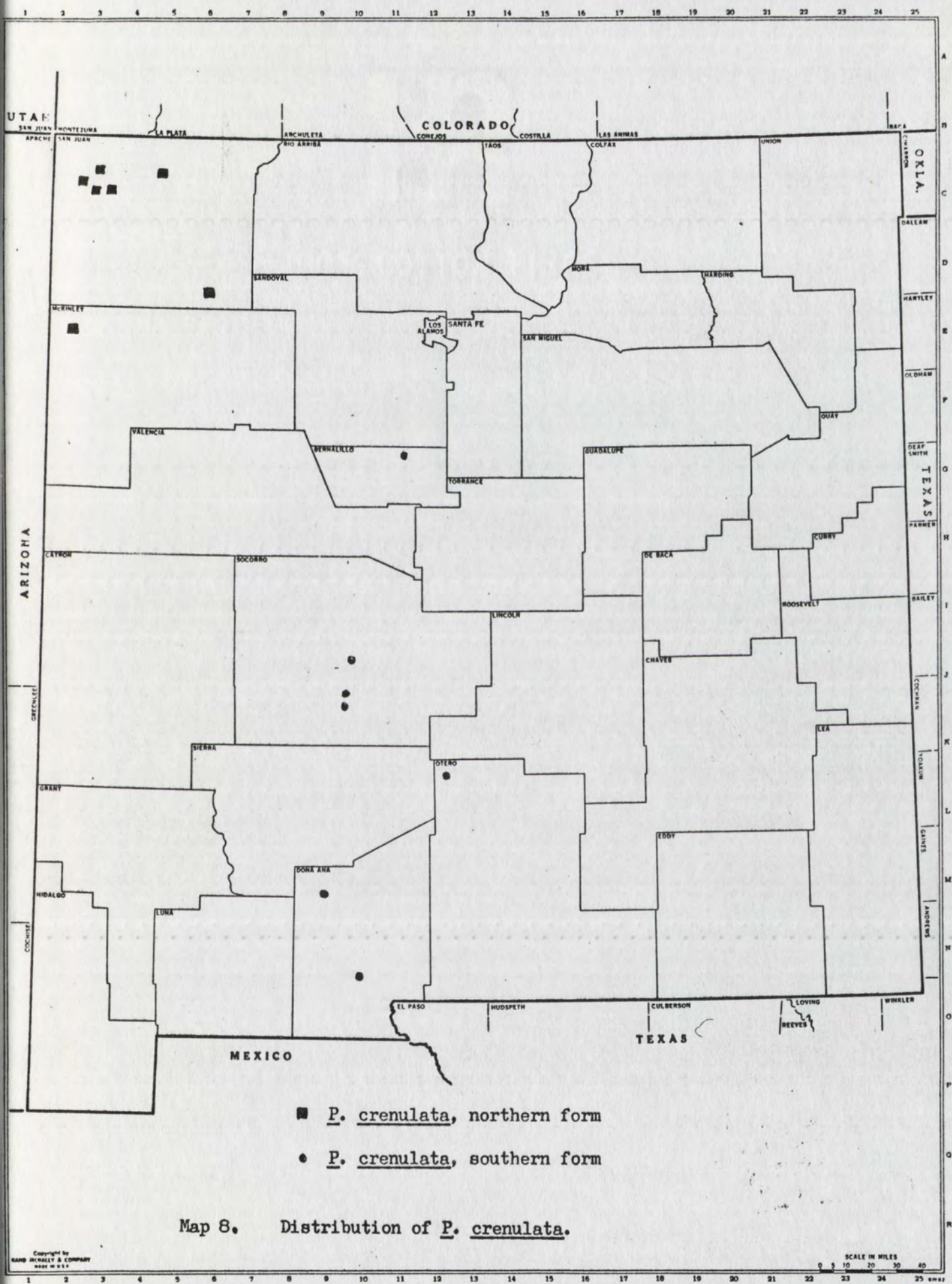
ft. elevation.

The identity of the New Mexico plants is uncertain. There appear to be two forms, neither of which corresponds very well to any of the taxa described by Voss (1937). The northern form comes close to what he designates as P. corrugata, but the flower parts of the New Mexico plants are smaller than those of P. corrugata as he describes them. The more southern form is similar to Voss's description of P. crenulata, but does not fit very well the description of any of the three varieties he describes. Also, the southern form does not appear sufficiently different from the northern form to warrant putting them in two different species. Therefore, because P. crenulata is the older name and because P. corrugata has, at times, been considered a variety of P. crenulata, I have assigned the New Mexico plants to P. crenulata. It does, however, seem advisable not to assign these plants to a variety or varieties since they do not fit any of the presently named varieties, and it does not seem proper to create a new variety or varieties without more extensive study of the whole species. Thus I have designated these two taxa as the northern and southern forms. Following is a key to these forms.

Key to the New Mexico forms of Phacelia crenulata

1. Sepals 4-7 mm long in fruit; corolla 6.3-8.0 mm; stamens  
7.5-9.0 mm, exserted 2.8-4.5 mm; style 9-11 mm . . northern form
1. Sepals 2.7-4.0 mm long in fruit; corolla 4.5-6.0 mm long;  
stamens 5.0-7.2 mm, exserted 1.2-3.2 mm; style  
5-9 mm . . . . . southern form







The northern form is variable in pubescence, varying from nearly glabrous to glandular pubescent. The southern form is more uniformly glandular pubescent.

The closest relatives of P. crenulata seem to be P. intermedia and P. coerulea. Phacelia intermedia is rather easily separated from the northern form of P. crenulata on the basis of sepal and corolla lengths, exsertion of the stamens, and seed length, all these structures being larger in P. crenulata. Separation from the southern form, however, is more difficult, the characteristics used in the key being the most important. Kearney and Peebles (1960) report that in Arizona P. crenulata and P. intermedia are difficult to separate satisfactorily. It may well be that P. intermedia should be considered a variety of P. crenulata. At the moment, however, because of the difference in morphological characters and the apparent distinctness of the ranges in New Mexico, it seems best to consider P. intermedia as a separate species.

A chromosome number of  $n = 11$  has been reported by Cave and Constance (1944) for P. crenulata var. ambigua.

The entire complex of P. crenulata, P. corrugata, P. coerulea, P. intermedia, and P. integrifolia is in great need of critical studies involving chromosome counts, crossing experiments, and more collections and field observations over the entire range of the complex.

Phacelia intermedia Wooton, Bull. Torrey Club 25:457. 1898.

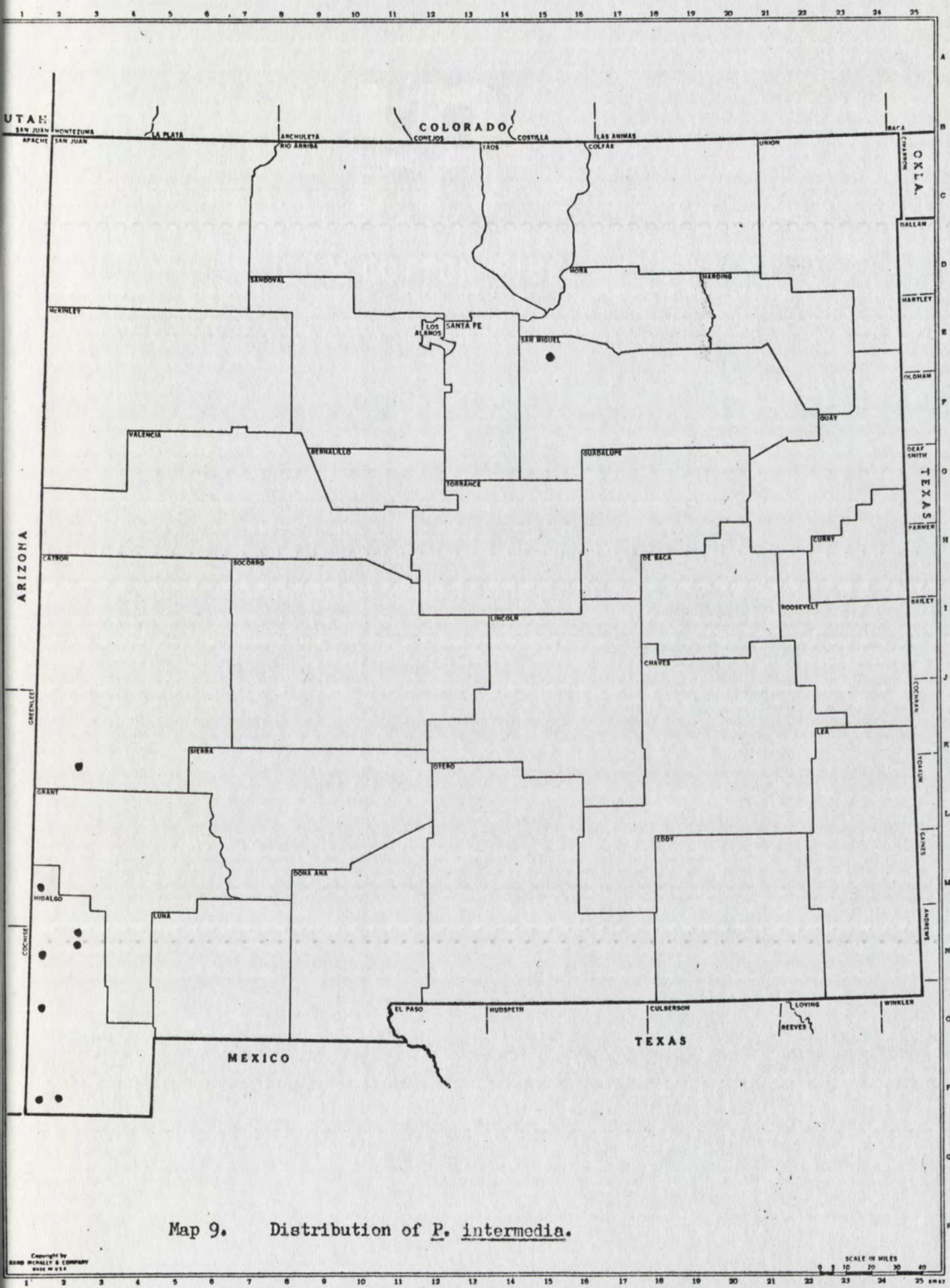
P. crenulata Woot. var. vulgaris Brand, Das Pflanzenreich IV, 251:78. 1913, in part.



Annual, with one main stem or branching at the base, erect, 8-23 cm high. Stems slender, reddish, glandular pubescent to glandular hirsutulous. Rosette sometimes not distinct. Rosette leaves somewhat persistent, 3.0-8.5 cm long, 1.4-1.9 cm wide, pinnatifid; lobes serrate, subacute to obtuse, densely pubescent or hirsutulous with gland-based trichomes usually appressed, especially on the adaxial side; some gland-tipped trichomes present; petioles 2.3-4.3 cm long, pubescence similar to that of the stem. Cauline leaves 0.4-8.0 cm long, 0.2-2.3 cm wide, pinnatifid to serrate, subacute to obtuse, pubescence similar to that of the basal leaves; petioles 0.1-3.5 cm long, pubescence similar to that of the stem. Inflorescence of groups of scorpioid racemes, these becoming about 6 or 7 cm long in fruit; pedicels 0.8-2.0 mm long in fruit, pubescence similar to that of the stem. Sepals 2.8-4.0 mm long in fruit, somewhat heteromorphic, linear to slightly obovate, acute to subacute, glandular hirsute. Corolla 4.6-7.0 mm long, campanulate, purple or blue lobes, white in the throat; lobes slightly crenulate to subentire, pubescent externally; appendages 1.0-1.8 mm long, narrowly lunate, slightly crenulate. Stamen filaments 5.3-6.5 mm long, exserted 1-2 mm, purple, glabrous; anthers yellow. Style 6-8 mm long, cleft 4.0-4.5 mm, purple. Capsules 2.3-3.0 mm long, globose, obtuse, glandular pubescent. Seeds 4 per capsule, 2.0-2.5 mm long, ovate, excavated on one side with a prominent ridge down the middle, reticulate, heavily corrugated on the ridge and margins, dark brown with a light marginal band.

Type: New Mexico. Las Cruces, Dona Ana Co. (No collector given.)







Range: Western Texas, New Mexico, Arizona, and southern Utah;  
in New Mexico 4,500-6,000 ft elevation.

This species, a member of the P. crenulata group, is apparently closely related to P. coerulea and P. crenulata. It differs from the former primarily in pubescence and size of the flower parts and from the latter primarily in pubescence, seed size, and petiole length. The range indicated by the collections in the University of New Mexico Herbarium overlaps only slightly the ranges of P. coerulea and P. crenulata (assuming that the location of the plant reported in San Miguel County (Bartlett s.n.) is in error). Voss (1937), however, reports a range extending as far east as Dona Ana County, in which case the range of P. intermedia does overlap the ranges of P. coerulea and P. crenulata and one might expect to find hybrids.

No chromosome number has ever been reported for P. intermedia, but, on the basis of those numbers reported for its close relatives, it would be expected to have a number of  $n = 11$ .



## SUMMARY

Collections of Phacelia contained in the University of New Mexico Herbarium and collections of the genus which I made during the spring and summer of 1965 and 1966 showed 10 species of Phacelia to be present in New Mexico. These are P. sericea, P. ivesiana, P. heterophylla, P. integrifolia, P. congesta (2 varieties), P. popei (3 varieties), P. neomexicana (3 varieties), P. crenulata (2 forms), P. coerulea, and P. intermedia. Phacelia sericea, P. heterophylla, and P. neomexicana are mountain species, the rest are desert or plains species. Phacelia sericea, P. ivesiana, and P. heterophylla are not closely related to one another or to any of the other species. The remaining species are all members of the P. crenulata species group. Within this group P. congesta appears to have no very close relatives in New Mexico, P. popei and P. neomexicana appear to be closely related to each other, P. coerulea, P. crenulata, and P. intermedia seem to be very closely related and are difficult to separate, and P. integrifolia appears closely related to the preceding three species.

Possible cases of introgression are reported and discussed.

Phacelia heterophylla appears, in some populations, to be somewhat contaminated by P. hastata, which is not found in New Mexico.

Phacelia integrifolia, P. coerulea, and P. crenulata appear to participate in some hybridization and introgression among themselves. Further studies, including field observations, chromosome counts, experimental crossings, and chemical analyses, are particularly needed for a better understanding of these problem species.



## APPENDIX

## CITATION OF SPECIMENS

P. sericea. Taos Co.: edge of meadow around Lake Williams at base of Mt. Wheeler, 7/24/65, Bobisud 126.

P. ivesiana. San Juan Co.: east of Aztec, 6/1/52, Clark s.n.; south of Farmington, 5/11/52, Clark s.n.

P. heterophylla. Bernalillo Co.: 3.3 mi NW of Sandia Park, 5/8/49, Gordon & Norris 101; Sulfur Canyon, Sandia Mts., 6/29/32, Castetter 4871. Catron Co.: Quaking Aspen Canyon, 7/25/62, Jones and Martin 75. Grant Co.: east of Santa Rita, 8/14/42, Clark 10,409; Sawyer Peak, 8/15/42, Clark 10,442. Lincoln Co.: near headwaters of the south fork of Eagle Creek, 7/25/53, Dunn 9024; Monjeau Lookout, Sierra Blanca, 8/17/52, Castetter 4856; 2.4 mi W of Alto, 8/18/49, Gordon & Dunn 837. Otero Co.: north of Cloudcroft, 7/31/65, Bobisud 131. Rio Arriba Co.: near Canjilon Lakes, 8/14/65, Bobisud 136, 137, 138; on trail to Truchas Peak, 8/6/49, Gordon & Norris 254. Sandoval Co.: La Cueva, 8/11/31, Castetter 4873; 4 mi E of Fentons Hiway, Jemez Mts., 7/12/31, Castetter, 4874; N of Jemez Springs, 8/13/31, Clark 4399. San Juan Co.: 3 mi S of Washington Pass, 8/9/58, Watson s.n. San Miguel Co.: 4 mi S of Cowles, 7/16/49, Castetter & Dittmer 4863. Santa Fe Co.: on N.M. 22, 8/19/65, Bobisud 141; on N.M. 22, 7/4/65, Bobisud 120; on N.M. 22, 8/19/65, Bobisud 142, 143; Hyde State Park, 8/7/65, Bobisud 134; Santa Fe



Ski Area, 8/7/65, Bobisud 135. Socorro Co.: Mt. Withington, 7/11/52, Castetter 4850. Taos Co.: Palo Flechado Hill, 7/16/32, Castetter 4872; 1 mi below Twining Ski Area, 7/24/65, Bobisud 128; 1 mi below Twining Ski Area, 7/3/65, Bobisud 119; Lake Williams at the base of Mt. Wheeler, 7/24/65, Bobisud 127. Torrance Co.: Manzano Mts., 8/2/42, Clark 10,291; Manzano Mts., 7/1/51, Dittmer 4870. Valencia Co.: La Mosca Peak, 7/27/52, Castetter 4858; Mt. Taylor, 7/23/60, Osborn 469; 3 mi NE La Mosca Lookout, Mt. Taylor, 1/19/61, Osborn 702.

P. integrifolia. Bernalillo Co.: 6 mi S of Albuquerque, 4/22/61, Martin 4773; Albuquerque, 5/1/63, King 127; Albuquerque, 5/4/65, Bobisud 108; Albuquerque, 5/23/65, Bobisud 109; Albuquerque, 4/7/66, Bobisud 156. Catron Co.: W of Reserve, 8/17/42, Clark 10,520. Chaves Co.: on road to Bottomless Lakes State Park, 5/28/65, Bobisud 110. Dona Ana Co.: Mesilla Valley, 4/15/07, Wooton & Standley 3295; 12 mi N of Las Cruces, 4/19/65, Bobisud 106; 12 mi N of Las Cruces, 5/30/65, Bobisud 114; Mesilla, 4/9/66, Bobisud 148. Guadalupe Co.: 1 mi E of Santa Rosa, no date, no collector given. Lea Co.: near Jal, 5/30/55, Castetter 7911. Los Alamos Co.: on N.M. 4 near TA-33, 7/17/65, Bobisud 125; on N.M. 4 about 2 mi from TA-33, 4/11/66, Bobisud 155. Otero Co.: White Sands Nat'l. Mon., 4/21/39, Bell s.n.; 3 mi W of Cloudcroft, 7/31/65, Bobisud 132. Sandoval Co.: Bandelier Nat'l. Mon., 7/31/57, Yarnell 55; Frijoles Canyon, 6/12/41, Clark 9680; Bandelier Nat'l. Mon., 7/17/65, Bobisud 124. Santa Fe Co.: on N.M. 22 near Rancho del Monte, 7/4/65, Bobisud 121; on N.M. 22 outside Tesuque, 7/4/65, Bobisud



122; near San Ildefonso Pueblo, 8/15/65, Bobisud 140; near San Ildefonso Pueblo, 4/11/66, Bobisud 154. Sierra Co.: near Hot Springs, 4/27/37, Nielson 5. Socorro Co.: 5 mi S of Socorro, 4/26/49, Fleetwood s.n.; near San Mateo Mts. on N.M. 52, 7/11/52, Castetter 4851; NE slope of North Oscuro, 8/4/48, Dunn & Lint 4177; 5 mi W of Socorro, 5/23/59, Martin 3095; 15 mi S of jct. of U.S. 380 and Interstate 25, 4/19/65, Bobisud 107; 18 mi S of jct. of U.S. 380 and Interstate 25, 5/30/65, Bobisud 115; 5 mi S of jct. of U.S. 380 and Interstate 25, 5/30/65, Bobisud 116; 5 mi S of Socorro, 4/8/66, Bobisud 144a,b; 25 mi S of Socorro, 4/8/66, Bobisud 145a; Nogal Canyon on U.S. 85, 4/10/66, Bobisud 150; 31 mi S of Socorro, 4/10/66, Bobisud 153. Valencia Co.: 4 mi S of Belen, 5/30/65, Bobisud 117; 1.5 mi S of Belen, 6/1/65, Bobisud 118; 25 mi W of Albuquerque, 4/30/59, Martin 3035.

P. congesta var. congesta. Eddy Co.: Carlsbad Caverns Nat'l. Park, 4/18/65, Bobisud 101; Walnut Canyon, 4/3/56, McKechnie 460; Walnut Canyon, 5/4/54, Brasil s.n.; Oak Springs, 5/18/51, Dittmer 4848.

P. congesta var. rupestris. Catron Co.: Arroyo, Red Rock Canyon, 6/20/52, Castetter 4862. Eddy Co.: Sitting Bull Falls, Guadalupe Mts., 5/19/51, Clark 3294; Sitting Bull Falls, 5/29/65, Bobisud 111; Sitting Bull Falls, 6/21/66, Bobisud 158.

P. popei var. popei. Quay Co.: W of Tucumcari, 4/18/43, Clark s.n. Socorro Co.: Chupadera Mesa, 8/16/49, Gordon & Dunn 697.



P. popei var. arizonica. Hidalgo Co.: roadside near Rodeo, 4/23/53, Castetter 4854; Little Hatchet Mts., 4/6/37, Woods s.n.; East Animas Foothills, 4/7/37, Woods 6; 10 mi N of Cloverdale, 6/8/49, Dittmer 4859.

P. popei var. similis. Dona Ana Co.: E slope of Organ Mts., 5/25/52, Castetter 4853; Afton, W of Las Cruces, 4/8/66, Bobisud 147. Eddy Co.: between Roswell and Carlsbad, 5/17/51, Dittmer 4878; Carlsbad, 4/8/56, McKechnie 190; Carlsbad Caverns Nat'l. Park, 4/18/65, Bobisud 102; 10 mi N of White City, 4/18/65, Bobisud 103; about 10 mi N of White City, 5/29/65, Bobisud 112. Guadalupe Co.: E of Vaughn, 5/21/50, Clark s.n. Lea Co.: N of Eunice, 4/28/54, Castetter 4866. Lincoln Co.: 25 mi S of Vaughn, 5/17/51, Dittmer 4879; Lincoln Forest, 4/17/27, collector not given, s.n. Otero Co.: NE of Alamogordo, 4/19/65, Bobisud 105; NE of Alamogordo, 5/30/65, Bobisud 113. Roosevelt Co.: Kenna, 4/24/54, Castetter 4849. Santa Fe Co.: Santa Fe Airport, 7/15/53, McKinley 85; Santa Fe Airport, 5/8/52, McKinley s.n.

P. popei, var. not determined. Socorro Co.: Chupadera Mesa, 8/15/48, Dunn & Lint 4421.

P. neomexicana var. neomexicana. Catron Co.: Beaverhead roadside, 6/21/52, Castetter 4852. Socorro Co.: South Baldy, Magdalena Mts., 7/16/60, Jones 323.

P. neomexicana var. pseudo-arizonica. San Juan Co.: Chaco



Canyon Nat'l. Mon., 6/17/45, Clark s.n.

P. neomexicana var. alba. Bernalillo Co.: Sandia Rim Road, 7/7/31, Castetter 4869; on N.M. 44 5 mi S of turnoff to Sandia Crest, 8/5/65, Bobisud 133. Catron Co.: 5 mi W of Datil, 9/4/48, Norris & Zweifel s.n.; near Aragon, 8/7/52, Castetter 4855. Colfax Co.: E side of Agua Fria Peak, 8/10/49, Gordon & Norris 407. Lincoln Co.: Ruidoso, 6/14/36, Humphrey s.n. Otero Co.: Cloudcroft area, 7/3/49, Castetter & Dittmer 4865; 6 mi NE of Mescalero, 9/14/60, Martin 4508; 7 mi E of Cloudcroft, 6/7/59, Martin 3184; Mescalero Indian Reservation, 6/10/36, Plumb s.n.; 1 mi NE of Cloudcroft, 6/29/52, Dunn 8157; 1 mi NE of Cloudcroft, 7/29/51, Dunn 7559; Sleepy Grass Picnic Area 2 mi E of Cloudcroft, 7/31/65, Bobisud 129; 9 mi N of Cloudcroft on N.M. 24, 7/31/65, Bobisud 130. Rio Arriba Co.: 10 mi N of El Rito, 8/14/65, Bobisud 139. Sandoval Co.: Sandia Mts., 7/31/64, Tatschl s.n. San Miguel Co.: Beulah, 1899, Porter s.n.; Winsor Creek, 7/5/29, Castetter 4868. Socorro Co.: Bear Trap Canyon, San Mateo Mts., 7/27/60, Jones 520; San Agustin Plains on Rt. 60, 6/22/52, Castetter 4861. Taos Co.: 15 mi S of Antonito, 7/23/49, Castetter & Dittmer 4864.

P. coerulea. Dona Ana Co.: Lava flow SW of Las Cruces, 4/8/66, Bobisud 146. Hidalgo Co.: Skeleton Canyon, 4/23/63, collector not given. Los Alamos Co.: White Rock Canyon, 6/18/41, Clark 9747. Sierra Co.: 10 mi W of jct. of U.S. 85 and N.M. 180, 4/27/51, Dunn 7378. Socorro Co.: 5 mi S of Socorro, 4/8/66, Bobisud 144d; Nogal Canyon



on U.S. 85, 4/10/66, Bobisud 151.

P. crenulata, northern form. McKinley Co.: Mexican Springs, 5/2/34, Heggie 4. San Juan Co.: N of Shiprock, 5/9/48, Clark 14,511; S of Shiprock, 4/25/48, Clark s.n.; S of Farmington, 5/11/52, Clark s.n.; S of Shiprock, 4/25/48, Clark 14,465; Chaco Canyon Nat'l. Mon., 6/12/45, Clark s.n.; S of Shiprock, 7/10/65, Bobisud 123.

P. crenulata, southern form. Bernalillo Co.: Juan Tabo, 5/8/66, Bobisud 157. Dona Ana Co.: Mesilla Valley, 4/8/07, Wooton & Standley 3378; N of Hatch, 4/10/66, Bobisud 149. Otero Co.: T12S, R8E, 4/17/27, collector not given 1947. Socorro Co.: 5 mi S of Socorro, 4/8/66, Bobisud 144c; 25 mi S of Socorro, 4/8/66, Bobisud 145b; 31 mi S of Socorro, 4/10/66, Bobisud 152.

P. intermedia. Catron Co.: Whitewater Creek, 6 mi NE of Glenwood, 5/14/60, Martin 3961. Hidalgo Co.: S of Lordsburg, 6/8/49, Dittmer 4860; Peloncillo Mts., Animas, 5/20/37, Woods 66; Guadalupe Canyon, Guadalupe Mts., 4/15/62, Castetter 20,016; Steins, 4/19/44, Hershey 10983; Guadalupe Canyon, Guadalupe Mts., 4/15/62, Martin s.n.; S of Lordsburg, 4/29/51, Dunn 7453; E of NM-Ariz. border on Rt. 70, 4/22/53, Castetter 4857. San Miguel Co.: Headwaters of the Pecos, Aug. 1905, Bartlett s.n.



## LITERATURE CITED

- Anderson, E. 1949. Introgressive hybridization. John Wiley & Sons, Inc., New York, and Chapman & Hall, Limited, London. ix+109 p.
- Axelrod, D. I. 1952. Variables affecting the probabilities of dispersal in geologic time. Bull. Amer. Mus. Natur. Hist. 99: 177-188.
- Baillon, H. E. 1890. Hydrophyllaceae, p. 397-402. In H. E. Baillon, Histoire des plantes, X.
- Brand, A. 1913. Hydrophyllaceae, p. 1-210. In Engler, Das Pflanzenreich IV, 251.
- Cave, M. S., and L. Constance. 1942. Chromosome numbers in the Hydrophyllaceae. Univ. Calif. Publ. Bot. 18:205-216.
- Cave, M. S., and L. Constance. 1944. Chromosome numbers in the Hydrophyllaceae: II. Univ. Calif. Publ. Bot. 18:293-298.
- Cave, M. S., and L. Constance. 1947. Chromosome numbers in the Hydrophyllaceae: III. Univ. Calif. Publ. Bot. 18:449-465.
- Cave, M. S., and L. Constance. 1950. Chromosome numbers in the Hydrophyllaceae: IV. Univ. Calif. Publ. Bot. 23:363-382.
- Cave, M. S., and L. Constance. 1959. Chromosome numbers in the Hydrophyllaceae: V. Univ. Calif. Publ. Bot. 30:233-258.
- Constance, L. 1949. A revision of Phacelia subgenus Cosmanthus (Hydrophyllaceae). Contrib. Gray Herb. 168:1-48.
- Constance, L. 1963. Chromosome number and classification in Hydrophyllaceae. Brittonia 15:273-285.



- Edwards, S. 1817. Hydrophyllum canadense. Bot. Regist. 3: pl. 242.
- Gillett, G. W. 1955. Variation and genetic relationships in the  
Whitlavia and Gymnobythus phacelias. Univ. Calif. Publ. Bot. 28:19-78.
- Gillett, G. W. 1960. A systematic treatment of the Phacelia  
franklinii group. Rhodora 2:205-222.
- Gillett, G. W. 1961. An experimental study of variation in the  
Phacelia sericea complex. Amer. J. Bot. 48:1-7.
- Gillett, G. W. 1963. Flowering responses and phylogeny in the  
Phacelia franklinii group (Hydrophyllaceae). Amer. J. Bot. 50:  
798-801.
- Gray, Asa. 1875. A conspectus of the North American Hydrophyllaceae.  
Proc. Amer. Acad. 10:312-332.
- Heckard, L. R. 1960. Taxonomic studies in the Phacelia magellanica  
polyploid complex. Univ. Calif. Publ. Bot. 32:1-126.
- Heckard, L. R. 1963. The Hydrophyllaceae. Quart. Rev. Biol. 38:  
117-123.
- Howell, J. T. 1944. A revision of Phacelia section Miltitzia.  
Proc. Calif. Acad. IV, 25:357-376.
- Howell, J. T. 1946. A revision of Phacelia section Euglypta.  
Amer. Midland Natur. 36:381-411.
- Jussieu, A. L. de. 1789. Genera plantarum.
- Kearny, T. H., and R. H. Peebles. 1960. Arizona flora. 2nd ed.  
University of California Press, Berkeley. 1085 p.
- Stebbins, G. L. 1950. Variation and evolution in plants.  
Columbia University Press, New York and London. xx+643 p.



Voss, J. W. 1937. A revision of the Phacelia crenulata group for North America. Bull. Torrey Club 64:81-96, 133-144.

Wootton, E. O., and P. C. Standley. 1915. Flora of New Mexico. Contrib. U. S. Nat. Herb. 19:1-794.