UNIVERSITY OF COLORADO STUDIES

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NO. 30

A STUDY OF THE ECOLOGICAL DISTRIBUTION OF ANTS IN GREGORY CANYON, BOULDER, COLORADO

BY

JOHN T. BROWNE AND ROBERT E. GREGG

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INTRODUCTION

This investigation concerns both the presence and absence of ant species in the particular environments of three areas of Gregory Canyon, namely; north-facing slope, south-facing slope, and canyon bottom. The site chosen is in the foothills directly west of Boulder which extend from a lower altitudinal limit of 5400 feet to an upper limit of more than 8000 feet. Gregory is one of the smaller canyons of the lower foothills and penetrates the mountain front for only one mile before it receives even shorter tributaries. Because of the small size of this canyon, the accessibility of all of its parts, and the resemblance of its geology and general environment to other canyons in the region, we consider it ideal for the kind of study undertaken. (Figure 1.)

Several other workers have included the canyon in their regional studies on ants. Robbins (1910) made an early attempt to summarize the ant fauna of this part of Colorado, and Byars (1936) conducted a general survey on the ant fauna of the plains and foothills in Boulder County. Gregg (1947) discussed the indicator species of ants in the several life zones of Colorado, including the Transition Zone where Gregory Canyon is located, and later (1963) the same author presented an extensive account of the ecology and distribution of ants for the entire state of Colorado. Delfin (1954) carried out a general entomological survey of Gregory Canyon and reported several species of ants. Borchert (1956) concentrated on the ants of moist canyon bottom sites of five of the foothill canyons in the area, including Gregory. The bulk of the data for the present report was gathered during the summers of 1957 and 1958 and represents the results of 33 field trips (see Appendix, Table I). The purpose of this study in part is to learn something of the precise ecological distribution of ants in a topographically complex area showing marked environmental contrasts in close proximity, and in part to show the geographic affinities of the ant populations in these circumscribed but contrasting locations.

The actual research area lies within the following limits: 39° 59′ to 40° 01′ north latitude, and 105° 17′ to 105° 19′ west longitude (see Figure 2). This area is bounded on the south by Green Mountain (8100 ft.), on the west by the Kossler Lake Road, on the north by Flagstaff Mountain (7000 ft.), and on the east by the Canyon mouth (at 5700 ft.) which is on a north-south line parallel to the "Flatirons." Included in the study also is Long Canyon which drains into Gregory, and Panther Canyon which is a tributary of Long Canyon. In addition,

FIGURE 1. Entrance to Gregory Canyon, Boulder, Colorado. Left—north-facing slope of Green Mountain; right—south-facing slope of Flagstaff Mountain.

there are several small ravines that join the main drainages. The major stream, Gregory Creek, is usually three to four feet wide at its maximum, but overflowing in the spring, and is reduced to small springlets and pools in the fall. The summer source of water is ground water, springs, and intermittent rain. Gregory Canyon trends mainly east-west, but it turns south at an altitude of 6500 feet, and is joined by Long Canyon at 6750 feet.

The canyon bottom for the whole of its length contains lush deciduous vegetation and an abundance of wild life. The lower part of the south-facing wall of the canyon, about 6100 feet, is formed by the dry, warm, open slope of Flagstaff Mountain and is covered with sparse pine woodland and grass. The moist, cool, densely forested slope of Green Mountain forms the north-facing wall of the canyon. Canyon Hill is located about one-fourth mile to the west of the canyon mouth, and beyond the hill is a broader and more open basin (Verde Park) which forms the southwestern limit of Gregory Canyon. Long Canyon opens into this basin. The topographic form of both of these canyons is the typical V-shape of youthful valleys. The upper reaches of Gregory and especially of Long Canyon become more heavily clothed with Douglas fir and there are scattered patches of aspen. From both canyons there are extensions of canyon bottom vegetation into the lateral ravines. Of special interest in Long Canyon is a stand of eastern paper birch, isolated and endemic at this spot. The nearest occurence of this species, again in geographic isolation, is in the Black Hills of South Dakota.

Moisture conditions of the soil in Gregory Canyon (Appendix, Table II)

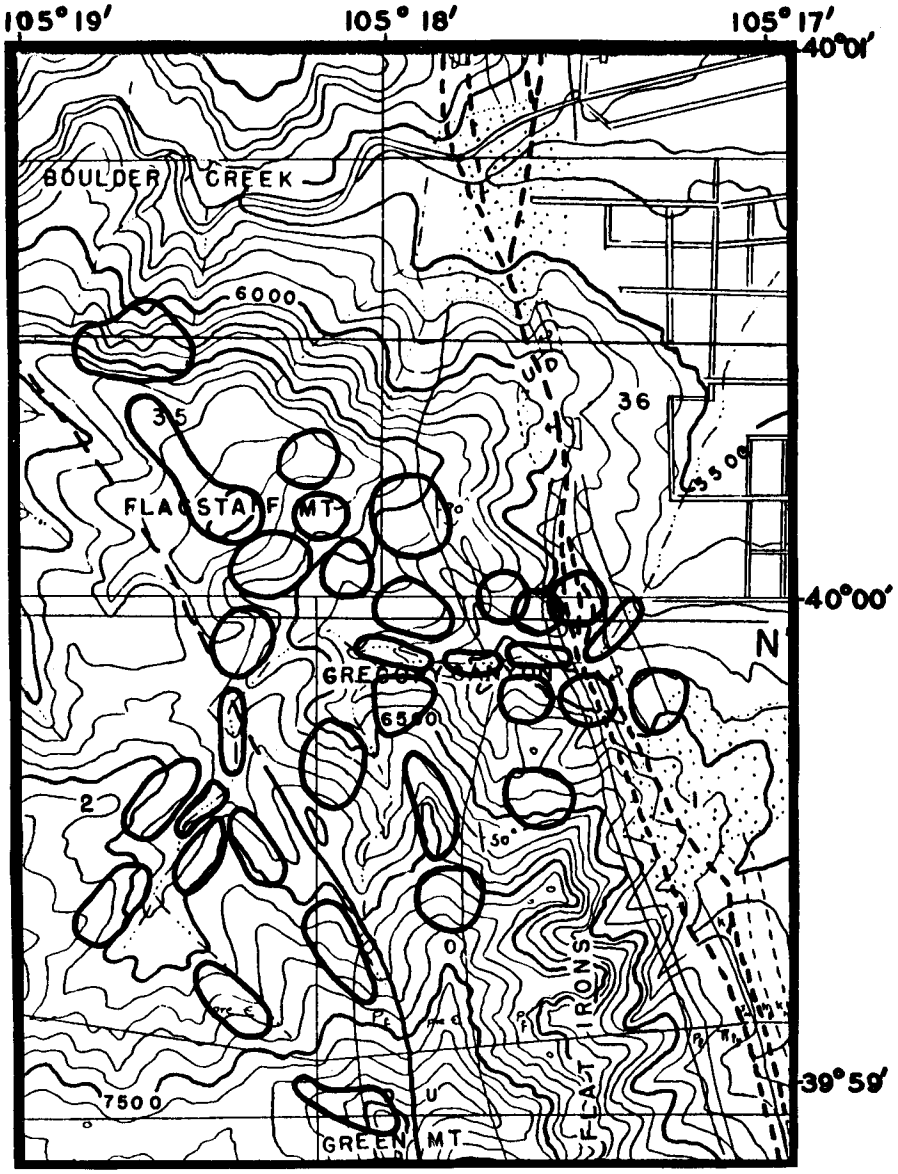


FIGURE 2. Collecting Stations. Gregory Canyon area, Boulder, Colorado. Scale 1/15,800. Contour interval 100′ base U.S.G.S. Topographic maps courtesy Z. Hunter. Curving lines and dashed lines trending north and south represent fault planes.

vary considerably among the three parts of the canyon, and vary also at different elevations in each part. The south-facing slope is drier than either the canyon bottom or the north-facing slope. At lower elevations (Transect I, Figure 3), moisture was found to be less by as little as 1.71 percent and as much as 4.83 percent on the south-facing slope in contrast to the canyon bottom. Also at Transect I moisture was found to be less by as little as 5.26 percent and as much as 10.23 percent on the south-facing slope as compared to the north-facing slope. The soil moisture percentages at Transect 2 varied along the same lines but were even more pronounced. In general, the north-facing slope showed the highest percent of moisture of the three canyon areas. Its moisture exceeded that of the canyon bottom by a minimum of 3.55 percent (Transect 1) and a maximum of 21.22 percent (Transect 2). Of course, the soil moisture in the immediate vicinity of Gregory Creek or of springs and pools would be expected to be very high, but these measurements were not made and would not alter the general picture of the canyon environments anyway since they represent special circumstances.

Determinations of soil moisture content were made from samples collected into tightly capped one-half pint cans which had been previously cleaned and weighed. The samples were obtained from three sites along each of two north-south transects, T 1 and T 2 (see map, Figure 3). On the first transect, soil was taken at 6100 feet from the north and south slopes, and at 5900 feet in the canyon bottom. On the second transect, sites were selected at 6700 feet on both north and south slopes, and at 6575 feet in the canyon bottom. Three samples were taken at each point on the transect line. They were all obtained under rocks of medium size, and included topsoil from just beneath the rock to a depth of approximately five inches. The samples were weighed accurately to one-tenth of a gram and estimated to the nearest one-hundredth. The cans were heated in an oven at 105°C., until a constant dry weight was obtained for each. The results are expressed as percent of water per dry weight of the earth, and are computed using the formula:

$$\begin{matrix}\text{percent water}\\ \text{per}\\ \text{dry weight soil}\end{matrix} = \frac{\text{Gms. water in sample}}{\text{Dry weight of soil}} \times 100$$

Environmental temperatures were taken during each field trip, but it was not possible to record them for each of the three parts of the canyon on the same day. Consequently, the monthly and overall averages were relied upon to give a fair indication of the temperature regime in any particular part which were then compared with the averages of the other parts of the canyon. In all cases, the temperature at the surface of the soil is higher than either the sub-surface or the aerial temperatures at a given time. The temperature of the air tends to be only slightly higher than the sub-surface temperature which it therefore approaches. Since the ants build their nests below soil surface in most cases, or are in contact with the surface under rocks, they live most of the time at temperatures below that of the open soil surface. The temperatures of the nests probably remain fairly constant for any short period, but fluctuate slowly in conformity with seasonal

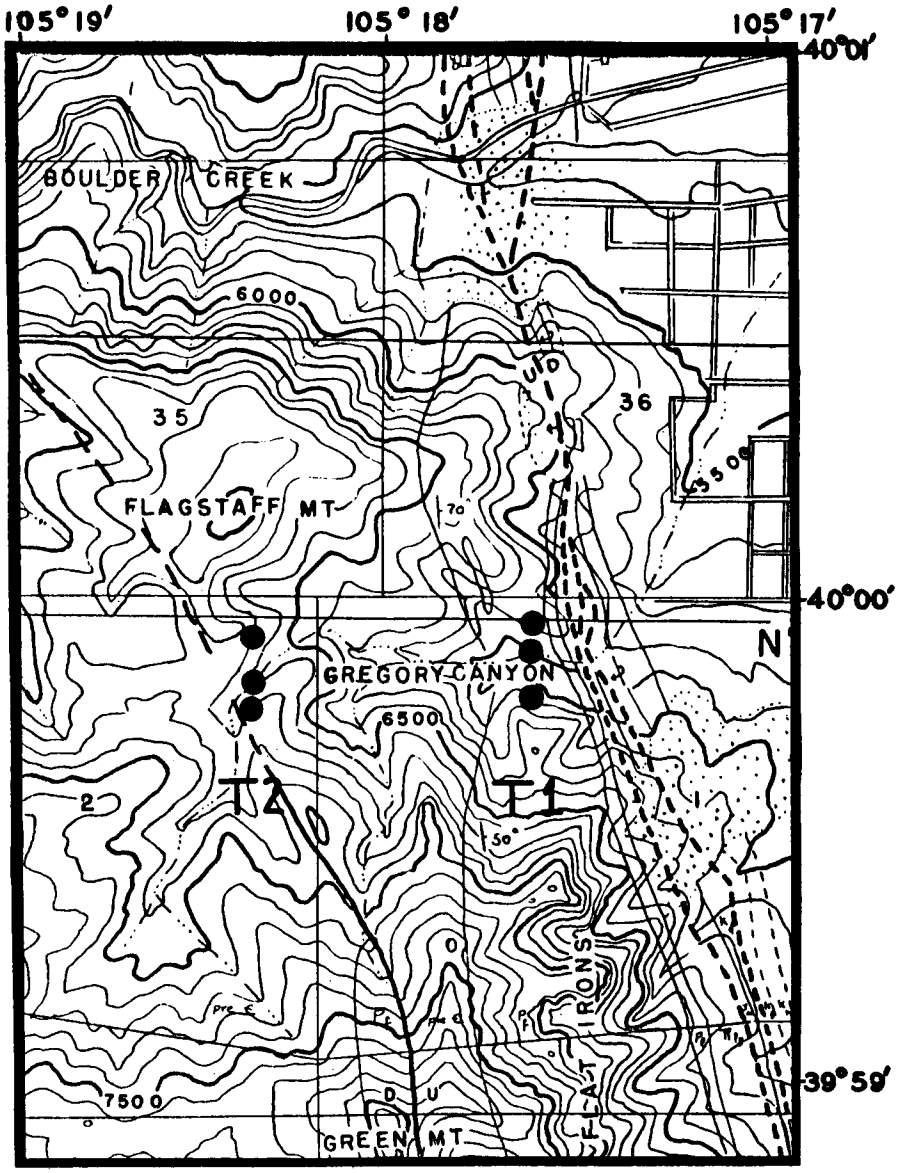


FIGURE 3. Soil Sample Collecting Sites.

changes. The ants are exposed to warm, and perhaps even high temperatures, during their foraging expeditions. Average temperatures of the three areas, and especially the overall averages, show that the south-facing slope is definitely warmer than the other two parts, and the canyon bottom tends to be warmer than the north-facing slope. However, the differences between the latter two areas are less conspicuous owing probably to the fact that the canyon bottom, like the north-facing slope, has a rather dense plant cover.

On account of differences in compass direction, angle of slope, and height of canyon walls, the amount of sunlight received by different areas changes drastically. The amount of light received and the angles at which it strikes the ground have profound effects on the amount of heat generated. When the angle of incidence is 90 degrees the highest temperatures are produced, and it is noteworthy that the south-facing slope receives sunlight impinging at high angles for longer periods of each day and for many more months of the year than either the north-facing slope or the canyon bottom. This situation therefore produces a strikingly greater summation of positive temperatures for the south-facing slope. The sharp contrasts in temperature and moisture conditions, and other factors as well, together with associated vegetational units in Colorado and other mountain canyons are known collectively as the Canyon Effect, and this subject has been described in greater detail by Gregg in 1963 (pp. 95, 225, and 246). The majority of foothill canyons run east and west with accompanying north and south walls, thus insuring a maximum of various climatic effects. Some valleys trend north and south, however, and their east-facing walls receive the greater amount of daily sunshine and atmospheric warmth. Those which slope toward and open at the south end may obtain more heat than those which point to the north.

Temperature readings in Gregory Canyon were taken at collecting sites usually two to three times a day in one general area. Surface and air temperatures were obtained with a Fahrenheit air thermometer, and the surface readings were made by placing the thermometer on the ground as close to a collecting site as possible. Air temperatures were taken six to eight inches above the ground. The subsurface temperatures were secured with a Fahrenheit soil thermometer at depths of approximately two inches. All readings were then converted to degrees Centigrade and are listed in Table III of the Appendix.

Before proceeding to the distribution of ant species in the canyon, it is necessary to present a brief characterization of the three study areas. The south-facing slope is a typical xerophytic environment for the region. In general, the wall is covered by grassland and ponderosa pine (*Pinus ponderosa* Laws.) communities interrupted by rock outcrops. The grassland community is composed of blue grass (*Poa pratensis* L.), brome grass (*Bromus* spp.), and timothy (*Phleum pratense* L.). Scattered throughout this community is sedge (*Carex* spp.), yucca (*Yucca glauca* Nutt.), kinnikinnick (*Arctostaphylos uva-ursi* (L.)), prickly pear (*Opuntia rafinesquei* Englm.), sage (*Artemisia* spp.), sumac (*Rhus glabra* L.), stone crop (*Sedum stenopetalum* Pursh.), knotweed (*Polygonum* spp.), and skunkbrush (*Rhus trilobata* Nutt.). The ponderosa pine community

blends with the Douglas fir community in the upper portions of Long Canyon. The south slope, less protected for the most part from the effects of erosion by wind and water, has a thin covering of sandy soil, granite, and sandstone flakes. Large boulders are strewn over its surface. The analyses of temperature and soil moisture conditions correlate well with the general aspects of this part of the canyon.

The north-facing slope, at low levels, is characterized by a gradation of grasses and ponderosa pine which blend rapidly with the dense Douglas fir (*Pseudotsuga taxifolia* (Poir.) Britt.) community. In the upper part of Gregory Canyon, the Douglas fir begins at the edge of the stream, and very few other plants can grow in the dense stands of this tree. Interspersed among the firs, however, throughout the north-facing slope may be found ground juniper (*Juniperus communis* L.), violets (*Viola* spp.), kinnikinnick, aspen (*Populus tremuloides* Michx.), saxifrage (*Saxifraga rhomboidea* Greene), wild strawberry (*Fragaria americana* (Porter) Britt.), pipsissewa (*Chimaphila umbellata* (L.) Bart.), and blue-eyed Mary (*Collinsia parviflora* Lindl.). The soil is generally quite moist and is covered with a duff of fallen needles from pine and fir. There are patches of sandy soil of siliceous nature in the open spots, and outcropping rocks are found everywhere. The lower average temperatures and greater moisture of this habitat fit expectations as judged from the appearance of vegetation.

The canyon bottom is typified by mixed stands of mesophytic deciduous trees and shrubs. A thornapple or hawthorn (*Crataegus* spp.) community extends westward from the mouth of the canyon for about a quarter of a mile. Overlapping this community and extending for the combined lengths of Gregory and Long Canyons, is a cottonwood-willow community. The conspicuous plants include narrowleaf cottonwood (*Populus angustifolia* James), willows (*Salix* spp.), wild plum(*Prunus americana* Marsh), wild raspberry (*Rubus idaeus* L.), poison ivy (*Rhus radicans* (L.) O. Ktze.), sumac, wild currant (*Ribes* spp.), horsetails (*Equisetum* spp.), red clover (*Trifolium pratense* L.), and violets. The canyon floor is also invaded by grassland communities. The intermittent stream has exposed the underlying Archean granite, and the ground is scattered with various sized rocks and boulders. The soil is of coarse sand and gravel in most places and is quite moist in early spring and summer. The temperature and moisture conditions indicate a relatively humid and sheltered environment.

The collecting of ants for this study was accomplished by the usual techniques of turning rocks, chopping logs, digging soil nests, opening thatched nests and other types of mound or domed structures, and the gathering of stray individuals. The specimens were identified, labeled, and preserved in small vials containing 85% ethyl alcohol. There follows the distributional information for each ant species obtained, and a map showing its occurrence in the canyon will be found in the Appendix. Table IV is a list of the species and the number of colonies of each that were collected. The map of collecting stations (Figure 2) shows the actual locations where field work was carried out.

ECOLOGICAL DISTRIBUTION
FAMILY FORMICIDAE

SUBFAMILY PONERINAE

GENUS *Ponera*

Ponera coarctata subsp. *pennsylvanica* Buckley

H. F. Borchert reported taking this species from the Gregory Canyon bottom in 1956, but specimens were not found during the course of this study. Collection records, however, are relatively rare in this area probably due to the fact that it normally ranges over the eastern United States and Canada. A precise map location cannot be given.

SUBFAMILY MYRMICINAE

GENUS *Myrmica*

Myrmica brevinodis subsp. *sulcinodoides* Emery

The taxonomy of this subspecies is somewhat of a problem, and this form has been synonymized by Creighton with *Myrmica brevinodis* Emery. One nesting site was found at an altitude of 6725 feet under a fallen, rotting aspen log which was situated in the canyon bottom. Widely distributed in western northern United States and in Canada.

Myrmica schencki subsp. *emeryana* Forel

The distribution of this species is the eastern United States, west to the Rocky Mountains. All of the nests were located above 6500 feet in forested parts of the canyon. Insufficient collection records make description of any distributional pattern difficult.

Myrmica lobicornis subsp. *fracticornis* Emery

M. lobicornis fracticornis is a subspecies extensively distributed through Canada and the northern United States. It has a southern extension along the Rocky Mountains. Three nests were taken, two in the upper canyon bottom above 6700 feet, and one on the north-facing slope of Flagstaff Mountain at 6650 feet.

Myrmica lobicornis subsp. *lobifrons* Pergande

This subspecies is listed by Creighton as being more a resident of higher elevations than is *fracticornis,* thus restricting it to the western mountains. The cooler, more moist north-facing slope appears to be its preferred habitat in this local canyon. This ant along with *monticola,* appears to be one of the most numerous ants of this genus in the locality.

Myrmica monticola Wheeler

The type locality of this species, Buena Vista, is in Colorado, but its range has extensions north to Manitoba and east to North Dakota. All nests were taken from beneath small stones on the north-facing slope of Green Mountain and Flagstaff Mountain. Its preference for the more boreal environments of the canyon is readily noted from the records

of its nesting sites.

GENUS *Pogonomyrmex*

Pogonomyrmex occidentalis (Cresson)

Although no members of this species were collected in the Gregory Canyon area during this study, it has been taken previously by R. E. Gregg on the east front of Flagstaff Mountain and in Verde Park (Chicken Ranch Gulch). This species is relatively abundant on the plains adjacent to the study area. Its nests are easily recognized as mounds usually two feet across and about one foot high. The covering of the nest is a "stucco" of small gravel and other soil particles. Its range extends from southern North Dakota to central Oklahoma and west to Arizona, Nevada, and Utah. The various species of *Pogonomyrmex* in western United States are adapted to hot and dry, Sonoran conditions.

GENUS *Stenamma*

Stenamma diecki Emery

The range of this species extends over the northeastern United States, southern Canada, and west to the Pacific Coast states. It was found in eleven places in Gregory Canyon. It appears to favor the north-facing slope, although one nest was uncovered on the south-facing slope of Flagstaff Mountain. The nest was rather high on the slopes and in ponderosa pine woodland.

GENUS *Aphaenogaster*

Aphaenogaster (*A.*) *subterranea* subsp. *valida* Wheeler

This is a dominant species of the Transition Zone, and normally occurs from central Colorado north to British Columbia and west to the mountains of Utah. It is one of the most numerous of ants found in the Gregory Canyon area. It inhabits each of the three parts of the canyon but seems to prefer the open spots instead of the dense stands of fir.

GENUS *Pheidole*

Pheidole pilifera subsp. *coloradensis* Emery

This is a thermophilous insect which occurs from northern New Mexico to the Dakotas. It was found that this species is limited entirely to the warm, dry, south-facing slope of Flagstaff Mountain below 7000 feet. Every nest was located under rocks.

Pheidole ceres Wheeler

Ceres, like *pilifera,* is a thermophilous species whose range extends along the foothills of the Rockies southwestward to northern Arizona. Nesting sites were found principally on the south-facing slope of Flagstaff. It appears to be somewhat more tolerant of the moist conditions in the lower canyon bottom as two of the nests were discovered there.

GENUS *Crematogaster*

Crematogaster lineolata subsp. *emeryana* Creighton

A mountain dwelling subspecies of Colorado, New Mexico, and Arizona, it was found to inhabit the south and southeast-facing slopes of Gregory and Long Canyons and the canyon bottom below 6000 feet. It appears to prefer nesting in areas where the conditions are not so shaded or so moist as one would find in the dense stands of Douglas fir.

GENUS *Solenopsis*

Solenopsis (*D.*) *molesta* (Say)

S. molesta is an eastern form which is taken relatively rarely in this region. This appears to be the extreme western edge of its range. One nest was found at the mouth of Gregory Canyon on the lower portion of the south-facing slope of Flagstaff Mountain.

Solenopsis (*D.*) *molesta* subsp. *validiuscula* Emery

This subspecies was found under rocks throughout the study area. The generalized distribution indicates a widespread tolerance to varying environmental conditions. It is a western subspecies occurring from the Pacific Coast states to Colorado and New Mexico.

GENUS *Leptothorax*

Leptothorax nitens Emery

This is a western species which was found in three locations of the study

area. Specimens from two nests deviate morphologically from the typical *nitens*.

Leptothorax rugatulus Emery

Rugatulus is an inhabitant of the Transition Zone of the Rocky Mountains, and extends southwest to Arizona and northwest to the Cascade Range. Nests were located in all areas. The results obtained show that it seems to prefer the north-facing slopes but is not restricted to them.

Leptothorax (*M.*) *crassipilis* Wheeler

L. crassipilis normally nests in the foothills region of Colorado, Wyoming, Utah, New Mexico, Nevada, and Arizona. Specimens were taken from fifteen nests which were scattered throughout the test area. It appears to be most tolerant of the north-facing slope environmental conditions, and would seem to favor moist sites too inasmuch as it was found frequently in the canyon bottom.

SUBFAMILY DOLICHODERINAE

GENUS *Liometopum*

Liometopum apiculatum Mayr

This is another species which generally nests in the foothills region or the Transition Life Zone. Its geographic range includes Colorado, New Mexico, Arizona, and northern Mexico. A number of nests were uncovered on the south-facing slope of Flagstaff Mountain and in the lower canyon bottom. All nests occurred below 7000 feet. This species is obviously thermophilous, preferring the warmer and drier south-facing slope to the dense, shaded forest of the north-facing slope.

Liometopum occidentale subsp. *luctuosum* Wheeler

The type locality of this subspecies is Colorado Springs, Colorado. It ranges from southern Wyoming to New Mexico and Arizona and westward to the Californian mountains. One nest was discovered on the north-facing slope of Flagstaff Mountain at 6400 feet in a rotting log. The other two nests were located on the north-facing slope of Green Mountain, one in a rotting log and the other under a large rock.

GENUS *Iridomyrmex*

Iridomyrmex pruinosus subsp. *analis* (E. André)

This is also a western subspecies which appears to prefer the warm dry conditions of the south-facing slope of the canyon. Fourteen nests were found, all of which occurred on the south-facing slope of Flagstaff Mountain. All of the nests were situated under rocks.

GENUS *Tapinoma*

Tapinoma sessile (Say)

Tapinoma sessile is a dominant species which is widespread over the United States except for the desert regions of the southwest. Compared with other ants, a relatively great number of nests of this species was found in all areas throughout the canyon. Most of the specimens were taken under rocks, but several nests were discovered in and under fallen logs. Apparently, this is a species which is very tolerant of most environmental conditions as would be expected from its great geographic distribution. The local distribution in the study area correlates fully with this supposition.

SUBFAMILY FORMICINAE

GENUS *Brachymyrmex*

Brachymyrmex depilis Emery

The range of this small New World species extends from New England southward to Florida, and westward to California, the Dakotas, and British Columbia. Specimens were taken from four nests in the study area. No definite pattern can be assumed on this amount of data, but from our experience one may say it tends to require moist, shady locations. This is also supported by its known habitat preferences elsewhere.

GENUS *Camponotus*

Camponotus pennsylvanicus subsp. *modoc* Wheeler

This is a western subspecies which is relatively rare east of the Rocky Mountains. All of the nests were found on the north-facing slope of Green Mountain in the dense stands of Douglas fir trees. Three nests were taken either in or under fallen logs, two of them between 7200 and 7400 feet and the other at 6500 feet in altitude. In general, it appears to require moist conditions in all parts of its range, but is not especially boreal in its overall geographical distribution.

Camponotus laevigatus (F. Smith)

C. laevigatus is another strictly western species occurring from the Pacific Coast to the Rocky Mountains. This distinctive, shining black ant was taken in a log near the summit of Flagstaff Mountain. Its usual distribution is in the foothills of the western mountains, and it tolerates a rather wide range of conditions.

Camponotus ligniperdus subsp. *noveboracensis* (Fitch)

Though widespread in northern and central United States from the Atlantic to the Pacific Oceans, this ant is uncommon in Colorado. In the vicinity of Boulder, one record was obtained at the mouth of Bear Canyon, and one in Long Canyon on the canyon bottom at 6900 feet. So far as its known occurrence in the Rocky Mountains is concerned, the ant is a Transition Zone form.

Camponotus (*T.*) *vicinus* Mayr

This is a very abundant western species in this area. It is widespread and numerous throughout Gregory Canyon, and it appears to be highly tolerant of all three major environmental conditions studied here. Its range extends from somewhat east of the Rocky Mountains to the Pacific Coast and from British Columbia south into the highlands of Mexico.

GENUS *Lasius*

Lasius alienus subsp. *americanus* Emery

This is a cosmopolitan ant extending over most of the United States. In this area, it appears to prefer warm habitats, as all nests were taken on the lower south-facing slope of Flagstaff Mountain. The restricted distribution, however, is somewhat unexpected as other ubiquitous species were found to inhabit all slopes of the study area.

Lasius niger subsp. *neoniger* Emery

This subspecies occurs coast to coast over the northern United States and southern Canada. It would be expected to prefer the cooler boreal sites of the canyon, and it does seem to favor the more moist, cooler situations, but is not limited to them nor to any particular environmental condition in Gregory Canyon. A total of 27 nests were collected.

Lasius niger subsp. *sitkaensis* Pergande

L. n. sitkaensis is a close relative of *neoniger*. It has a transcontinental distribution in northern United States, and through Canada to Alaska; it is also common in mountains of the western states. The ant appears to select the cooler, more moist areas of the canyon bottom and the north-facing slope, which thus parallels its generally boreal distribution.

Lasius (*C.*) *brevicornis* subsp. *microps* Wheeler

This subspecies was taken from seven nesting sites, and most of the colonies were located on the north-facing slopes. Those that did occur in drier and warmer spots were under stones in stands of ponderosa pine. The tolerance of this insect for cooler and moister parts of the canyon may stem from its hypogaeic proclivities, or, these habits may indicate a definite requirement for abundant moisture. The insect is typical of western mountains.

Lasius (*C*) *subumbratus* Viereck

This species is described by Creighton as being endemic to the Transition and Canadian Life Zones of eastern Canada, northern New England, and the Rocky Mountain region. Most of the nests were

discovered on the north-facing slopes and the canyon bottom. It obviously prefers the cooler and moister situations. Its local distribution here is partly correlated with its known geographic distribution, and this in turn may be correlated with its hypogaeic habits similar to those of *L. brevicornis microps.*

GENUS *Formica*

THE PROFORMICA GROUP

Formica (P.) lasioides Emery

The geographical range of this species extends over the northern United States and southern Canada with southward extensions into mountainous regions. From present records, four of the nests were found in the canyon bottom, one on the summit of Flagstaff Mountain, and one on the north-facing slope of Green Mountain. This pattern may indicate that it prefers the intermediate conditions of the canyon bottom and does not succeed well in the other parts of the canyon. The number of nests of *lasioides* collected, however, is too small to justify a definite conclusion.

Formica (P.) neogagates Emery

This species is a close relative to the preceding ant. One nest was found in each of the three regions of the canyon. Since its geographical range extends over the northern United States and Canada with southern extensions in mountains, it might be expected to have a wide tolerance of varying environmental conditions. An inadequate number of records from this area, however, prevents interpretation of any definite pattern.

THE SANGUINEA GROUP

Formica (R.) sanguinea subsp. *subnuda* Emery

F. sanguinea subnuda is known to be a broadly distributed northern species whose range includes a southern extension into the Rocky Mountains. One nest was obtained on the upper north-facing slope of Green Mountain at an altitude of 7400 feet. In view of this ant's boreal geographic dispersal, its occurrence in the dark forest is not surprising, and it is common at higher elevations in Colorado.

THE RUFA GROUP

Formica integra subsp. *haemorrhoidalis* Emery

This is a western subspecies whose geographical distribution extends northwest to Washington and British Columbia. Specimens were taken from all three canyon environments, but were most numerous in moist situations. The species is generally considered to be rather abundant in Colorado foothill stations, although such was not found to be the case in this study. It is, however, a common Rocky Mountain ant.

Formica integroides subsp. *planipilis* Creighton

One nest of this subspecies was found, and it was situated in the canyon bottom at an altitude of 6750 feet. According to Gregg (1963) it is distributed through the mountains of eastern Nevada to western Colorado, and its presence on the eastern slope of Colorado is, therefore, quite unusual and unexpected. A closely related subspecies, *F. integroides coloradensis* Wheeler, is more typical of the Rocky Mountains, but this ant is usually found at higher elevations and appears to be commonest in the Canadian Zone. We obtained no records of it in the canyon.

Formica obscuripes Forel

The range of this western and midwestern species includes the Rocky Mountain region. The one colony found was located in the thin forest on the summit of Flagstaff Mountain. The nest was a three- to four-foot thatched mound. This particular species is common on the plains adjacent to Boulder, where it inhabits open sunny locations.

Formica obscuriventris subsp. *clivia* Creighton

This subspecies occurs throughout the northwestern part of the United States.

It has a southern extension along the Rocky Mountains where it is known to be a foothills ant. Nine nests were scattered along the canyon bottom and the lower part of the south-facing slopes. It appears to prefer the conditions between the extremes of the north-facing and south-facing slopes, namely, those that are warm but moist.

THE MICROGYNA GROUP

Formica rasilis Wheeler

One nest of this species was found along the south-facing slope of Long Canyon at an altitude of 6800 feet. The insect is a Rocky Mountain species.

Formica rasilis subsp. *densiventris* Viereck

Specimens were taken from two nests which were located on the south-facing slope of Flagstaff. The number of records for this species and the previous one are insufficient to discern any distributional pattern in the study area.

THE FUSCA GROUP

Formica fusca Linné

F. fusca is an exceedingly widespread and dominant species whose distribution occurs over the northern half of the northern hemisphere. This ant was one of the most abundant species present in the study area. It apparently has no significant preference for any of the varying conditions studied, and ranges indiscriminately over the whole locality.

Formica neorufibarbis Emery

This is a western and northwestern species which reaches to Alaska and British Columbia, and occurs also in the western mountain ranges of the United States. It obviously prefers the moist, cool, boreal conditions of the higher north-facing slopes. All of the nests were found either in or under fallen rotting logs.

THE PALLIDEFULVA GROUP

Formica (N.) pallidefulva Latreille

The range of this species spreads over the midwestern, eastern and especially the southeastern United States. But its range also extends to Colorado. In this local canyon, it appears to have a preference for the warmer south-facing slopes and canyon bottom. Unfortunately, records are fewer than could be desired. Five nests were discovered, three on the south-facing slopes and two in the lower canyon bottom.

Formica (N.) pallidefulva subsp. *nitidiventris* Emery

This ant is an eastern and northeastern subspecies but also occurs sporadically along the Rocky Mountain chain. It was found to inhabit the south-facing slope more than the other areas but is not restricted to it. Its virtual absence from the north-facing wall of the canyon may indicate that it prefers somewhat warmer and drier places.

GENUS *Polyergus*

Polyergus lucidus Mayr

One specimen of this eastern species was discovered in a nest of its host, *Formica (N.) pallidefulva nitidiventris*. The nest was located in the canyon bottom at an altitude of 6750 feet. Repeated efforts to locate more specimens have been unsuccessful. This is one of the few western records of this species and probably indicates that Boulder is near the extreme western edge of its range.

Polyergus rufescens subsp. *breviceps* Emery

One large nest of *P. rufescens breviceps* was found on the south-facing slope of Flagstaff Mountain at an altitude of 6425 feet. It was located under a rock along with its host *Formica fusca*. The western part of the range of this species lies in the Rocky Mountain region from New Mexico to Montana and extends north-westward to Washington.

DISCUSSION

As mentioned earlier, one of the objects of this study is to ascertain the degree to which the occurrence of various ant species actually correlates with the major ecological units (the macro-ecology or principal vegetation types) in a local canyon. The striking contrasts among these environmental complexes are here thrown into sharp focus, and on this account it was expected that any distributional correlations among the ants would also be sharply focused. These expectations have been confirmed in numerous cases as may be seen readily from the patterns on the accompanying maps. Stenokous species, or those having presumed narrow tolerances, show the clearest patterns and the closest associations with particular environmental situations, whereas eurokous (more tolerant) species range easily over two or more distinctly different habitats, and some of these appear to ignore all or most of the ecological changes. Where an ant species indicates fidelity to a given environmental complex, we assume that one or more ecological factors operating in minimal or maximal amounts are limiting the dispersal or at least the establishment of the species in other sites, because there are no physical barriers in the canyon to prevent the spread of colonizing individuals. Such conclusions must rest, of course, on a fair number of records for the spot occurrence of a species; single records, as with rare species, may be suggestive but are not in themselves conclusive.

We wished also to test the extent to which the detailed distribution of ants, with respect to local ecological conditions, corresponds with the broad continental distribution of those species and their general environmental requirements. Forty-six species and subspecies are treated in the foregoing discussions of the ants, and of these, 45 have their known distribution in Gregory Canyon plotted on maps. *Ponera coarctata pennsylvanica* is the only ant for which a map was not prepared. Some species are extremely rare, and it is only by good fortune that they are ever found, and others are rare in this region by virture of the fact that their ranges lie mainly in other parts of the country. Species that belong in these categories are given in the following list, but some ants which, though taken only once in the canyon, are well known ecologically and geographically in other parts of Colorado (Gregg, 1963), and whose habitat preferences can be logically inferred, are omitted from the list.

Ponera coarctata pennsylvanica
Solenopsis molesta 4 forms
Formica integroides planipilis
Polyergus lucidus

These four species, whose ecological preferences in Gregory Canyon must be left in doubt, constitute about 9% of the canyon fauna surveyed. This means that we are able to decide with reasonable satisfaction the preferences of the remainder of the fauna and correlate these with the zoogeography of the species concerned. Where abundant or moderately abundant records for the canyon were obtained, the correlations can be made directly. Where only one or two records from the canyon were made for species whose statewide distribution is adequately known from other studies, the probable preferences of these forms can be determined and included with the data for those species in which the canyon distribution is well documented. This has been done.

A group of species has been found to have no decided attachment with any one of the canyon habitats but lives on both slopes and the bottom. These ants occur either widely over most of the United States and Canada, or have a very broad distribution in the western states. They are generally eurokous species, sometimes dominant, and often very common insects of the North American fauna. Their disregard for local ecological differences is paralleled by their continental distribution. The obviously wide tolerances of these ants doubtless have enabled them to spread into numerous locations and some of them occupy stations that present ecological extremes. The species involved are as follows.

Stenamma diecki
Aphaenogaster subterranea valida
Leptothorax rugatulus
Solenopsis molesta validiuscula
Tapinoma sessile
Camponotus laevigatus
Camponotus vicinus
Lasius niger neoniger 15 forms
Formica lasioides
Formica neogagates
Formica integra haemorrhoidalis
Formica fusca
Formica rasilis
Formica rasilis densiventris
Polyergus rufescens breviceps

This constellation of forms amounts to almost 33% of the ant fauna in the area of investigation. Reference to these ants, in the preceding section, and to their distribution maps will show the reasons for their placement. Again, the

ecological data accumulated by Gregg for ants in all parts of Colorado were used for determining the proper allocation of species whose records show them to be very sparsely represented in the canyon. *C. laevigatus, F. haemorrhoidalis, F. rasilis* and *F. densiventris* are ants about which there might be some doubt, also *Polyergus breviceps,* but their known ecology elsewhere seems to justify their inclusion in this group. *Aphaenogaster valida, Tapinoma sessile,* and *Formica fusca* are strikingly abundant in the canyon and the interpretation of their records is unequivocal.

Ants which are restricted to, or almost restricted to the north-facing slopes, are those which seem to require cool and moist nesting sites. Some of them appear from the maps to occur only on the slopes, and others are found to be represented on the canyon bottom as well. The climatic differences of these two areas are not as marked as between the north-facing and the south-facing slopes, or even between the south-facing wall and the canyon bottom. This situation could account for some of the observed map patterns. The following list of species in this category is noteworthy.

Myrmica brevinodis sulcinodoides
Myrmica schencki emeryana
Myrmica lobicornis fracticornis
Myrmica lobicornis lobifrons
Myrmica monticola
Leptothorax crassipilis
Liometopum occidentale luctuosum
Brachymyrmex depilis — 15 forms
Camponotus pennsylvanicus modoc
Camponotus ligniperdus noveboracensis
Lasius niger sitkaensis
Lasius brevicornis microps
Lasius subumbratus
Formica sanguinea subnuda
Formica neorufibarbis

This group of species also comprises about 33% of the canyon ant fauna. The large number of forms in this category may be attributed to the circumstance that the study area is actually in the foothill (submontane) or Transition Zone and is therefore a part of the mountains physiographically. This zone is biologically one of the richest in the Rocky Mountain region. It is extensively forested and has many cool and shady spots which thus provide suitable conditions for species that normally occur in greater abundance at higher altitudes where average temperatures are lower and greater humidity prevails. We have not separated those ants which were found only on the north-facing slope from those that occur both on the slope and the canyon bottom as it seems questionable whether there is any real distinction of this sort. Some of the species are common in boreal habitats

such as exist at higher elevations in the mountains and at the higher latitudes of the continent; they are generally northern in distribution. Examples of these are *Myrmica lobifrons, Lasius sitkaensis,* and *Formica subnuda.* But some of the species are not especially boreal in affinities, being found extensively in western United States or the country as a whole where temperatures are moderate and moisture is plentiful. Examples of this type are *Myrmica emeryana, Liometopum luctuosum, Brachmyrmex depilis,* and *Camponotus modoc.* Where moisture is more critical than cool temperature in the requirements of some ants, conditions for those species will be satisfactory on the canyon bottom as well as the north-facing slope.

In contrast to the foregoing assemblage, there is another group of ants in the canyon that is restricted to the south-facing slope, or to the slope and the canyon bottom. These two types have not been separated, again for reasons similar to those mentioned above. In these species, warm temperatures may be more critical than high humidity, and the insects would find a variety of conditions suitable for their nests both on the south-facing slope (which is often quite hot) and the canyon bottom where considerable warmth and protection is afforded. The ants which we assign to this category are listed below.

Pogonomyrmex occidentalis	
Pheidole pilifera coloradensis	
Pheidole ceres	
Crematogaster lineolata emeryana	
Liometopum apiculatum	
Iridomyrmex pruinosus analis	11 forms
Lasius alienus americanus	
Formica obscuripes	
Formica obscuriventris clivia	
Formica pallidefulva	
Formica pallidefulva nitidiventris	

Thus a significant proportion, or 24%, of the canyon ants are to be found positively correlated with the warmest habitats of the studied area. Elsewhere in Colorado these species are characteristic of habitats subjected to high summer temperatures, and some of them are at home in very dry or xeric environments. Examples of the latter are such species as *Pogonomyrmex occidentalis,* the two *Pheidole, Iridomyrmex analis,* and *Formica obscuripes.* Most of these ants have the main part of their ranges in middle or southern United States, or in the southwestern United States and into Mexico. They are at least tolerant of very warm, and in some instances of very dry regions, and it is such characteristics that permit them to establish themselves in the foothills, but only in the warmest and most sheltered sites. The lower incidence (percentage) of ant species on the south-facing slope than elsewhere is probably a reflection of the seemingly smaller

total area with conditions suitable for Sonoran forms. This canyon is populated not only by a wealth of Transition Zone forms widely distributed in all sorts of foothill habitats, but also by many ants which descend from higher elevations. The overall environments of the lower hills and canyons appear to be more similar to the mountains in general (forested) than to the short grass plains beyond the mountain base. One of the species in the above list, namely, *F. clivia,* is almost confined to the canyon bottom. This high correlation may indicate narrow limits of tolerance for mesophytic conditions of temperature and moisture, but since only one ant of this sort has turned up in the study, we do not feel justified in recognizing a canyon-bottom ant fauna distinct from the other areas. The bottom fauna seems to be shared noticeably with both the north- and south-facing slopes.

Of all the species reported in this work, only *Leptothorax nitens* seems not to fit any of the categories we have used. It constitutes a little over 2% of the canyon fauna. The ant is known from Colorado to the Sierras of California, so presumably it inhabits a variety of environmental conditions, but it is rare in Colorado and its ecology is too uncertain yet to assign it to any particular group.

We may conclude that, in so far as the data are adequate, the local distribution of ant species resembles their continental distribution with regard to the types of environments chosen for nesting sites. The combination of factors necessary for maintaining the life of individuals and of the species are probably specific for each taxon. A species is permitted to exist at various stations where the factoral combination does not exceed the limits of its adaptability, and is usually excluded from establishing itself in sites or areas which fail to provide optimum conditions for that species. The study site, Gregory Canyon, seems to provide a natural experiment, in which a local area insures a control over geographical variables, while ecological variables occur side-by-side and in sharp contrast to each other.

SELECTED REFERENCES

BORCHERT, H. F. 1956. The ant faunas of foothill canyons in the vicinity of Boulder, Colorado. Master's thesis, University of Colorado, Boulder.

BYARS, L. F. 1936. An ecological survey of the ants of Boulder County. Master's thesis, University of Colorado, Boulder.

CREIGHTON, W. S. 1950. The ants of North America. Bull. Mus. Comp. Zool. Harvard University, Vol. 104, 585 pp.

DELFIN, E. E. 1954. An entomological survey of Gregory Canyon, Boulder, Colorado. Master's thesis, University of Colorado, Boulder.

GREGG, R. E. 1947. Altitudinal indicators among the Formicidae. Univ. Colo. Stud. Ser. D, 2:385-403.

———. 1963. The ants of Colorado, with reference to their ecology, taxonomy, and geographic distribution. Univ. Colo. Press, Boulder. 792 pp.

MARR, J. W. 1961. Ecosystems of the east slope of the Front Range in Colorado. Univ. Colo. Stud., Ser. Biol. No. 8, 134 pp.

MCHENRY, D. E. 1928. The vegetation of Gregory Canyon. Master's thesis, University of Colorado, Boulder.

ROBBINS, W. W. 1910. An introduction to the study of the ants of northern Colorado. Univ. Colo. Stud. 7 (4):215-222.

WEBER, W. A. 1953. Handbook of plants of the Colorado Front Range. Univ. Colo. Press, Boulder, 232 pp.

APPENDIX

TABLE I. Log of field trips, 1957-1958.

Date	Area	Altitude	Time	Weather
June 1957				
21	Canyon bottom	5700-5850	1000	Ptly. cldy., warm
July 1957				
2	North slope*	5850-6050	1350	Clear, warm
4	North slope	5850-6100	1045	Clear, warm
9	South slope*	5900-6200	1100	Ptly. cldy., warm
14	Canyon bottom	5900-6050	1130	Fair, warm
16	Canyon bottom	5900-6100	1300	Clear, hot
18	South slope	6000-6100	1000	Cloudy, warm
24	North slope	5950-6250	1200	Cloudy, cool
26	South slope	6050-6200	1300	Cloudy, warm
30	South slope	6850-6900	1430	Cldy., Int. rain
31	South slope	6800-6950	1400	Clear, hot
August 1957				
4	Canyon bottom	6750-6800	1300	Ptly. cldy., warm
7	North slope	6700-7000	1400	Cloudy, warm
10	North slope	7700-8100	1000	Clear, warm
22	Canyon bottom	6650-6800	0930	Ptly. cldy., warm
25	South slope	6950-7150	1200	Ptly. cldy., warm
26	North slope	6850-7025	1030	Ptly. cldy., warm
27	South slope	6600-6800	1000	Clear, warm
29	South slope	6600-6850	1400	Ptly. cldy., warm
September 1957				
2	North slope	7050-7400	1400	Clear, cool
18	North slope	7050-7550	1000	Clear, cool
26	Canyon bottom	6075-6300	1300	Ptly. cldy., cool
28	North slope	6850-7025	1000	Clear, warm
October 1957				
3	South slope	6600-6750	1330	Ptly. cldy., windy
6	South slope (Flagstaff Summit)	6900-7025	1200	Ptly.cldy., warm
27	South slope	6200-6450	1030	Clear, cool
May 1958				
22	North slope	6400-6500	1000	Cloudy, cool
24	North slope	6250-6600	0930	Clear, warm

Date	Area	Altitude	Time	Weather
June 1958				
8	South slope	6300-6600	1000	Clear, warm
9	North slope (Flagstaff Mtn.)	6250-6700	1100	Clear, warm
11	North slope	6500-6775	0830	Clear, cool
22	South slope	6425-6600	0930	Clear, warm
29	North slope	7050-7300	1000	Ptly. cldy., warm

Total field trips—33.

*North slope is understood to mean north-facing slope, and south slope is understood to mean south-facing slope in the interest of brevity for this table.

TABLE II. Soil moisture analysis, 1958.

Transect	Date	Can	Dry Weight	Water Loss	Percent Moisture	Average %	
South-facing slope:							
1	28 May	1	134.53	18.68	13.88		
		2	145.80	16.55	11.35		
		3	165.12	17.91	10.84	12.02	
	28 June	1	150.83	25.73	17.06		
		2	150.96	27.44	18.18		
		3	141.24	23.86	16.89	17.38	15.30
	28 July	1	142.40	22.11	15.46		
		2	140.01	23.04	16.46		
		3	107.24	18.95	17.58	16.50	
2	28 May	10	143.89	19.95	13.86		
		11	138.78	19.25	13.87		
		12	150.29	20.24	13.46	13.73	
	28 June	10	133.78	20.29	15.17		
		11	114.68	18.12	15.70		
		12	112.23	19.17	16.99	15.95	15.72
	28 July	10	119.67	20.12	16.90		
		11	136.40	23.83	17.47		
		12	137.35	24.77	18.03	17.47	
North-facing slope:							
1	28 May	7	117.33	25.82	22.01		
		8	121.43	26.78	22.05		
		9	113.82	25.84	22.70	22.25	
	28 June	7	118.12	26.40	22.35		
		8	131.89	28.58	21.67		
		9	121.20	28.95	23.89	22.64	22.32
	28 July	7	120.59	26.47	21.95		
		8	110.36	24.72	22.40		
		9	119.22	25.06	21.86	22.07	

Transect	Date	Can	Dry Weight	Water Loss	Percent Moisture	Average	%
2	28 May	16	64.69	28.20	43.59		
		17	78.58	29.97	38.14		
		18	84.30	30.66	38.37	40.03	
	28 June	16	81.19	27.24	33.55		
		17	59.32	27.57	46.31		
		18	60.60	30.31	50.02	43.29	35.81
	28 July	16	86.62	23.59	27.23		
		17	106.42	24.65	23.15		
		18	119.51	26.21	21.93	24.10	
Canyon bottom:							
1	28 May	4	129.39	21.32	16.44		
		5	111.28	19.00	17.07		
		6	109.26	21.91	20.05	16.85	
	28 June	4	123.21	24.27	19.70		
		5	109.98	20.39	18.54		
		6	110.33	20.98	19.02	19.09	17.46
	28 July	4	128.46	21.30	16.58		
		5	143.00	23.95	16.75		
		6	106.48	17.03	15.99	16.44	
2	28 May	13	121.08	28.21	23.70		
		14	123.22	29.22	23.71		
		15	118.15	28.49	24.11	23.71	
	28 June	13	110.90	22.60	20.38		
		14	121.51	26.24	21.59		
		15	91.12	22.08	24.23	22.07	22.49
	28 July	13	119.09	25.95	21.87		
		14	87.68	18.74	21.37		
		15	116.34	25.43	21.86	21.70	

TABLE III. Temperature.

Date	Surface	Subsurface	Air
Temperature (degrees C.), south-facing slope:			
July 1957			
18	22.78	24.44	21.11
	23.33	24.44	22.22
	38.89	30.00	30.00
26	28.33	25.00	24.44
	25.56	24.44	23.33
30	33.33	27.78	29.44
	33.33	30.00	29.44
31	33.89	31.11	32.78
	26.67	23.33	25.56
Average	29.57	26.73	26.48

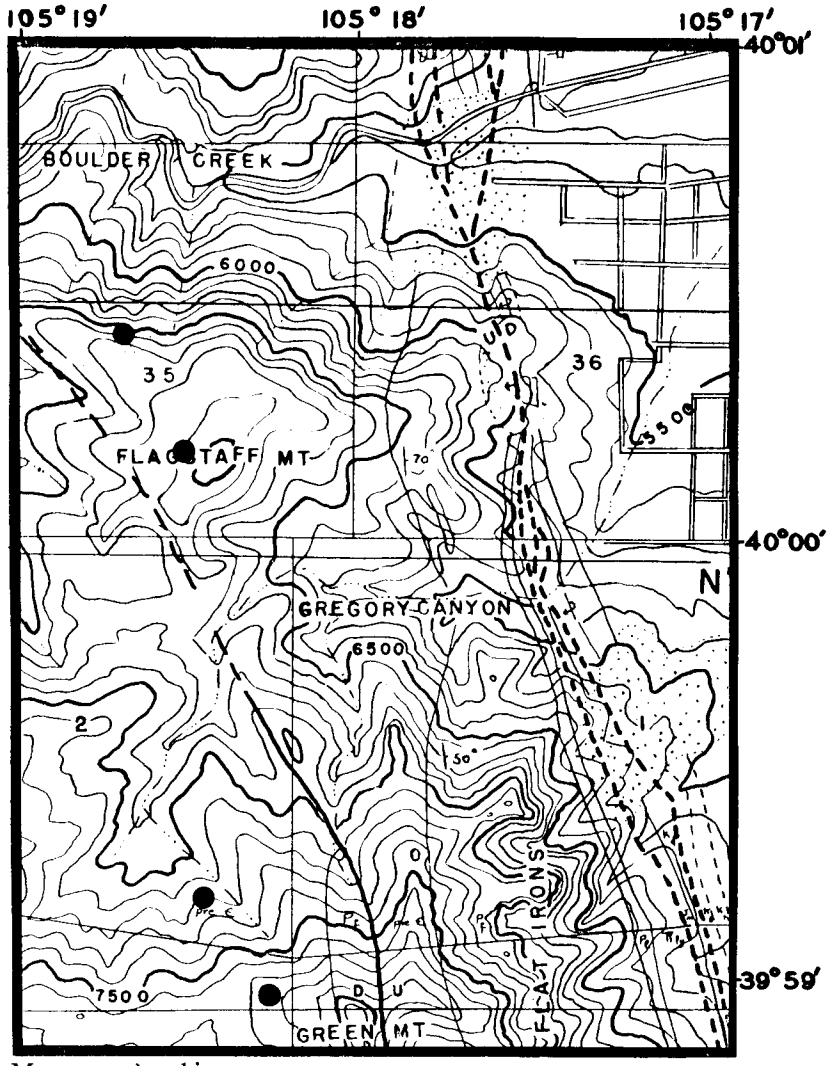
Date	Surface	Subsurface	Air
August 1957			
25	27.78	22.78	26.67
	40.00	32.22	35.56
27	28.89	26.67	26.67
	35.56	31.11	33.33
	28.89	23.33	26.67
29	23.89	21.67	21.11
	27.78	22.22	24.44
	28.89	22.22	26.67
Average	30.21	25.28	27.64
October 1957			
3	36.67	25.00	25.56
27	17.22	15.56	12.22
	23.33	14.44	17.78
Average	25.74	18.33	18.52
Overall average	28.77	24.89	25.75
Temperature (degrees C.), north-facing slope:			
July 1957			
2	34.44	31.11	33.33
4	26.11	21.11	20.00
	43.33	33.33	31.11
	30.56	25.56	22.22
24	21.11	18.89	20.56
	23.33	21.67	21.67
	23.33	19.44	21.11
Average	28.88	24.44	24.29
August 1957			
7	24.44	17.22	23.33
	21.11	16.67	22.78
10	34.44	22.22	31.11
	25.56	20.00	23.89
26	23.33	18.89	22.22
	21.67	18.89	20.00
Average	25.09	18.98	24.06
September 1957			
2	20.00	17.78	18.89
	20.56	17.78	19.44
18	17.78	15.56	16.67
28	22.78	18.89	21.11
	23.33	19.44	22.22
	23.33	18.33	22.78
Average	21.30	17.96	20.19
Overall average	25.29	20.15	22.87

Date	Surface	Subsurface	Air
Temperature (degrees C.), canyon bottom:			
July 1957			
14	28.33	23.33	26.67
	31.67	33.89	29.60
16	29.44	26.11	27.22
	28.89	24.44	28.89
	37.78	27.22	31.67
Average	31.22	26.60	28.81
August 1957			
22	20.00	17.78	18.89
	21.11	15.56	20.56
	22.78	18.89	21.67
Average	21.30	17.41	20.37
September 1957			
26	19.44	18.89	17.78
	20.00	18.89	18.89
Average	19.72	18.89	18.33
Overall average	25.23	22.50	23.49

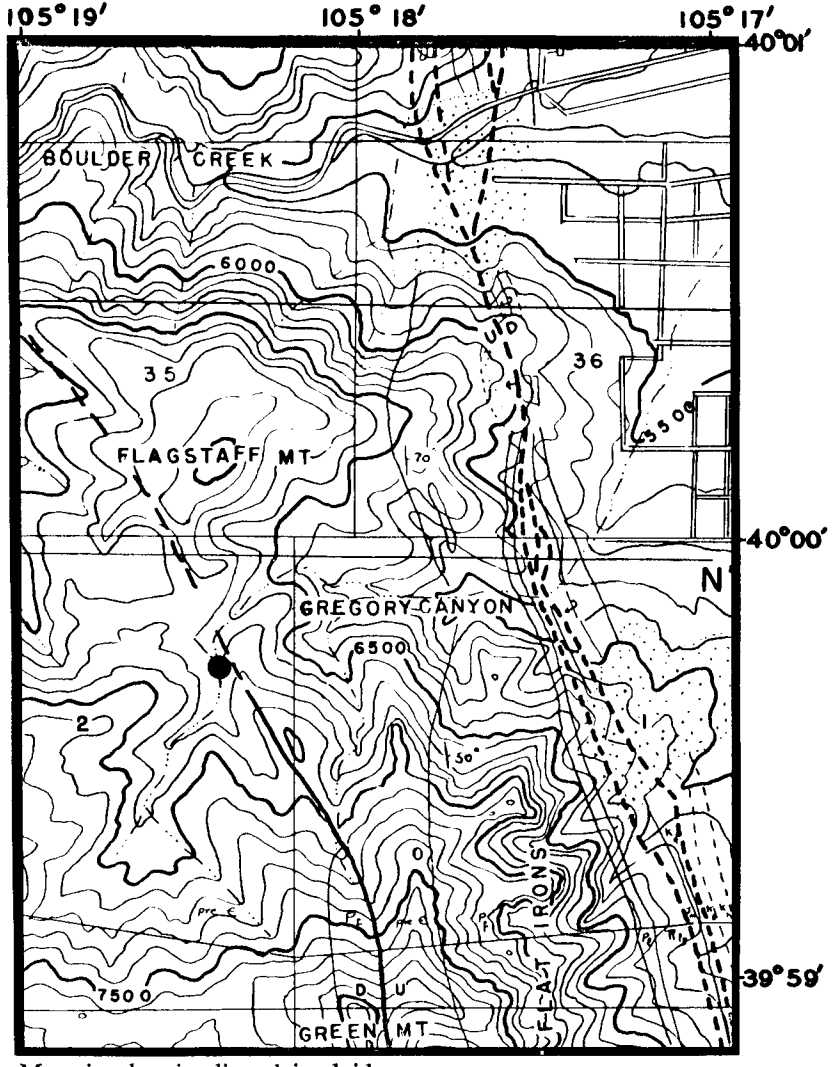
TABLE IV. List of ant species inhabiting Gregory Canyon area.

Name	Colonies Collected
Subfamily Ponerinae	
Genus *Ponera*	
Ponera coarctata subsp. *pennsylvanica* Buckley	1
Subfamily Myrmicinae	
Genus *Myrmica*	
Myrmica brevinodis subsp. *sulcinodoides* Emery	1
Myrmica schencki subsp. *emeryana* Forel	4
Myrmica lobicornis subsp. *fracticornis* Emery	3
Myrmica lobicornis subsp. *lobifrons* Pergande	9
Myrmica monticola Wheeler	9
Genus *Pogonomyrmex*	
Pogonomyrmex occidentalis (Cresson)	2
Genus *Stenamma*	
Stenamma diecki Emery	13
Genus *Aphaenogaster*	
Aphaenogaster (*A.*) *subterranea* subsp. *valida* Wheeler	43
Genus *Pheidole*	
Pheidole pilifera subsp. *coloradensis* Emery	9
Pheidole ceres Wheeler	10
Genus *Crematogaster*	
Crematogaster (*A.*) *lineolata* subsp. *emeryana* Creighton	6
Genus *Solenopsis*	
Solenopsis (*D.*) *molesta* (Say)	1
Solenopsis (*D.*) *molesta* subsp. *validiuscula* Emery	22

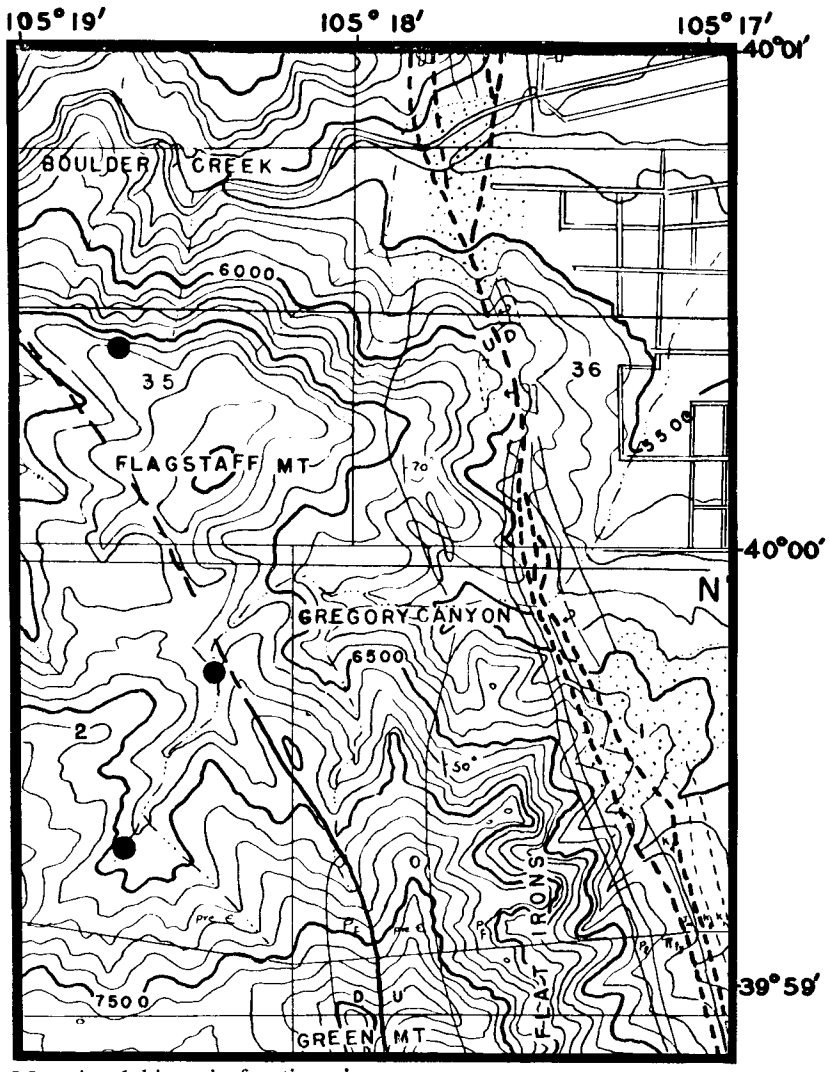
Name	Colonies Collected
Genus *Leptothorax*	
Leptothorax nitens Emery	3
Leptothorax rugatulus Emery	20
Leptothorax (M.)crassipilis Wheeler	15
Subfamily Dolichoderinae	
Genus *Liometopum*	
Liometopum apiculatum Mayr	19
Liometopum occidentale subsp. *luctuosum* Wheeler	3
Genus *Iridomyrmex*	
Iridomyrmex pruinosus subsp. *analis* (E. André)	14
Genus *Tapinoma*	
Tapinoma sessile (Say)	49
Subfamily Formicinae	
Genus *Brachymyrmex*	
Brachymyrmex depilis Emery	4
Genus *Camponotus*	
Camponotus pennsylvanicus subsp. *modoc* Wheeler	7
Camponotus laevigatus (F. Smith)	1
Camponotus ligniperdus subsp. *noveboracensis* (Fitch)	2
Camponotus (T.) vicinus Mayr	33
Genus *Lasius*	
Lasius alienus subsp. *americanus* Emery	6
Lasius niger subsp. *neoniger* Emery	27
Lasius niger subsp. *sitkaensis* Pergande	20
Lasius (C.) brevicornis subsp. *microps* Wheeler	7
Lasius (C.) subumbratus Viereck	16
Genus *Formica*	
The Proformica Group	
Formica (P.) lasioides Emery	6
Formica (P.) neogagates Emery	3
The Sanguinea Group	
Formica (R.) sanguinea subsp. *subnuda* Emery	1
The Rufa Group	
Formica integra subsp. *haemorrhoidalis* Emery	8
Formica integroides subsp. *planipilis* Creighton	1
Formica obscuripes Forel	1
Formica obscuriventris subsp. *clivia* Creighton	9
The Microgyna Group	
Formica rasilis Wheeler	1
Formica rasilis subsp. *densiventris* Viereck	2
The Fusca Group	
Formica fusca Linné	47
Formica neorufibarbis Emery	8
The Pallidefulva Group	
Formica (N.) pallidefulva Latreille	5
Formica (N.) pallidefulva subsp. *nitidiventris* Emery	11
Genus *Polyergus*	
Polyergus lucidus Mayr	1
Polyergus rufescens subsp. *breviceps* Emery	1
Total colonies collected	484



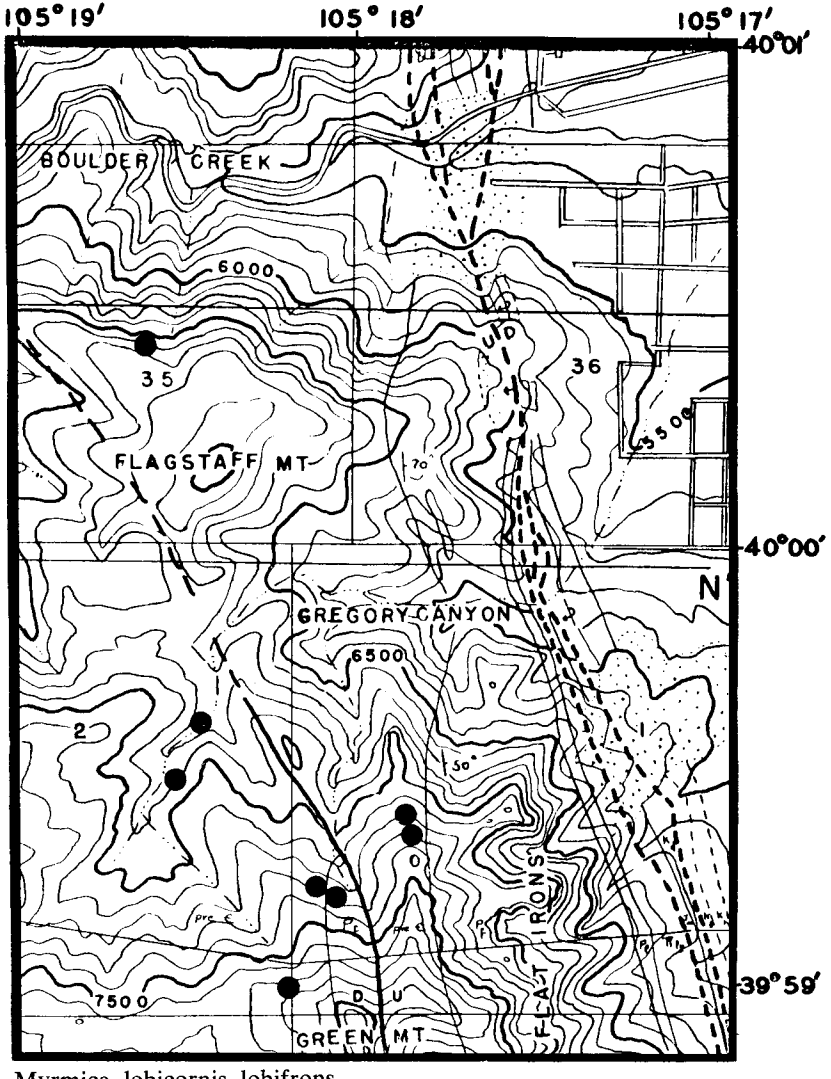
Myrmica schencki emeryana



Myrmica brevinodis sulcinodoides



Myrmica lobicornis fracticornis



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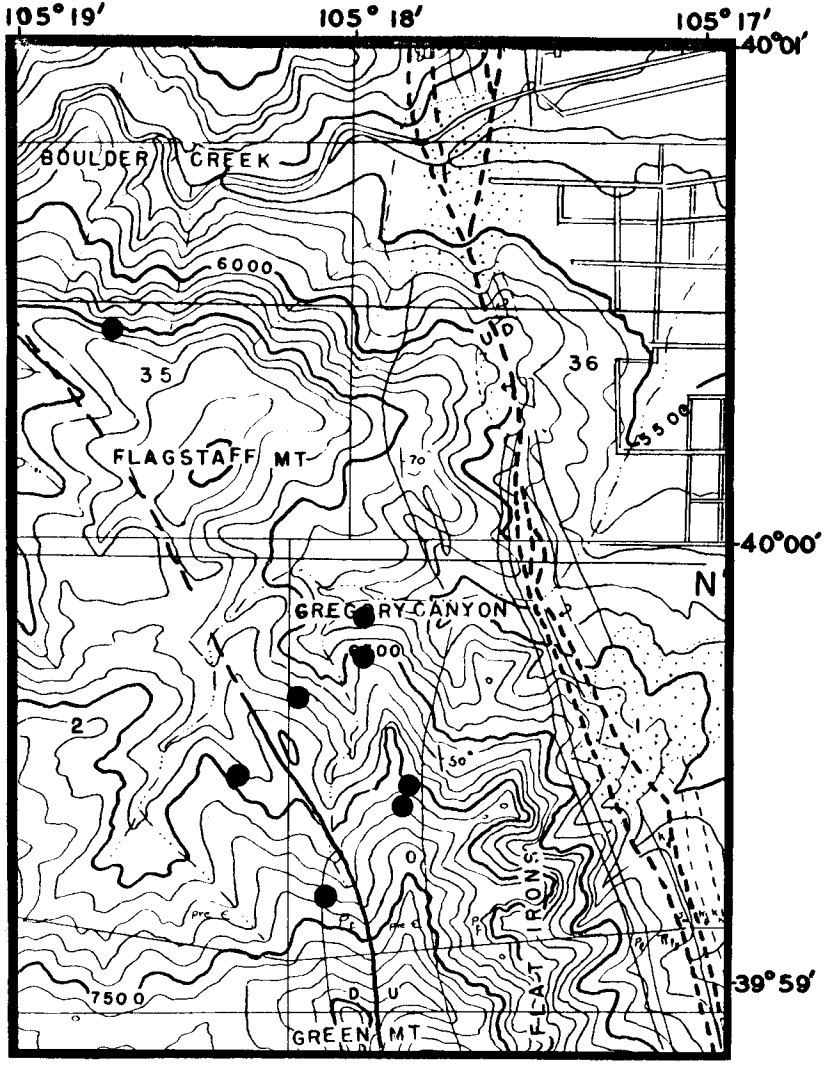

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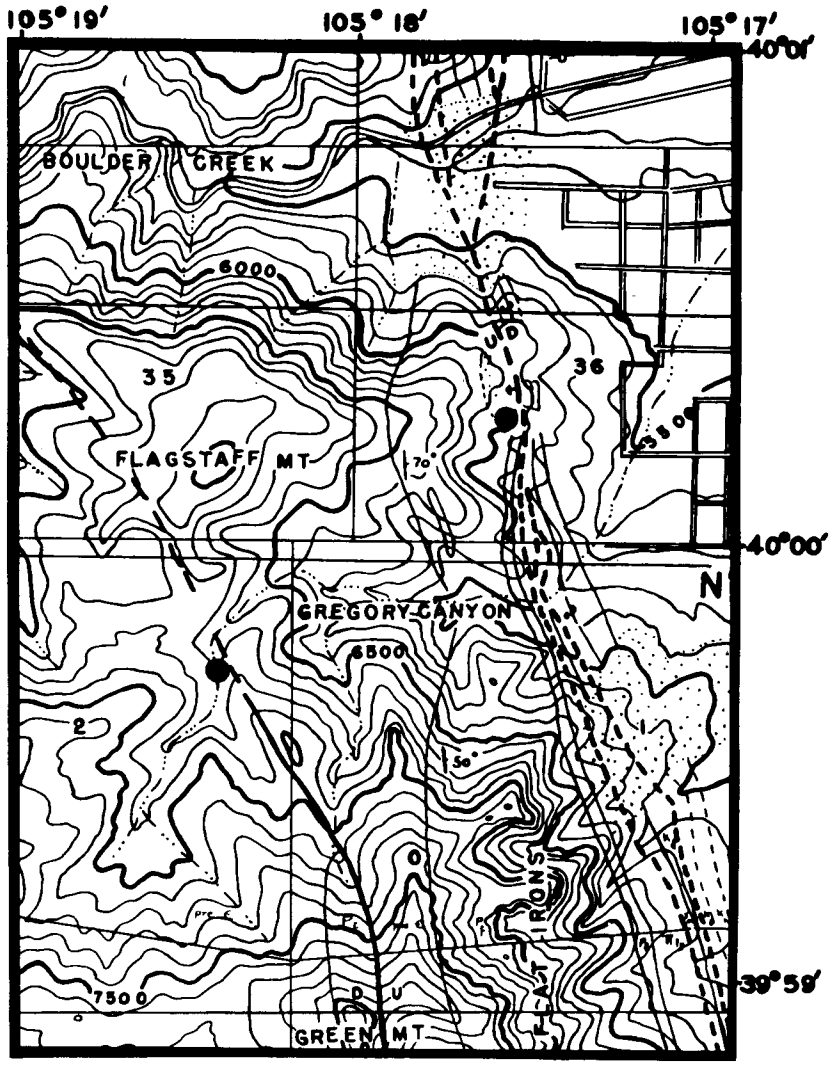
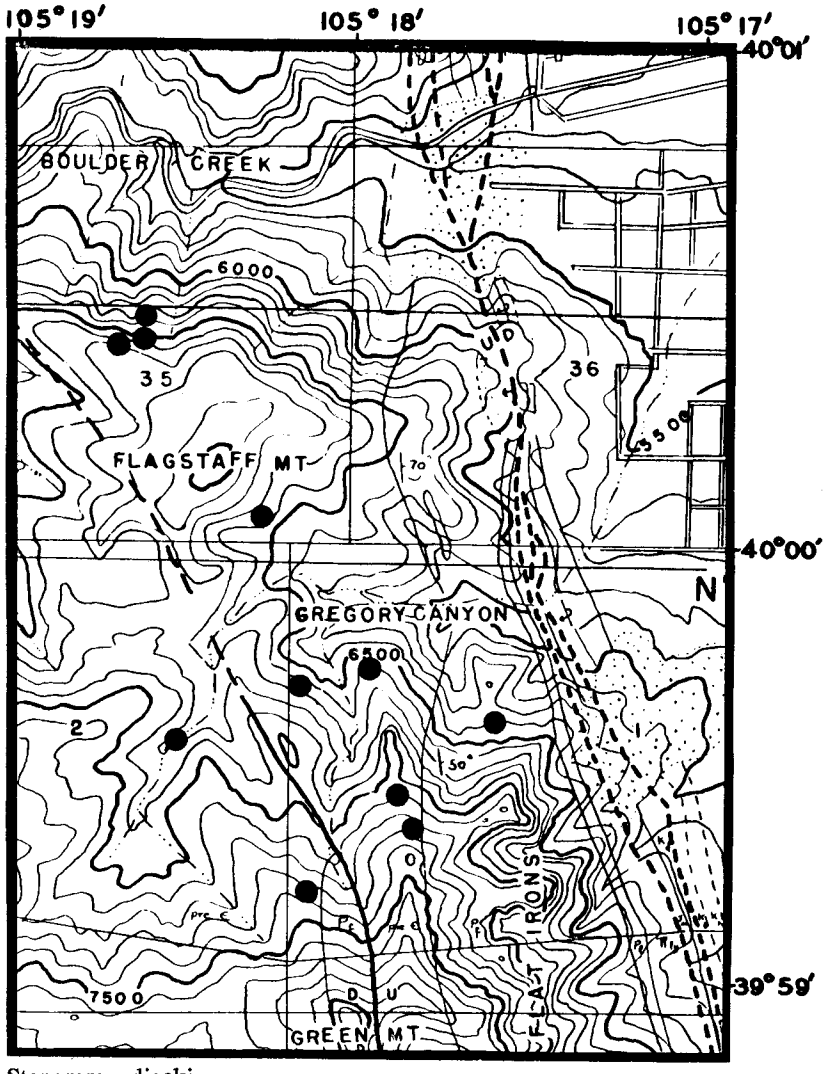
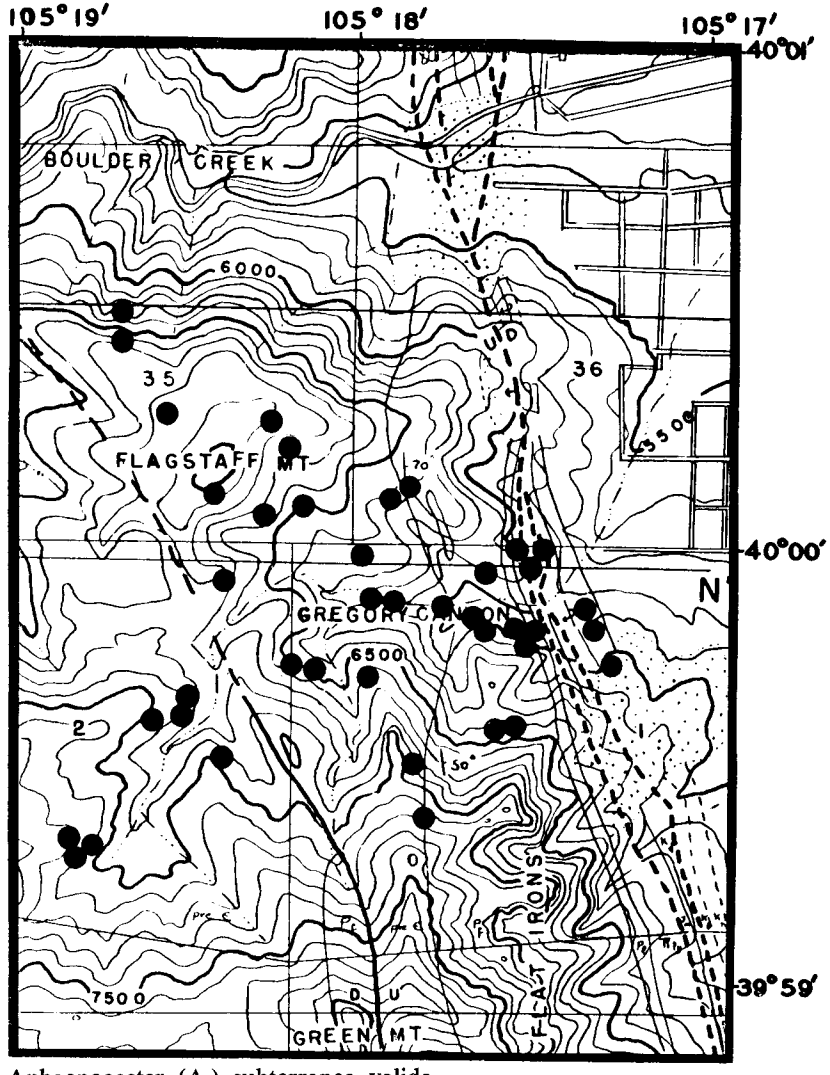


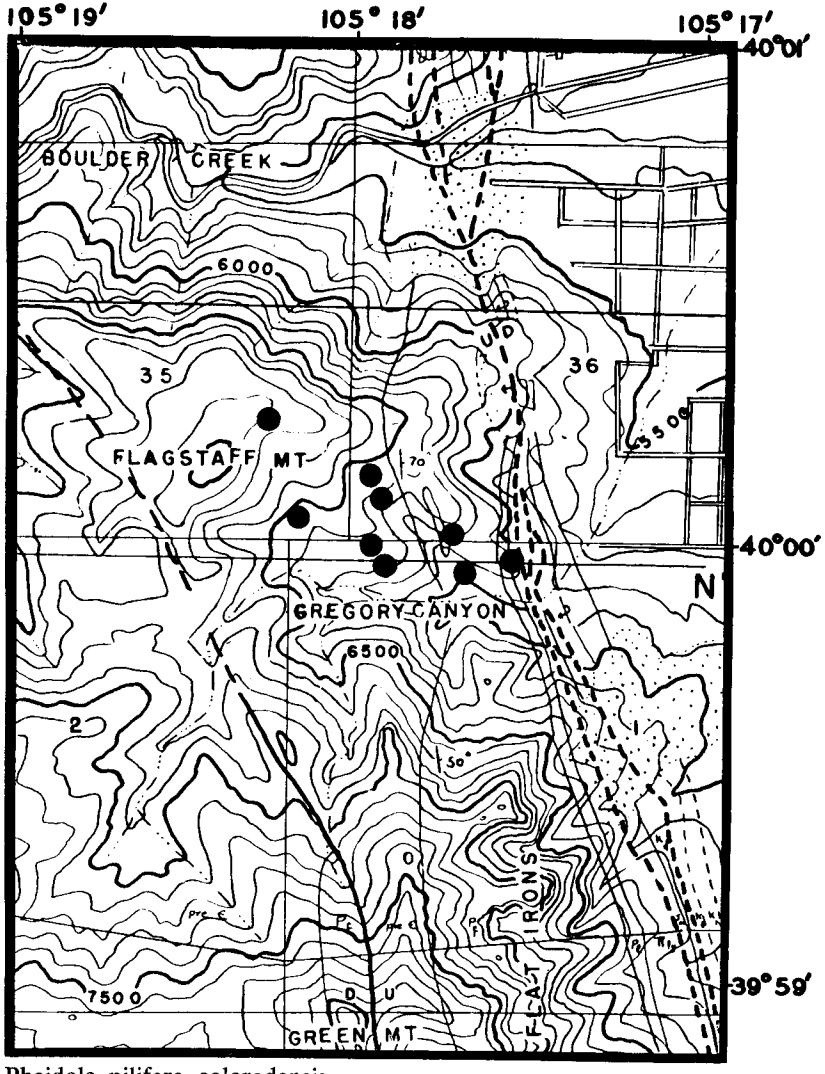
Pogonomyrmex occidentalis



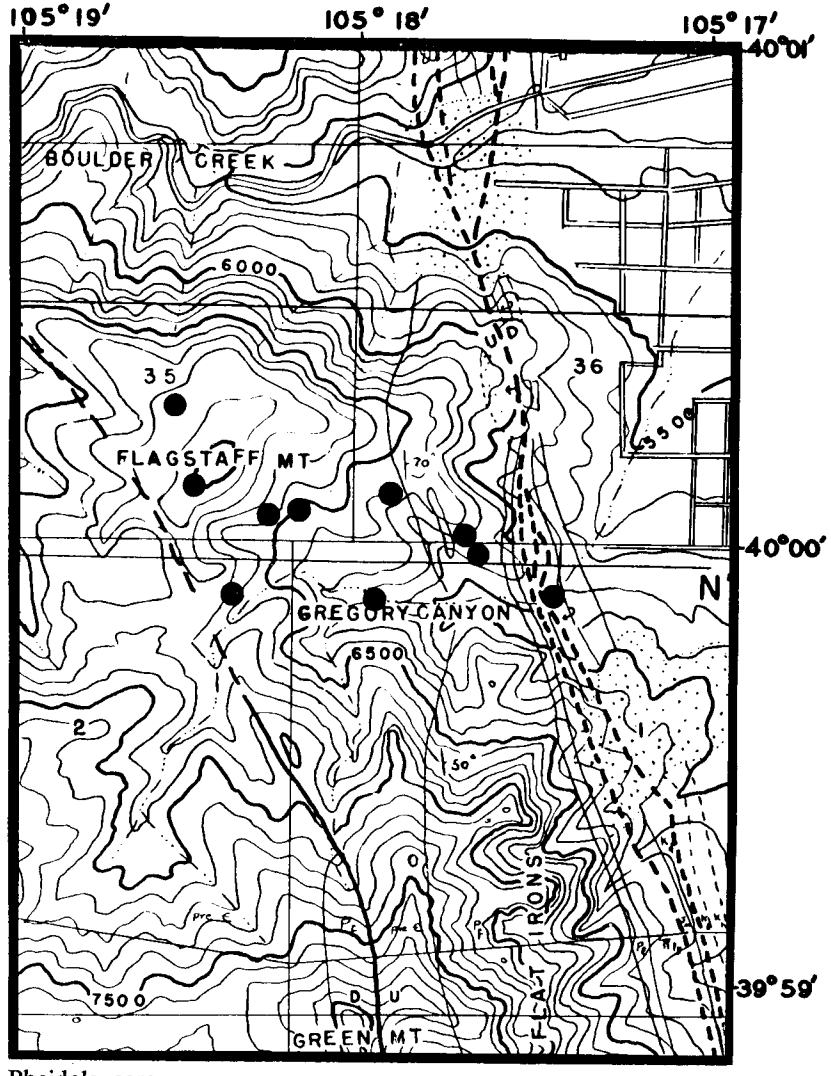
Stenamma diecki



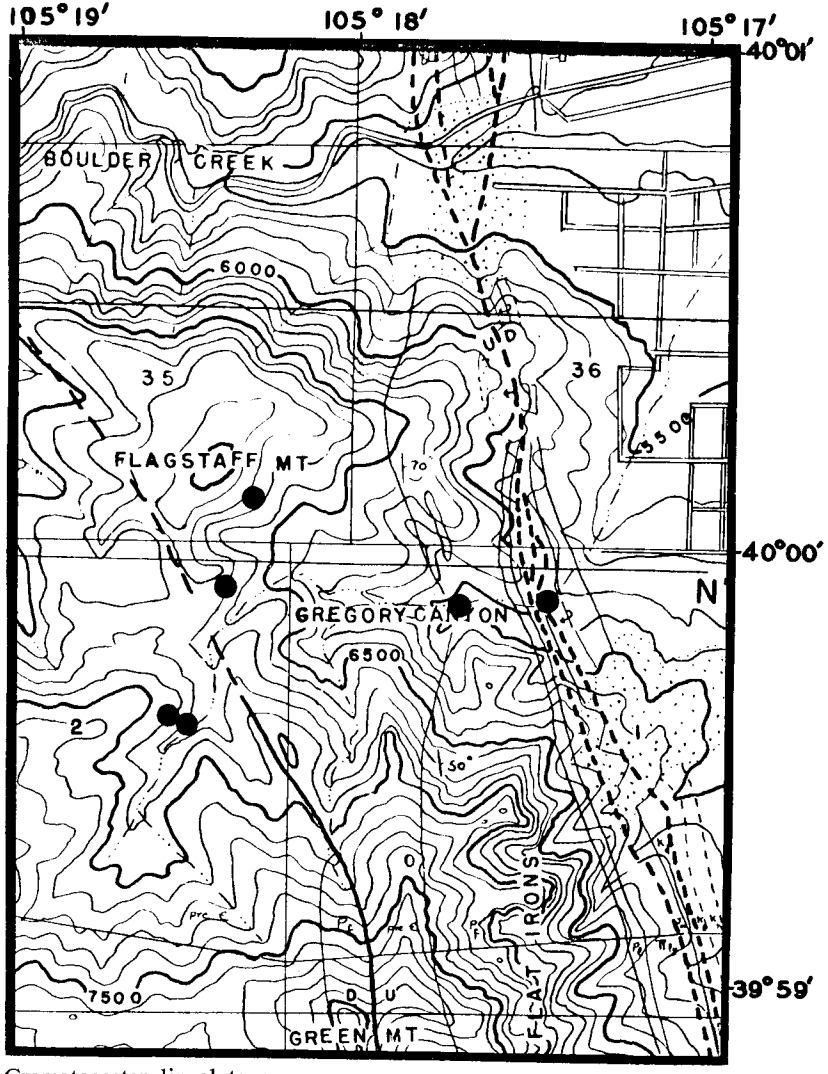
Aphaenogaster (A.) subterranea valida



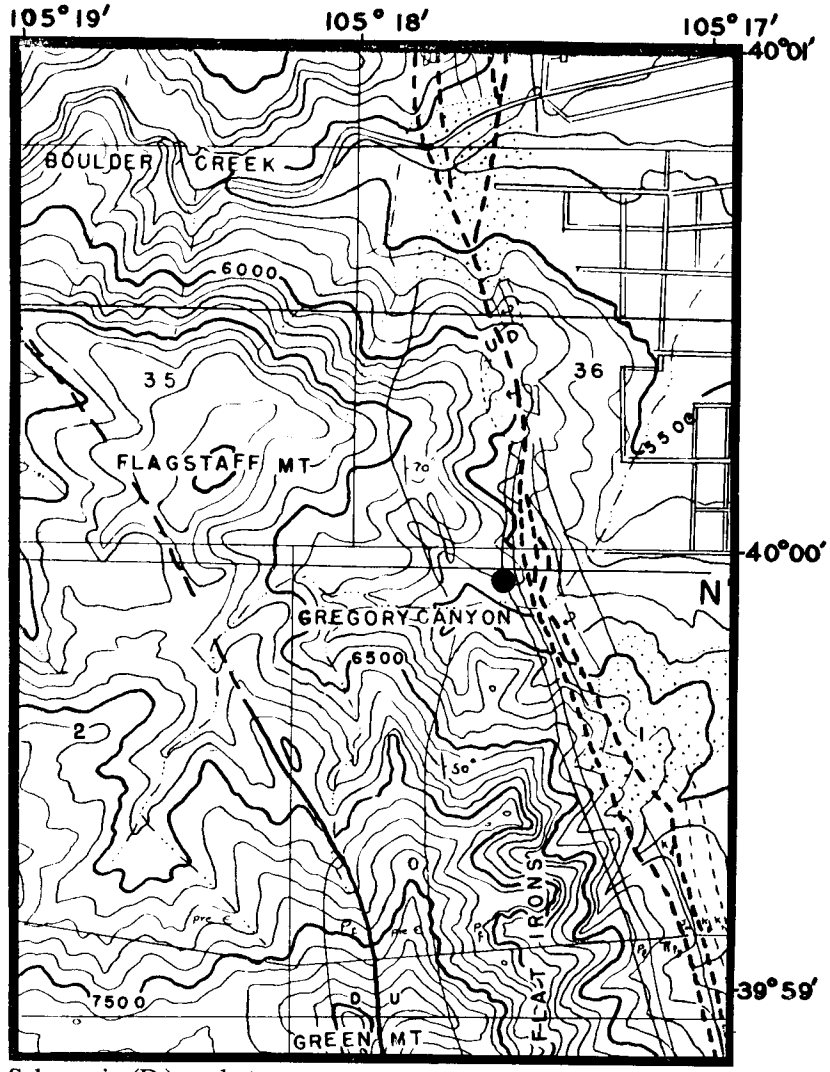
Pheidole pilifera coloradensis



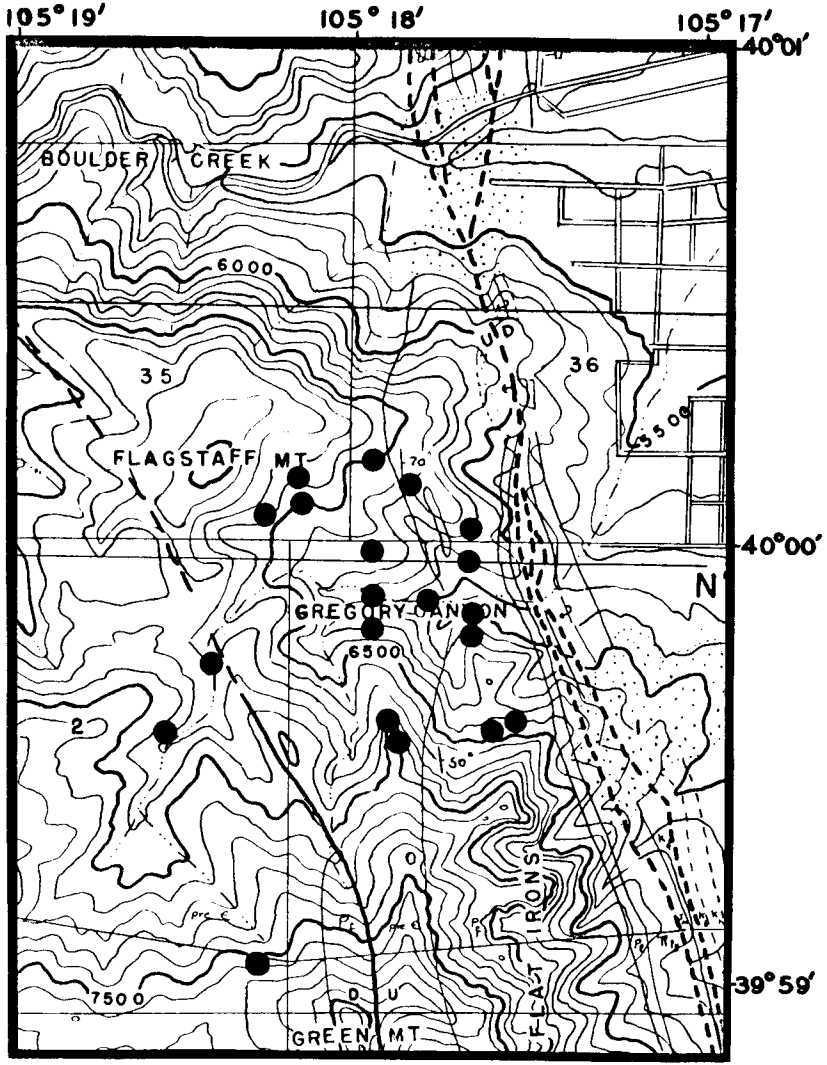
Pheidole ceres



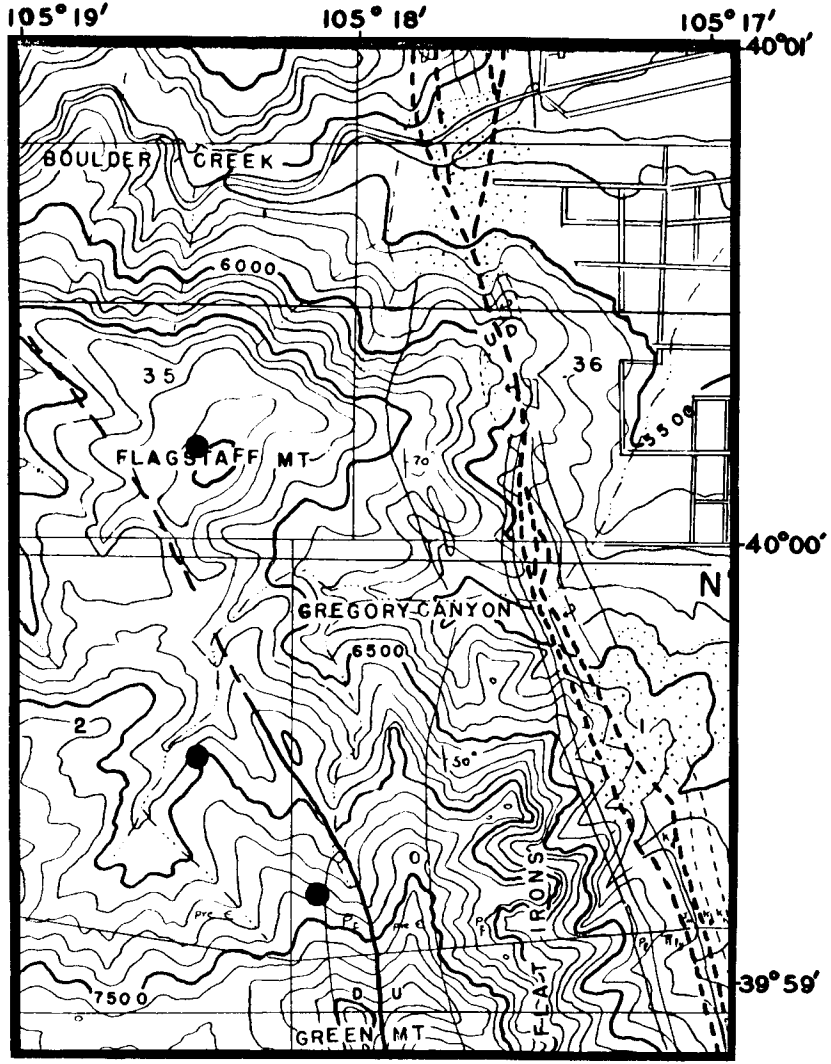
Crematogaster lineolata emeryana



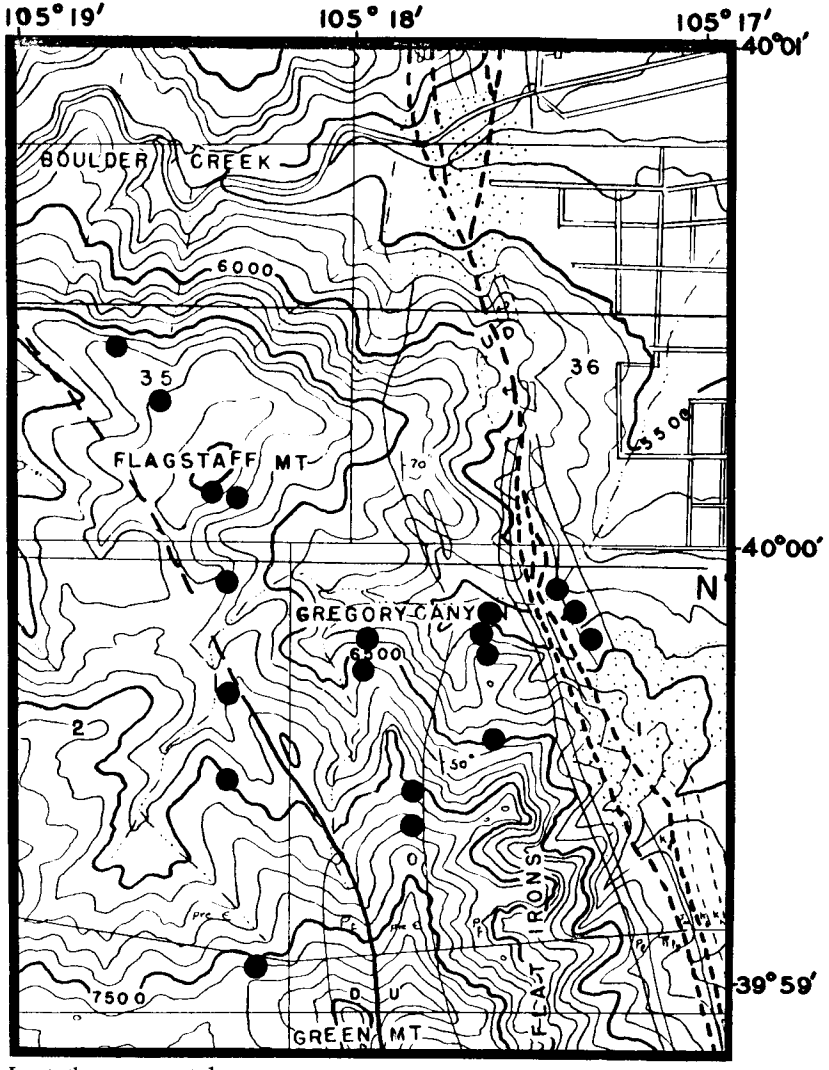
Solenopsis (D.) molesta



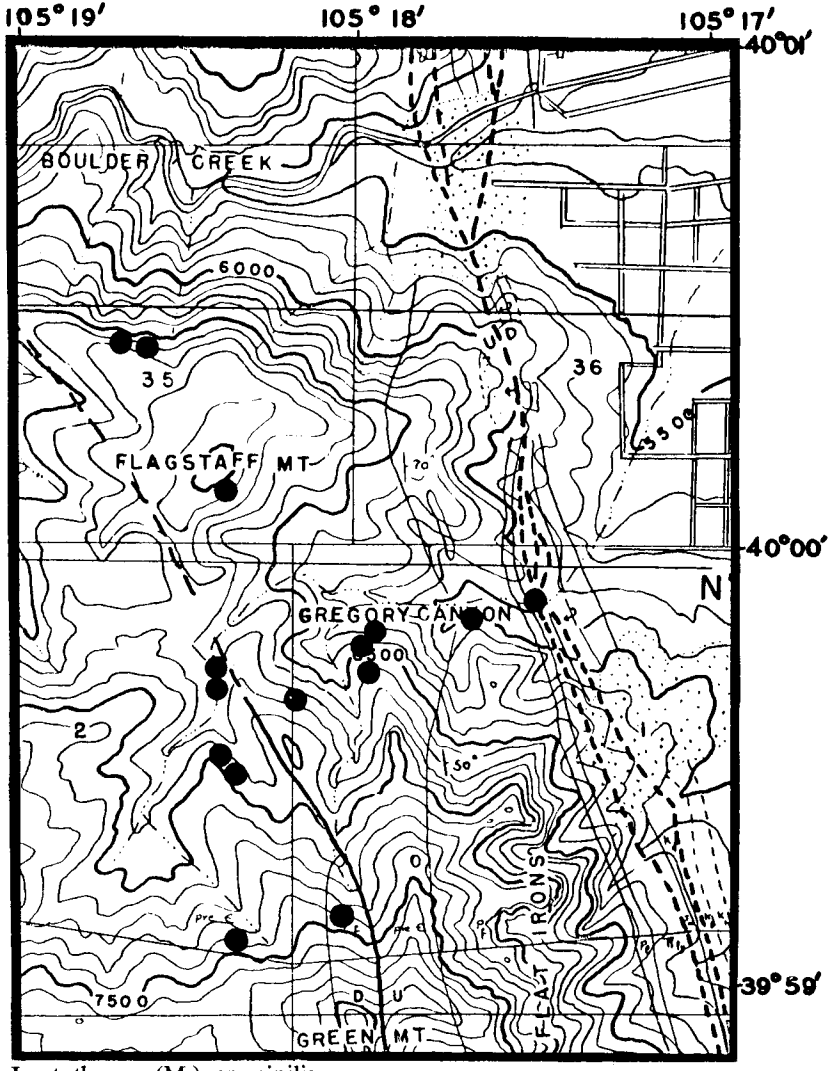
Solenopsis (D.) molesta validiuscula



Leptothorax nitens



Leptothorax rugatulus



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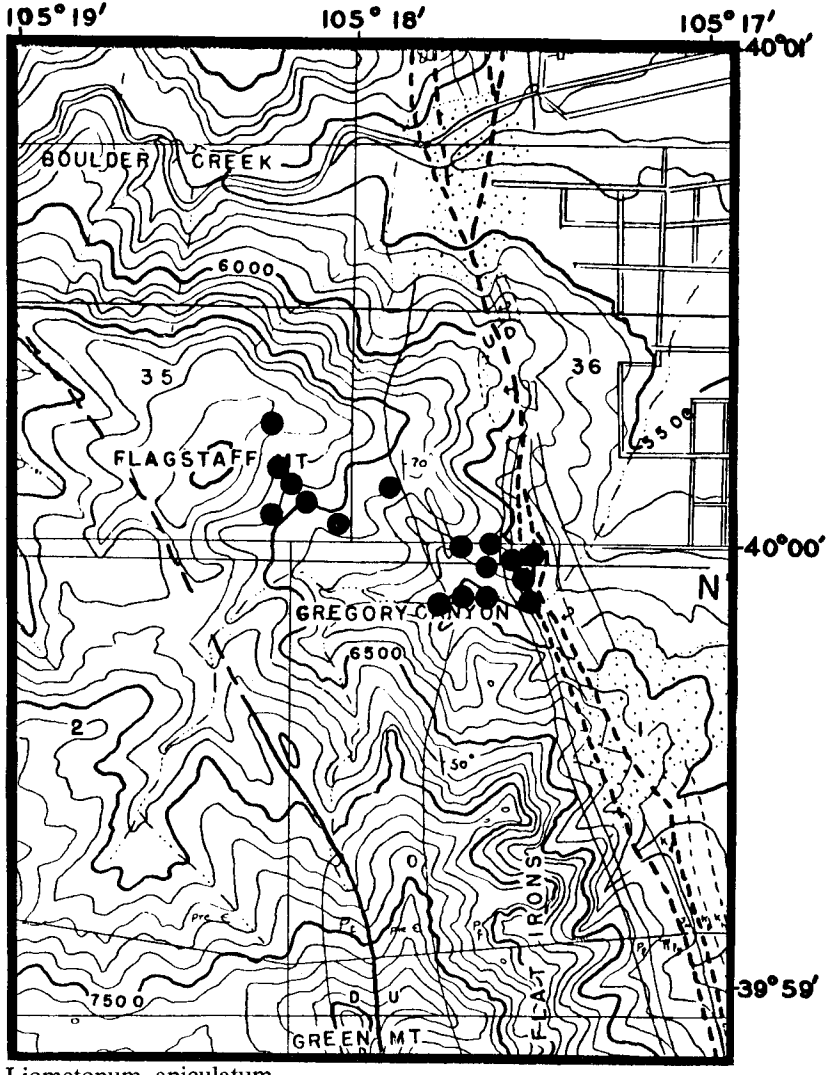
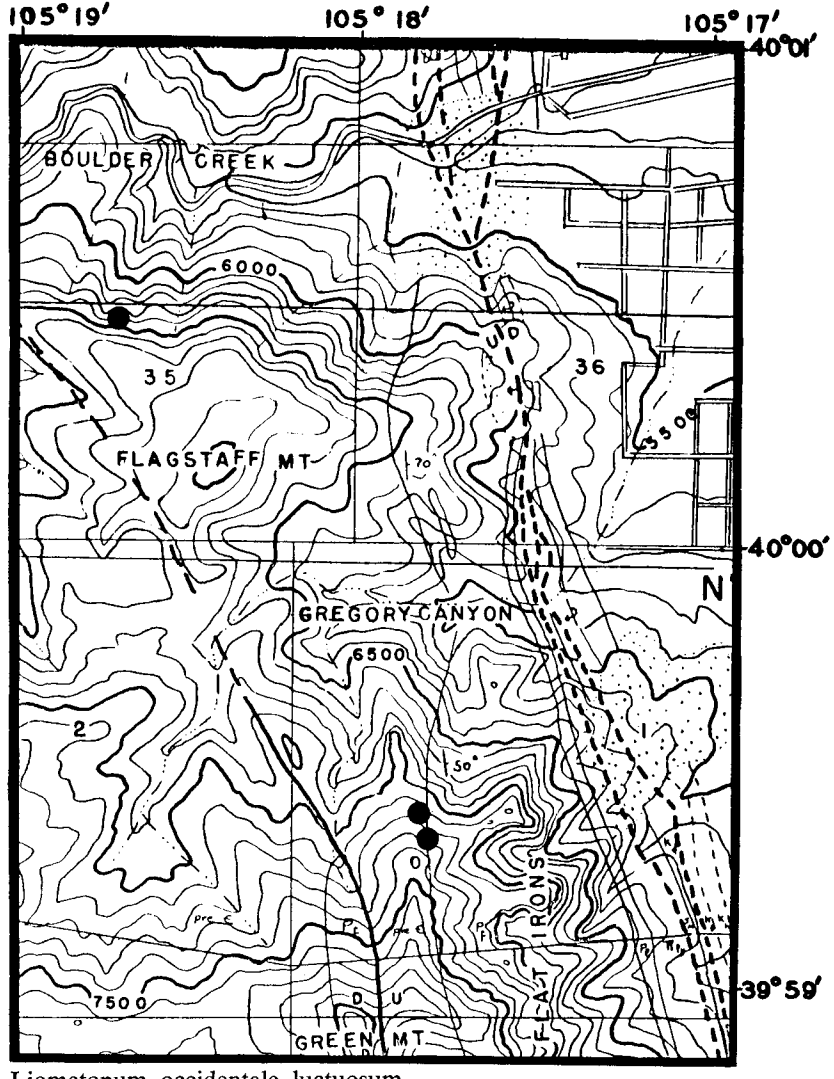
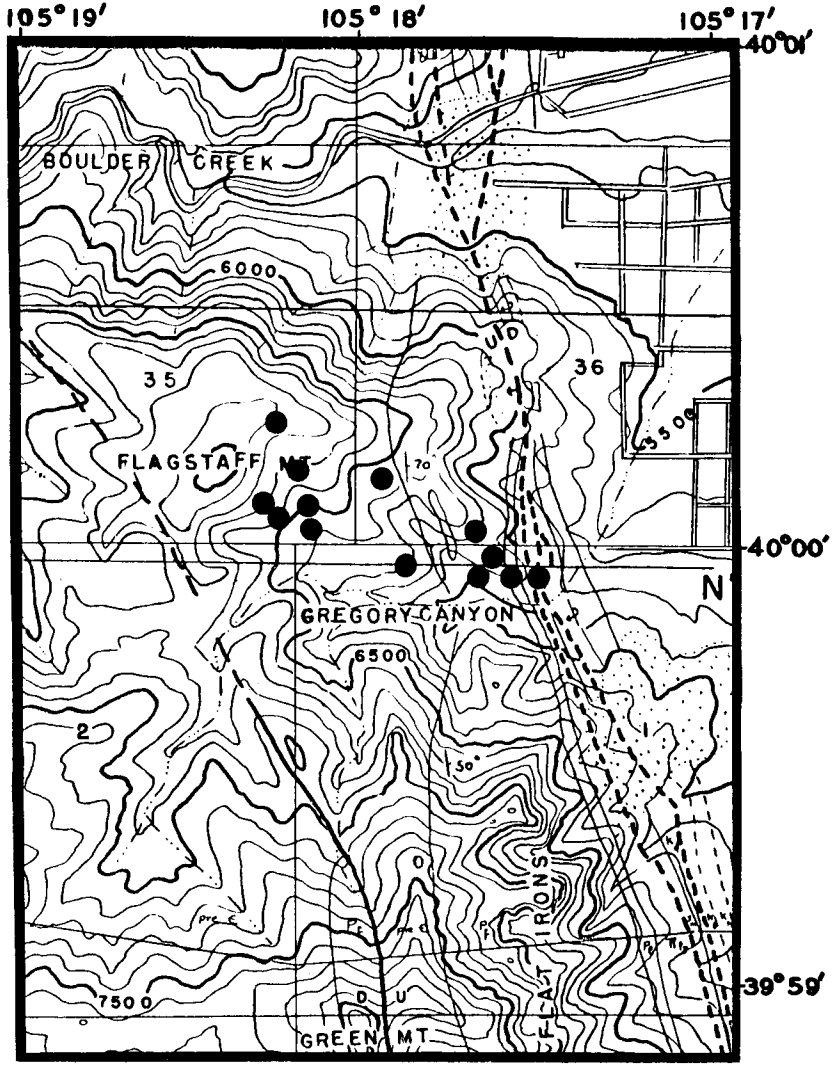


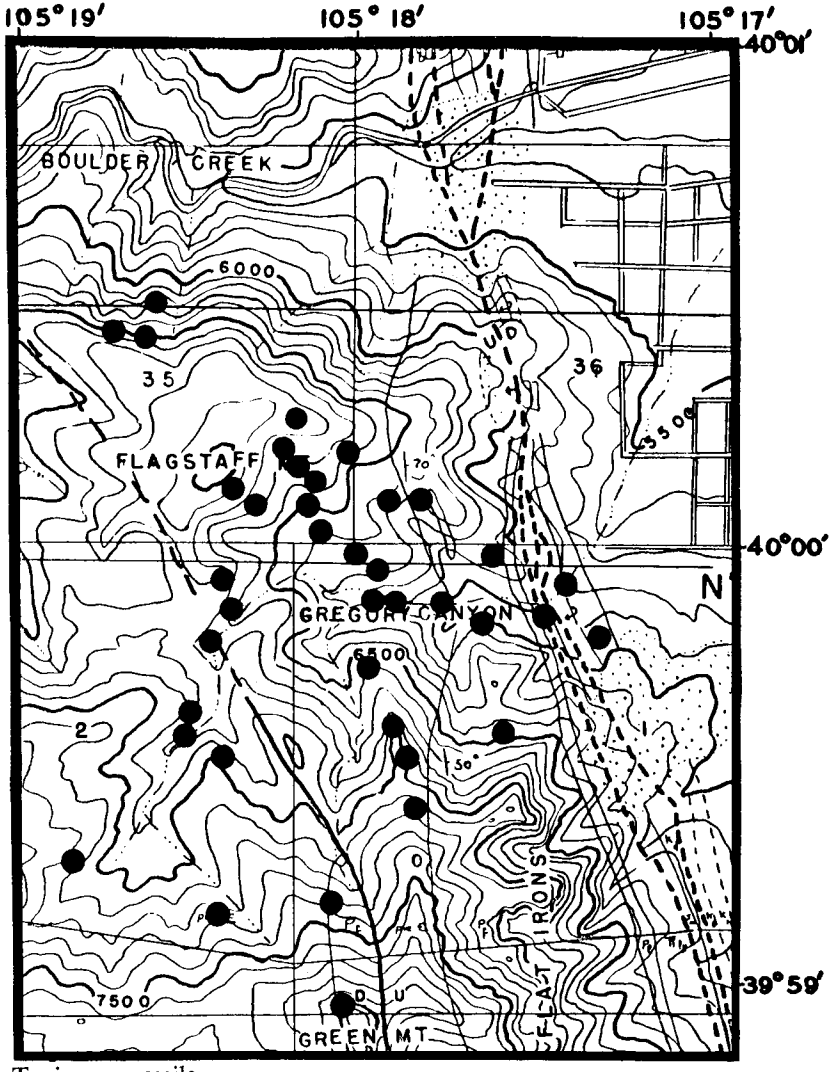
Liometopum apiculatum



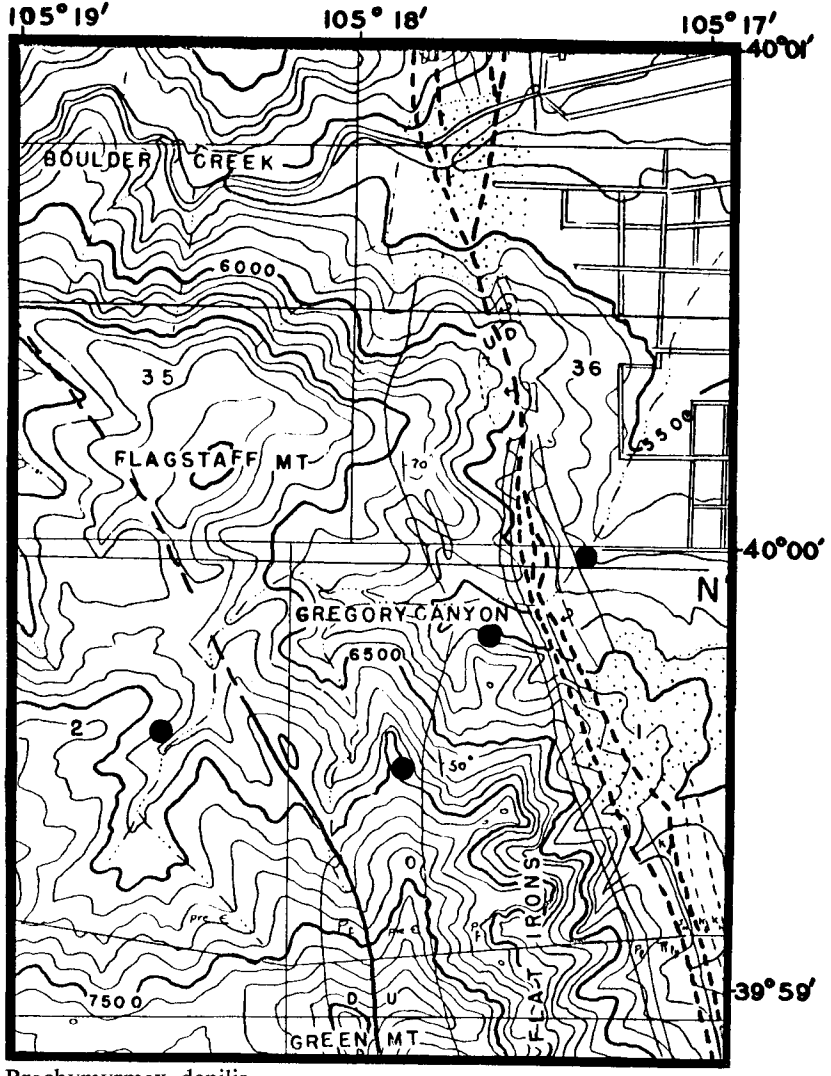
Liometopum occidentale luctuosum



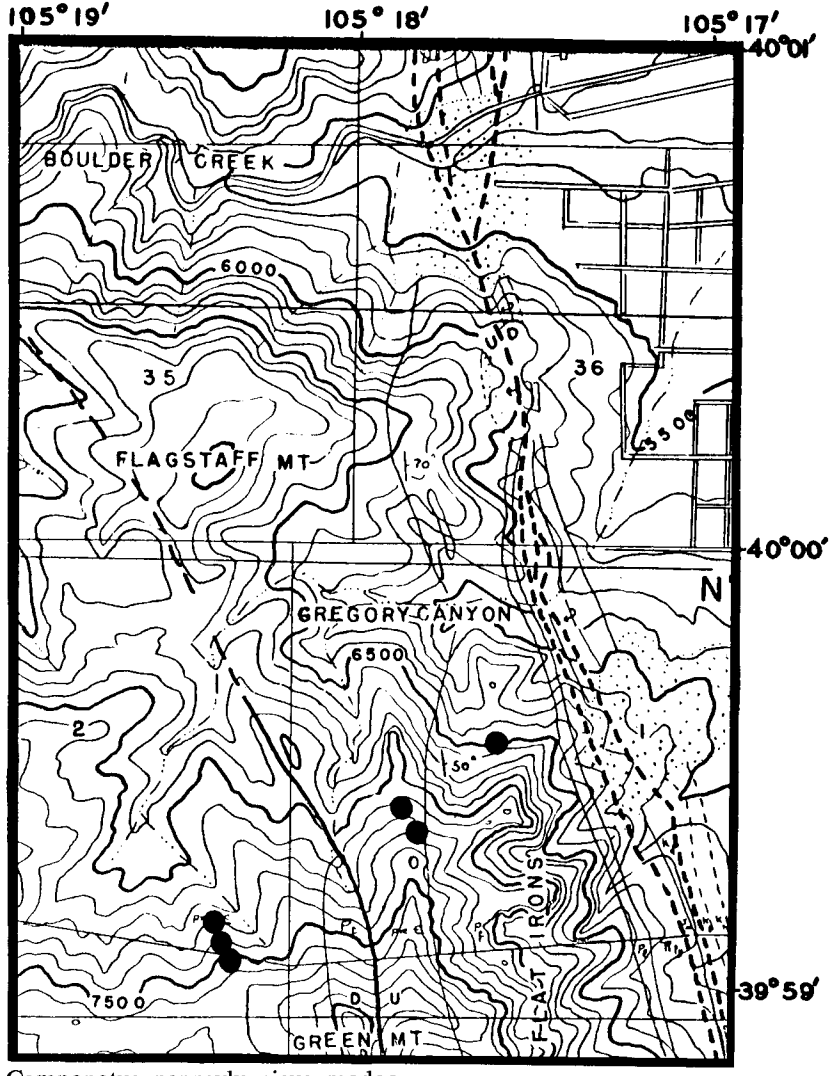
Iridomyrmex pruinosus analis



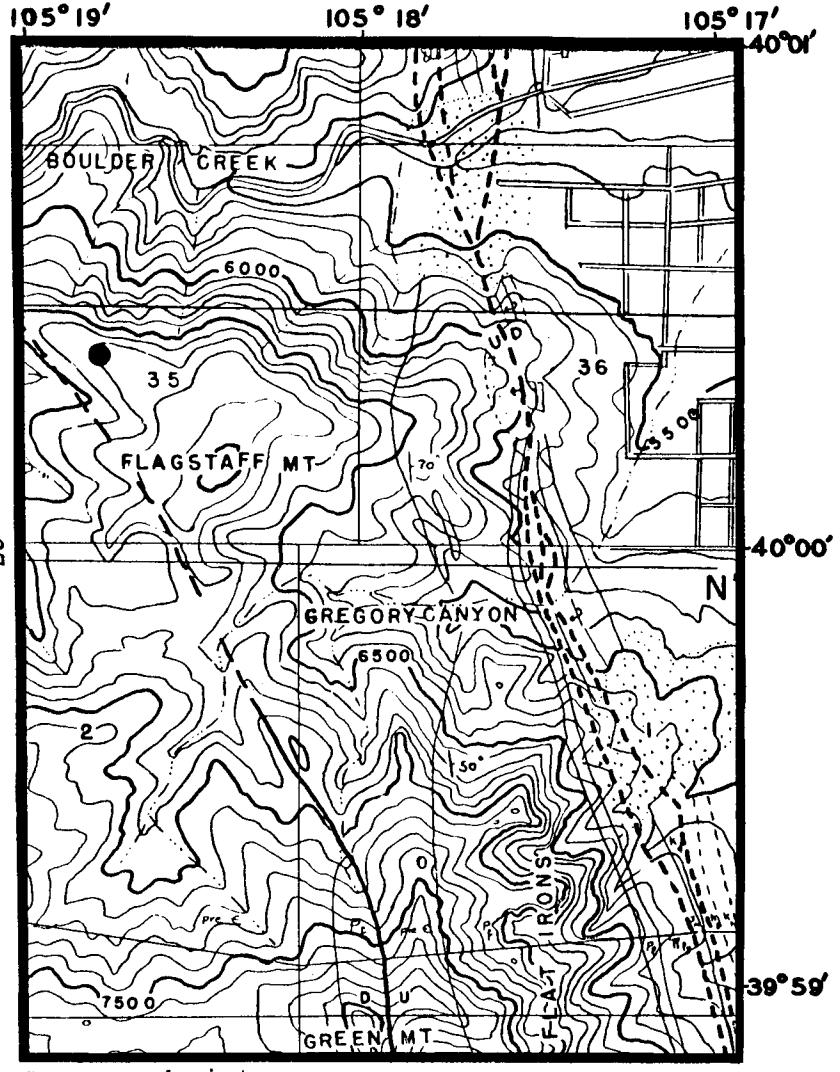
Tapinoma sessile



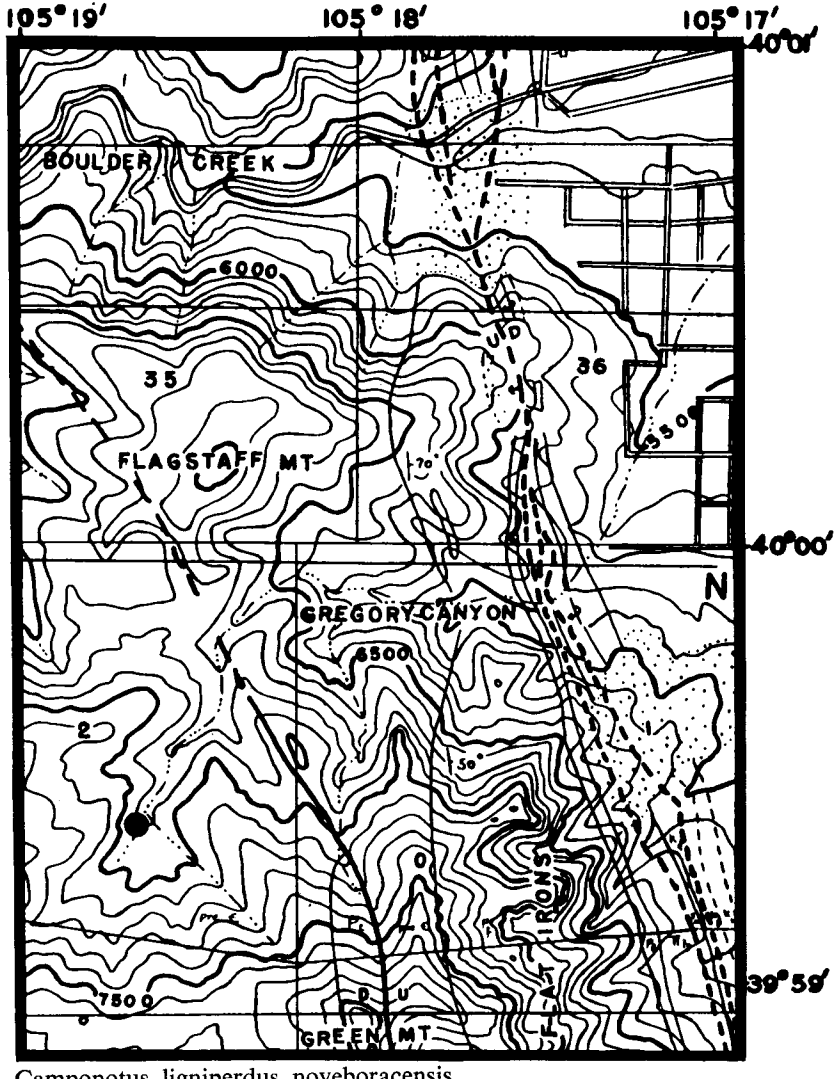
Brachymyrmex depilis



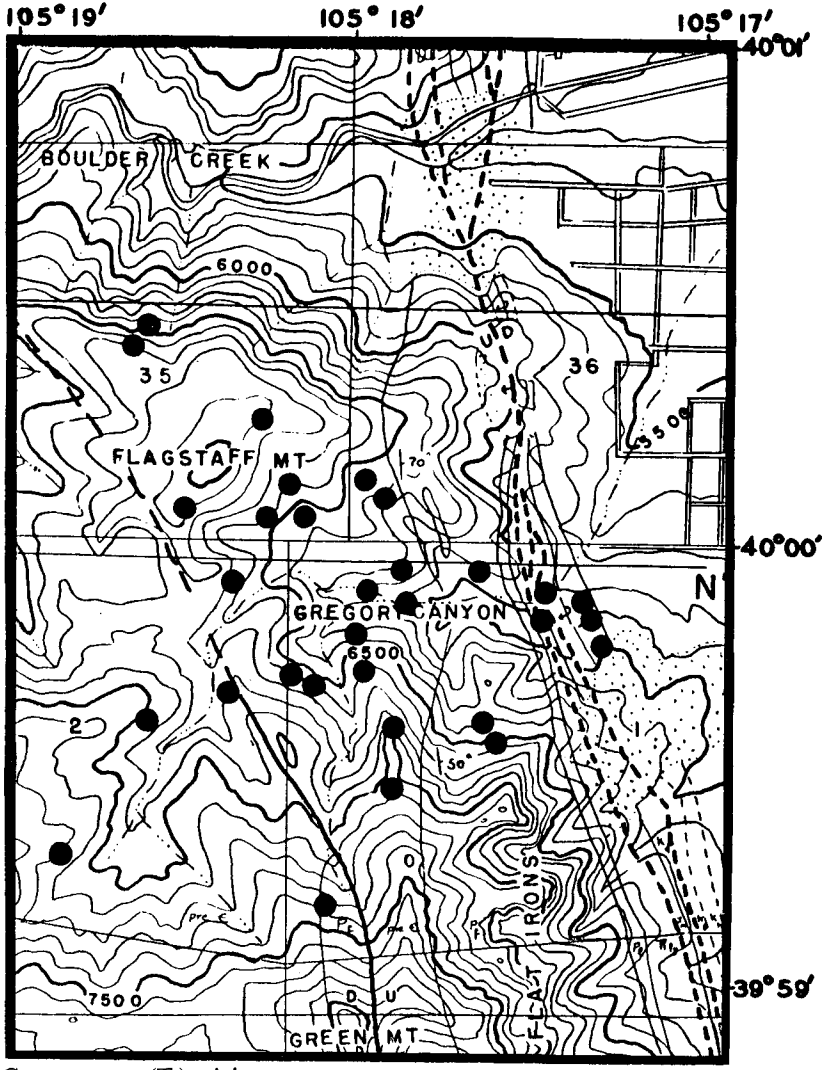
Camponotus pennsylvanicus modoc



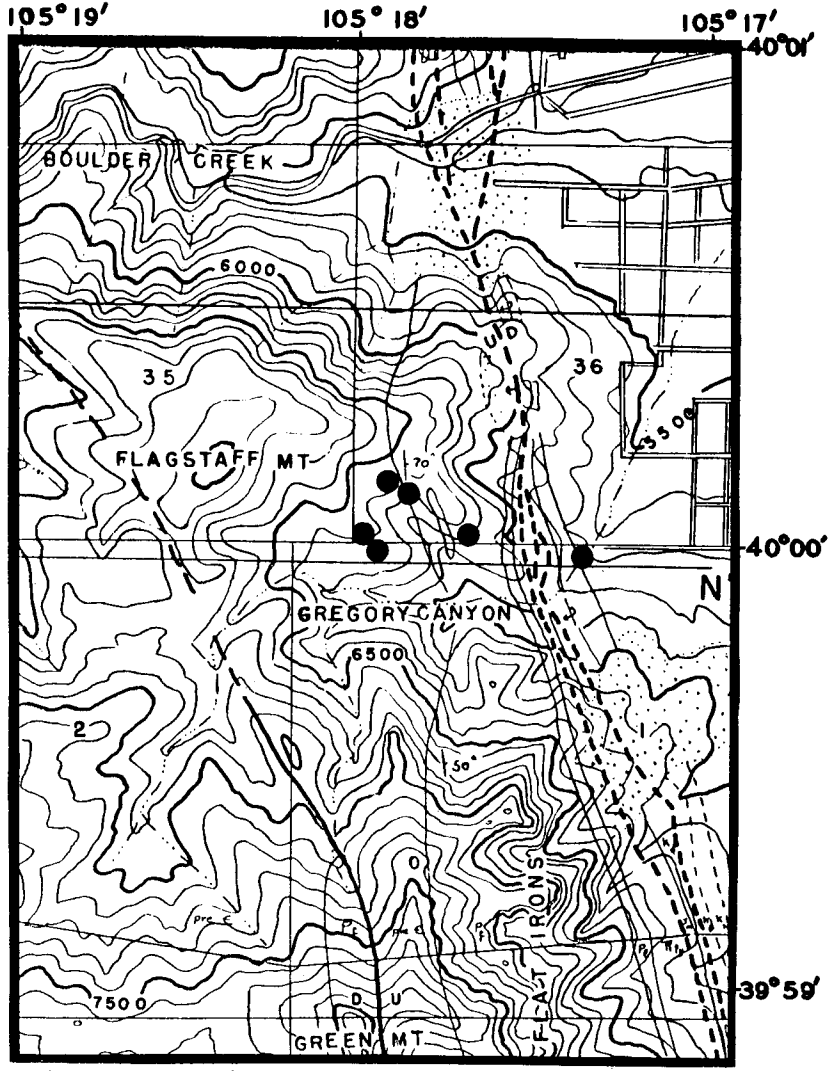
Camponotus laevigatus



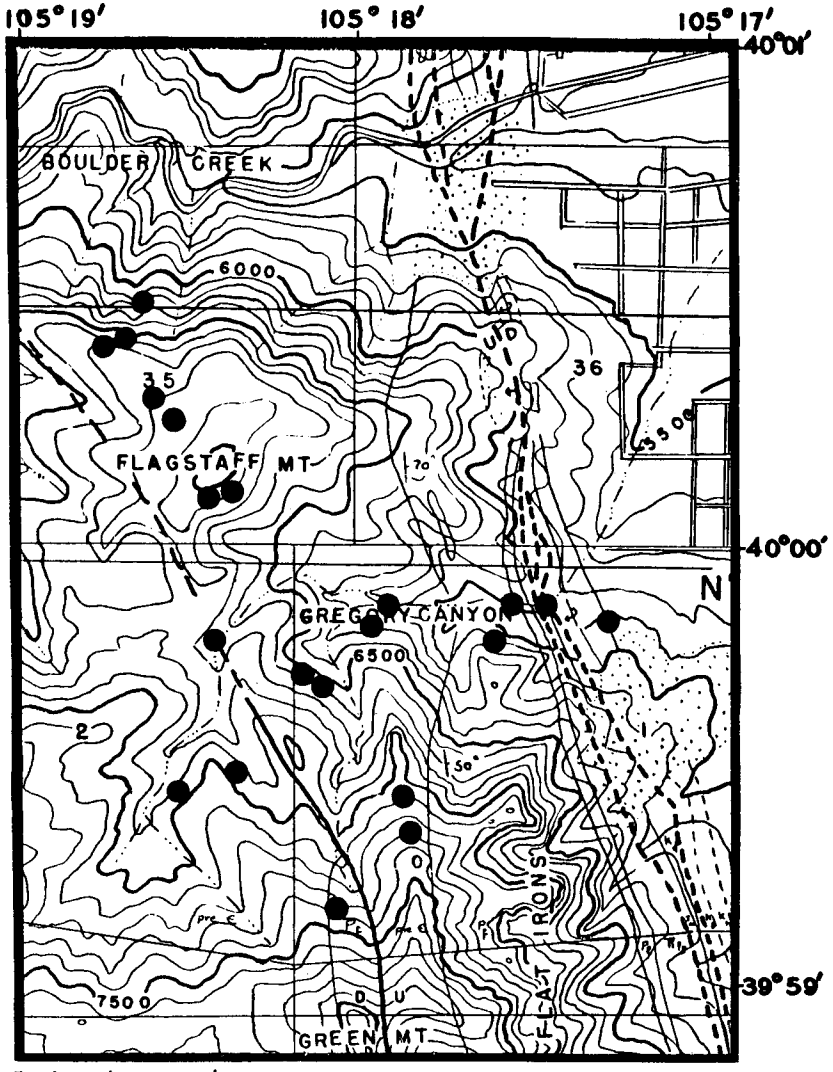
Camponotus ligniperdus noveboracensis



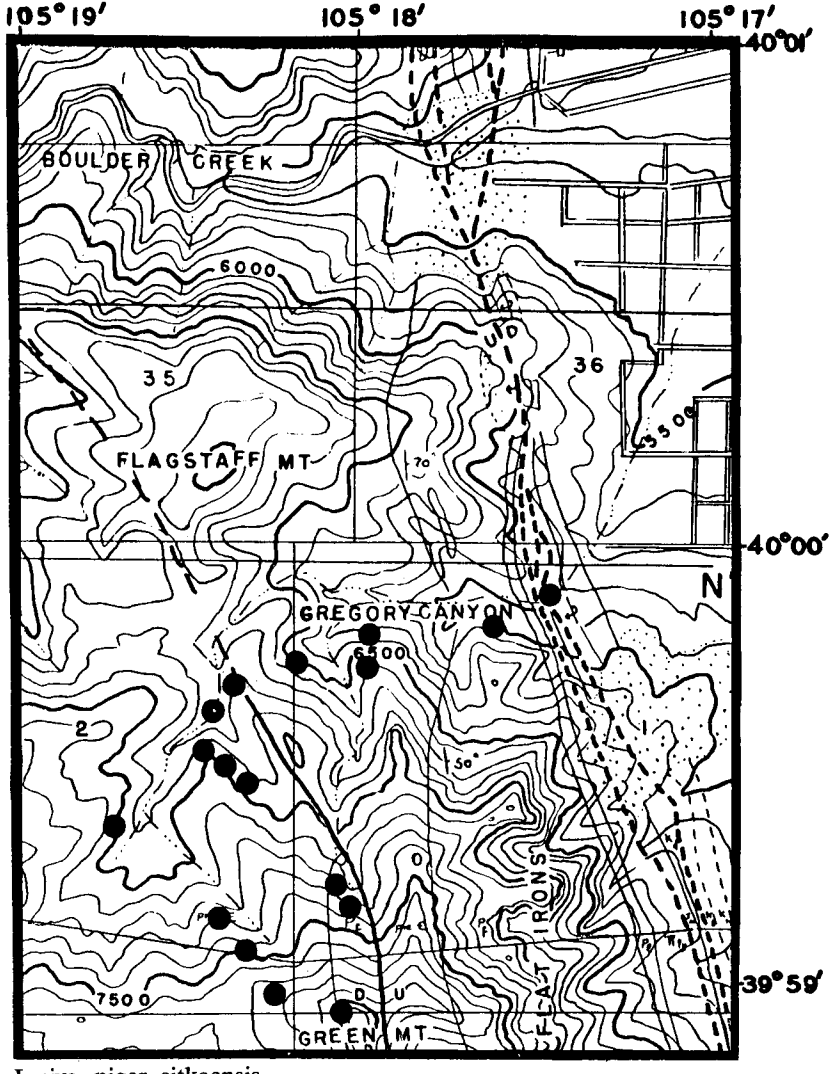
Camponotus (T.) vicinus



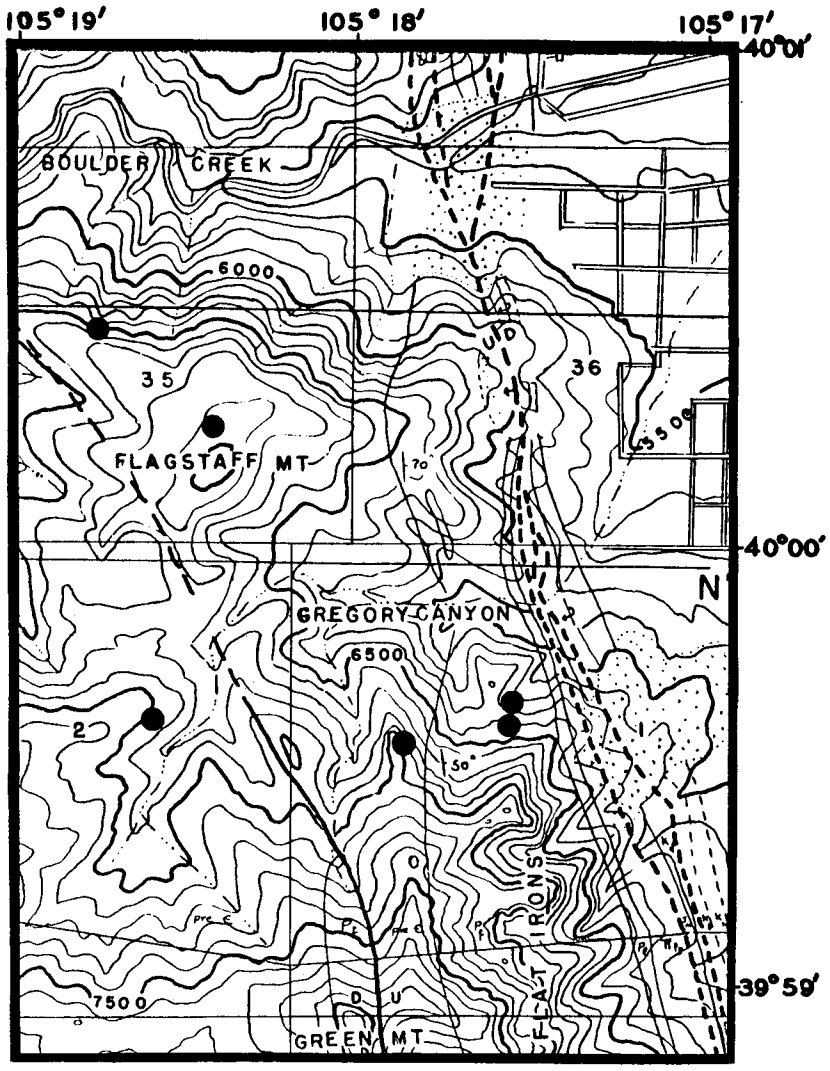
Lasius alienus americanus



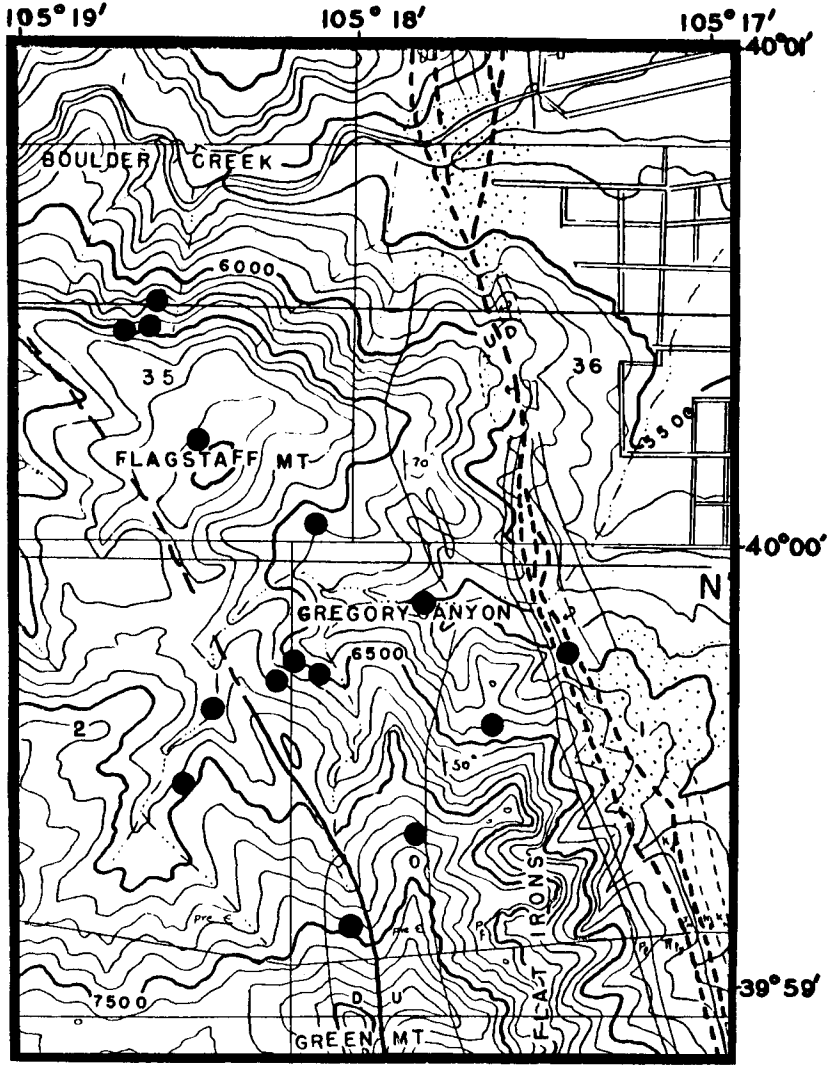
Lasius niger neoniger



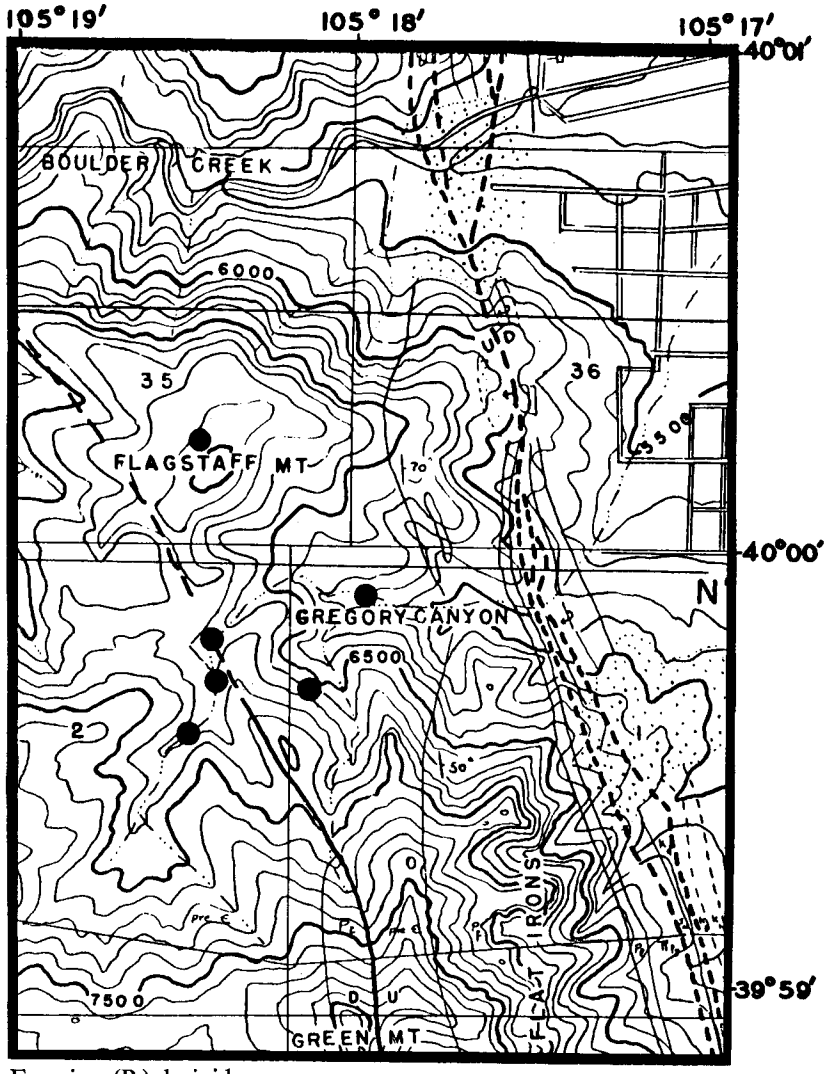
Lasius niger sitkaensis



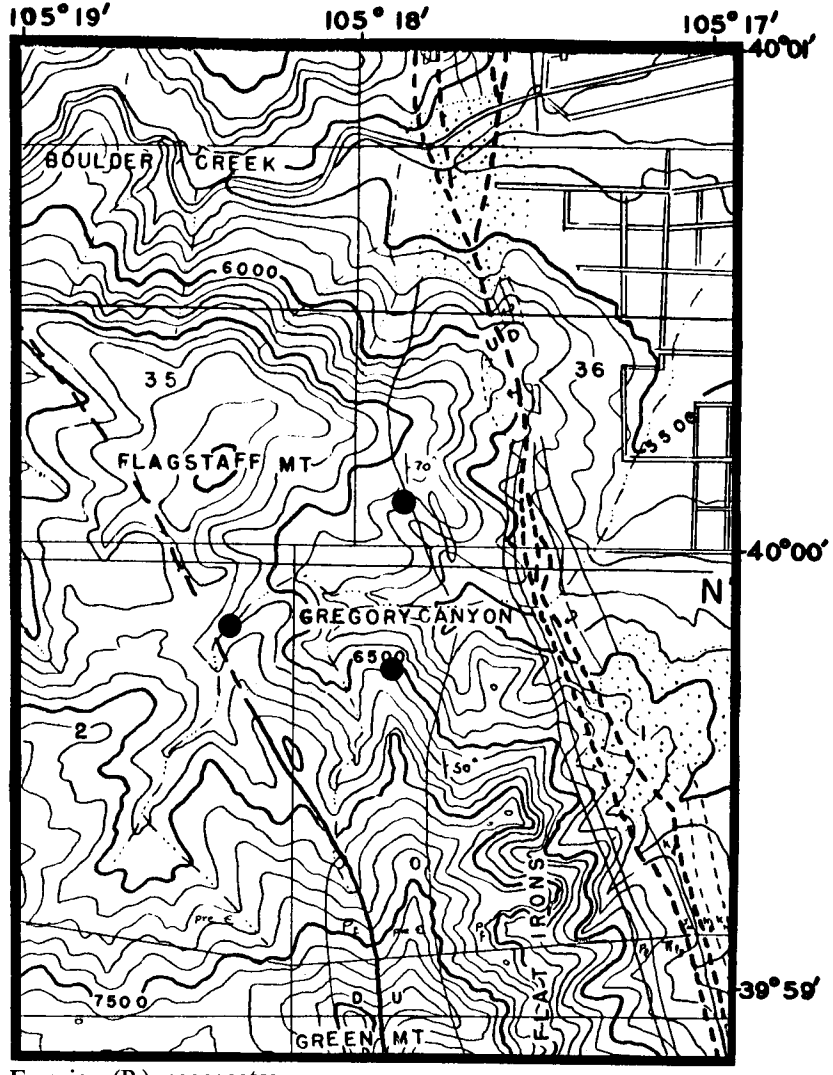
Lasius (C.) brevicornis microps



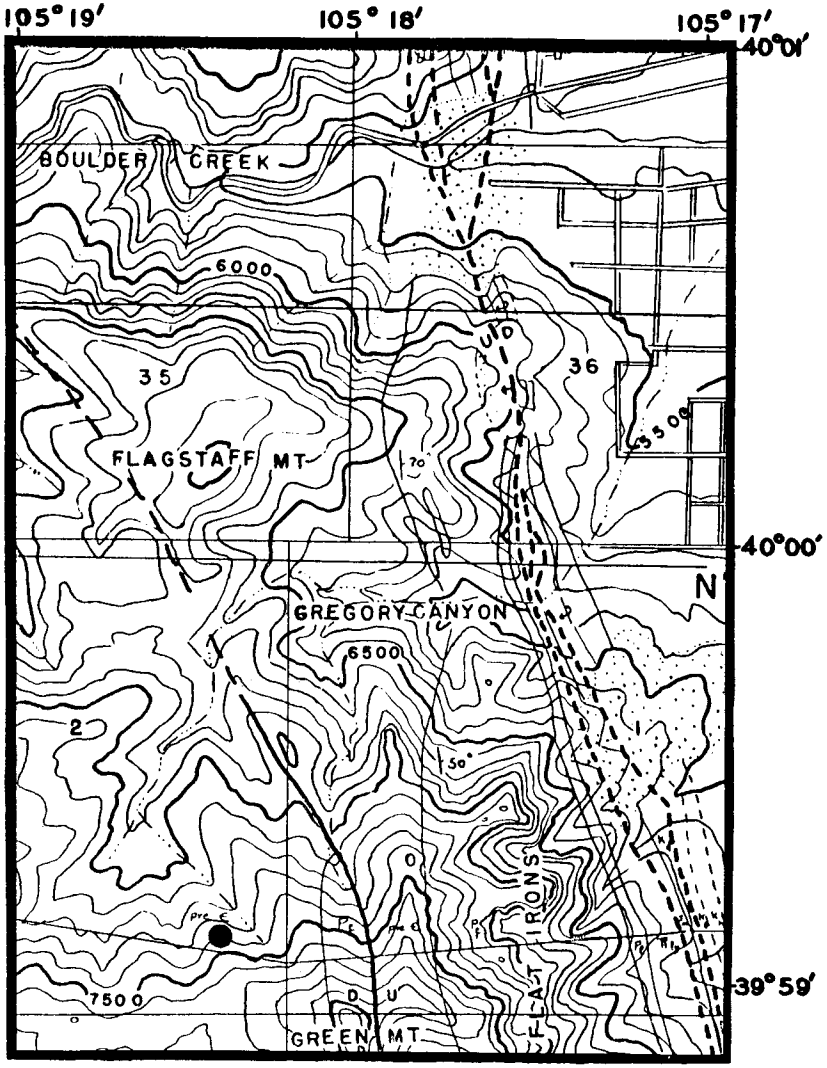
Lasius (C.) subumbratus



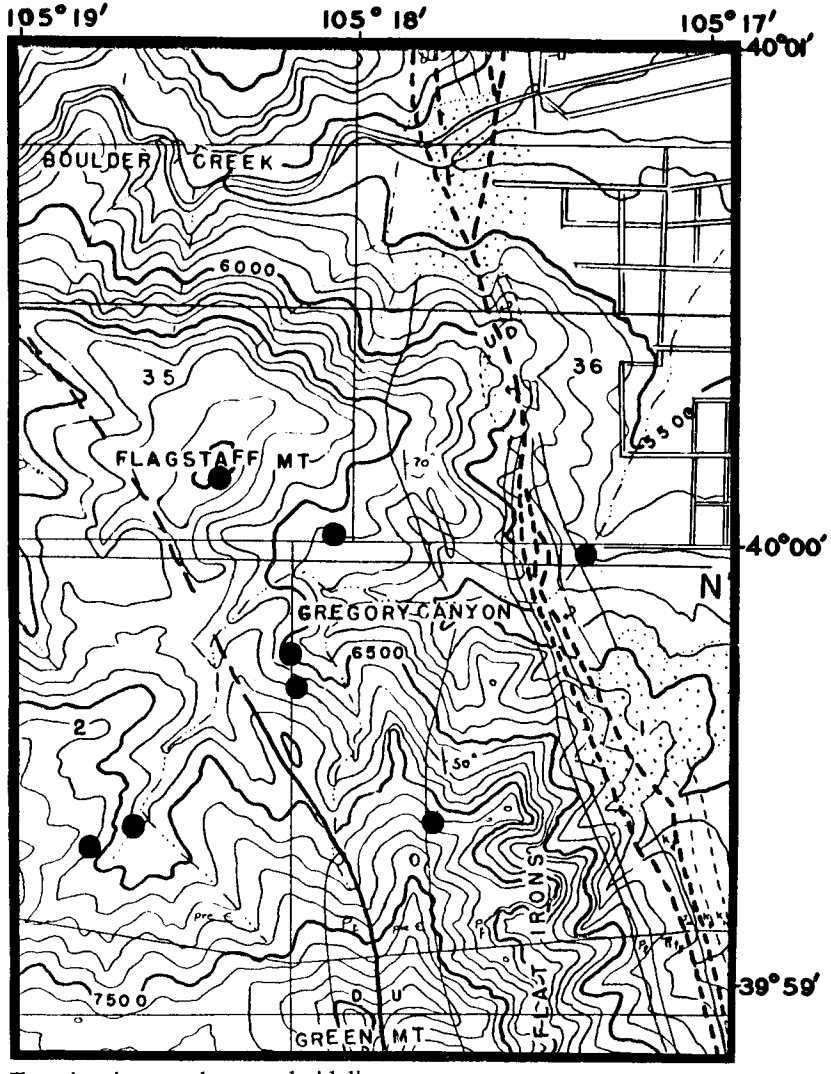
Formica (P.) lasioides



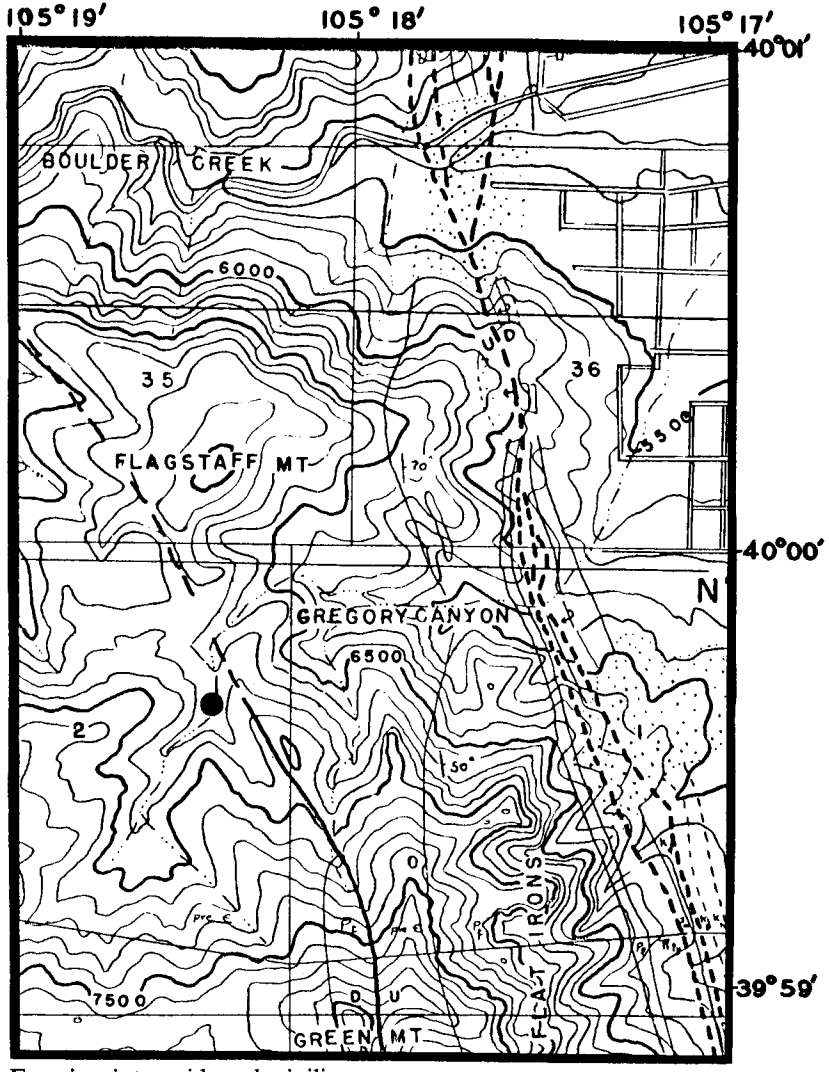
Formica (P.) neogagates



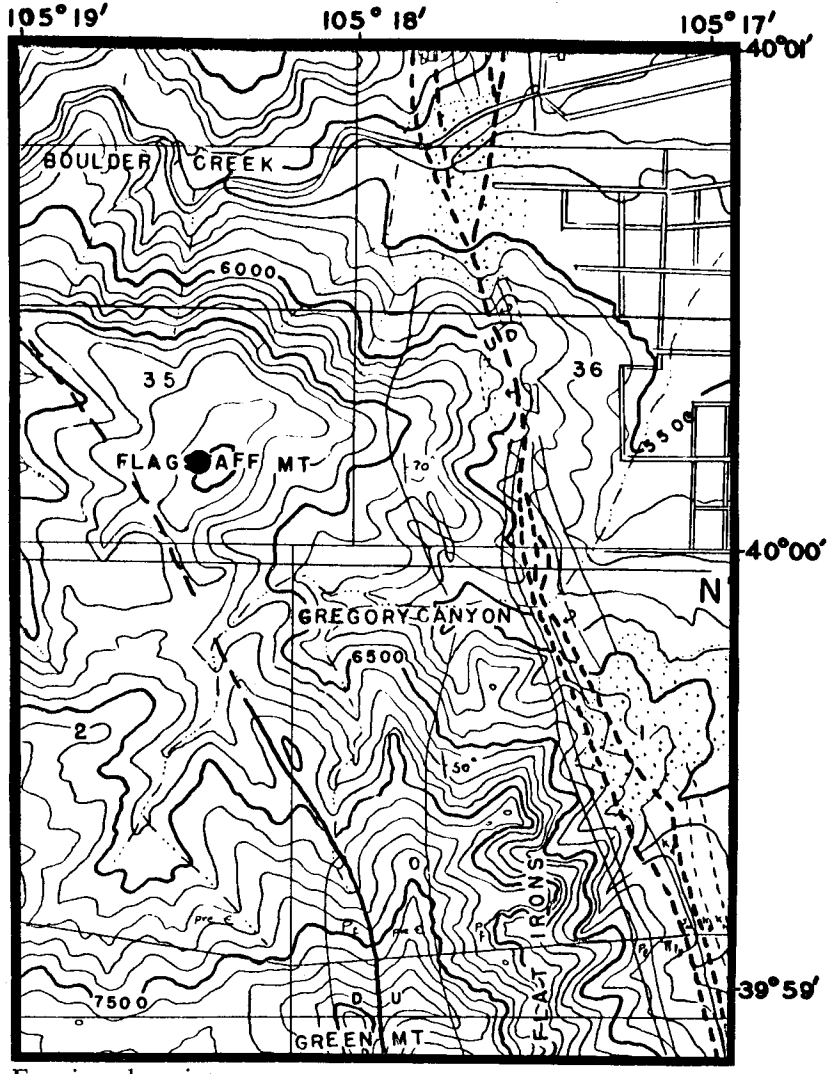
Formica (R.) sanguinea subnuda



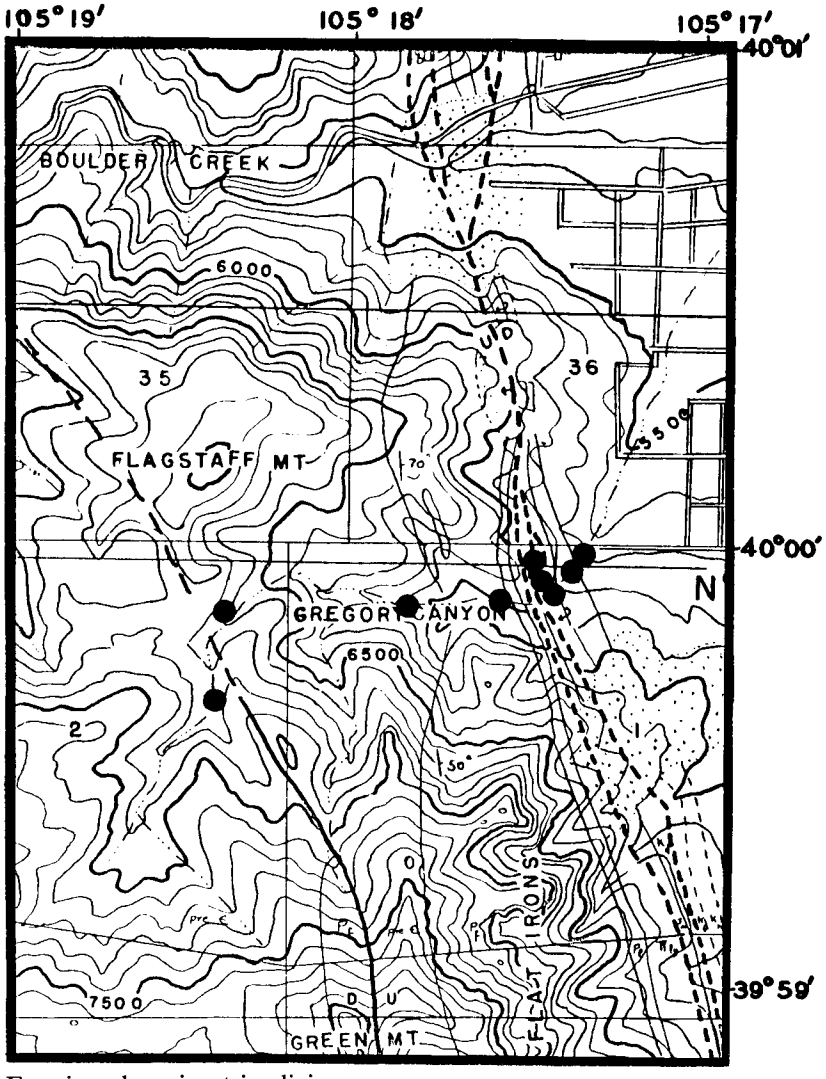
Formica integra haemorrhoidalis



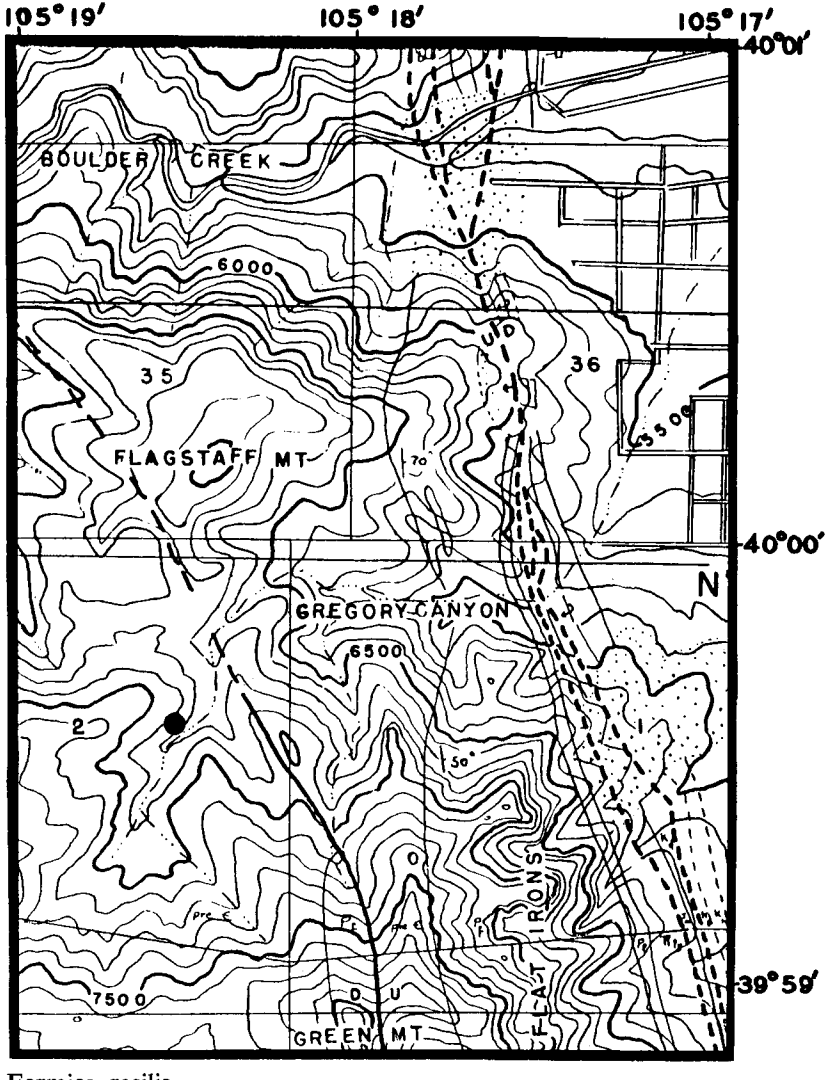
Formica integroides planipilis



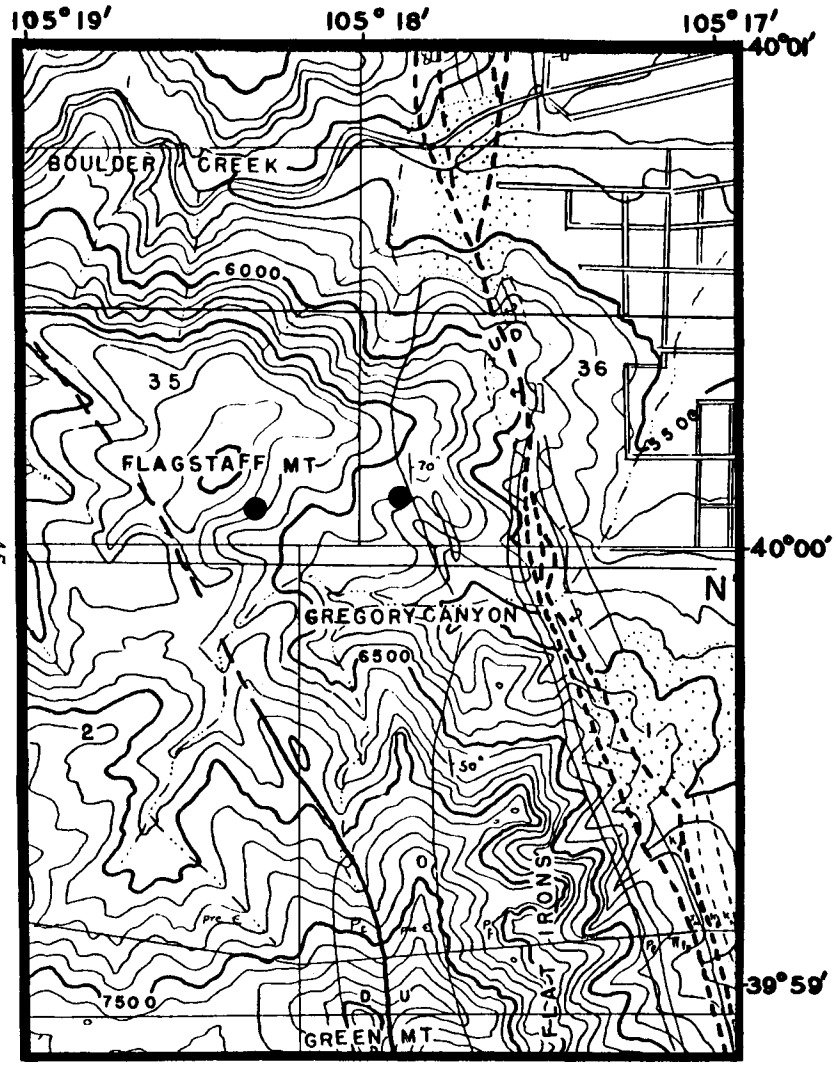
Formica obscuripes



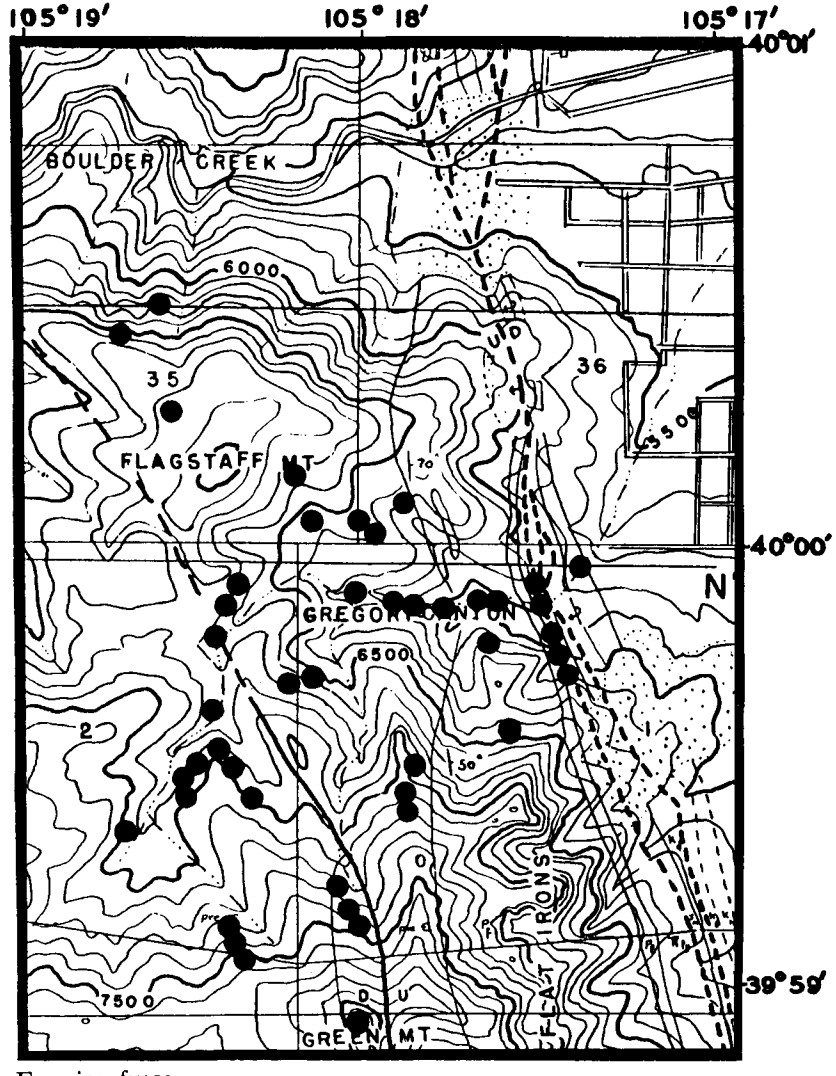
Formica obscuriventris clivia



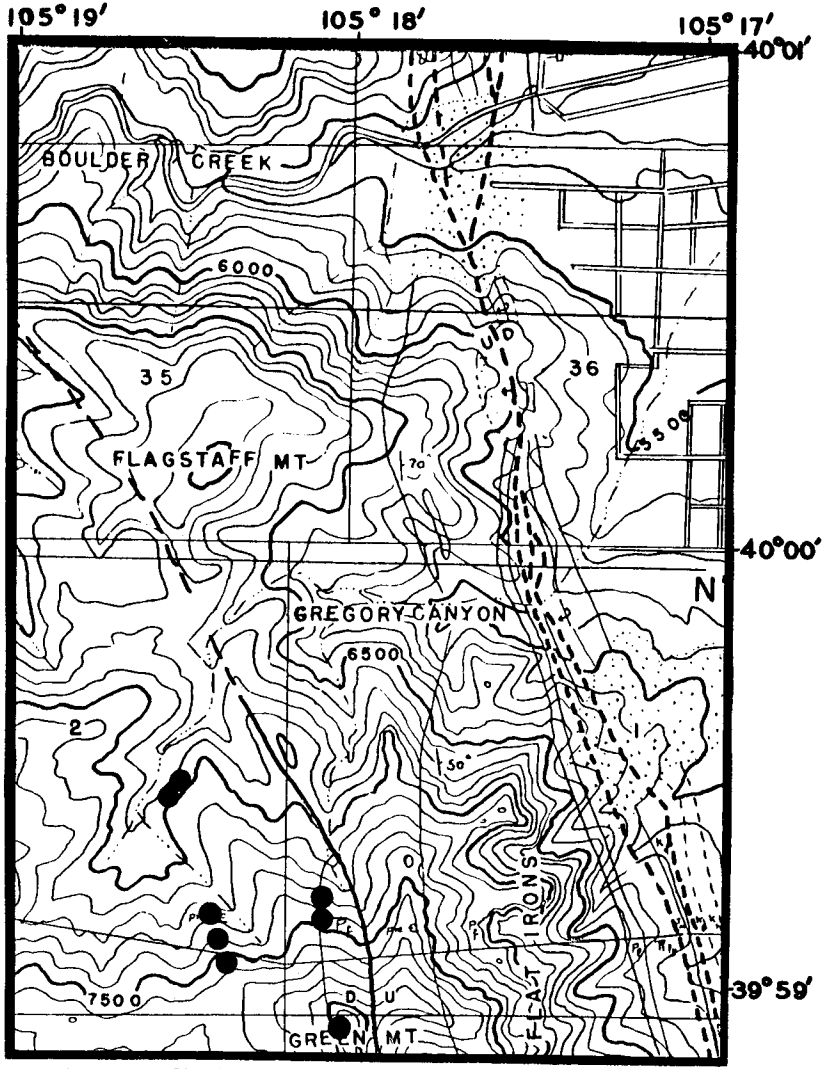
Formica rasilis



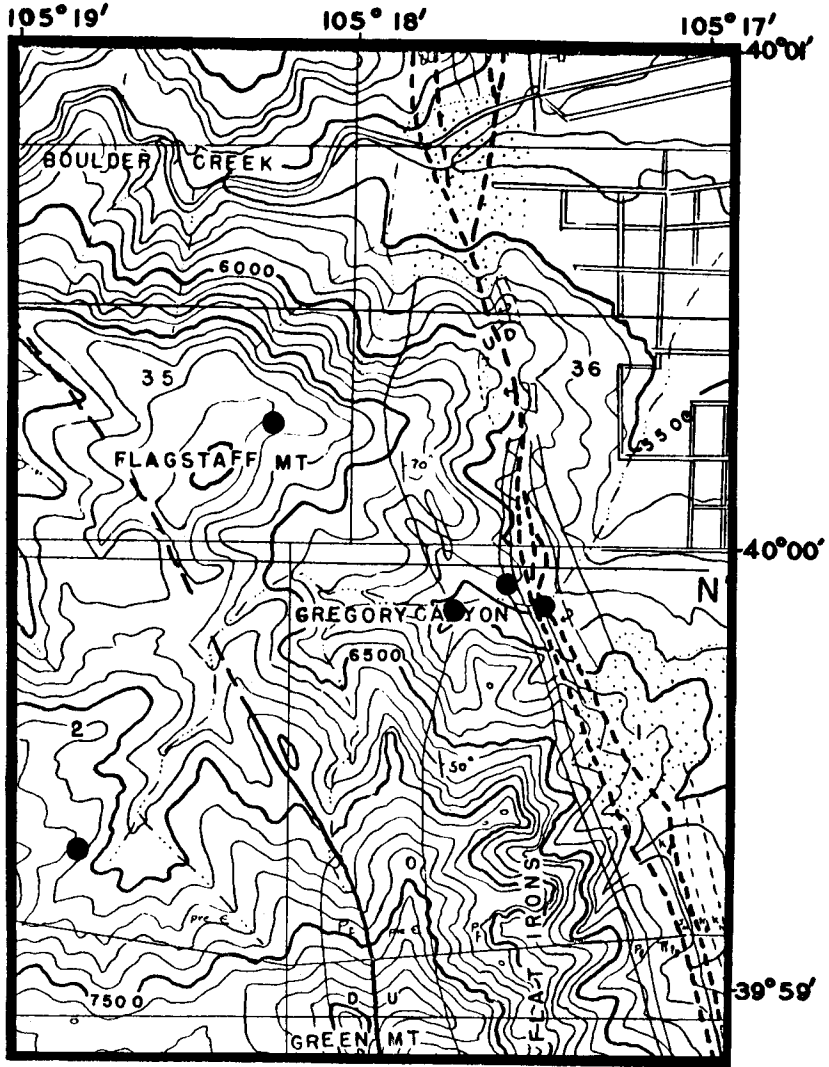
Formica rasilis densiventris



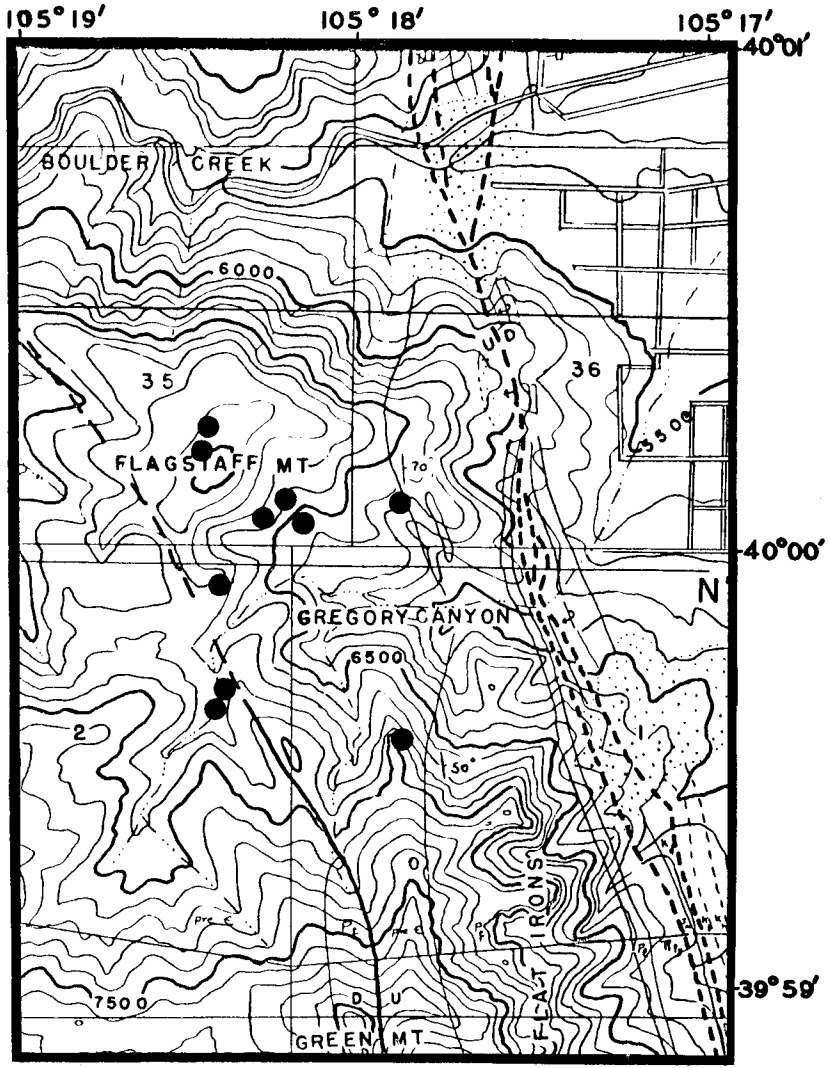
Formica fusca



Formica neorufibarbis



Formica (N.) pallidefulva



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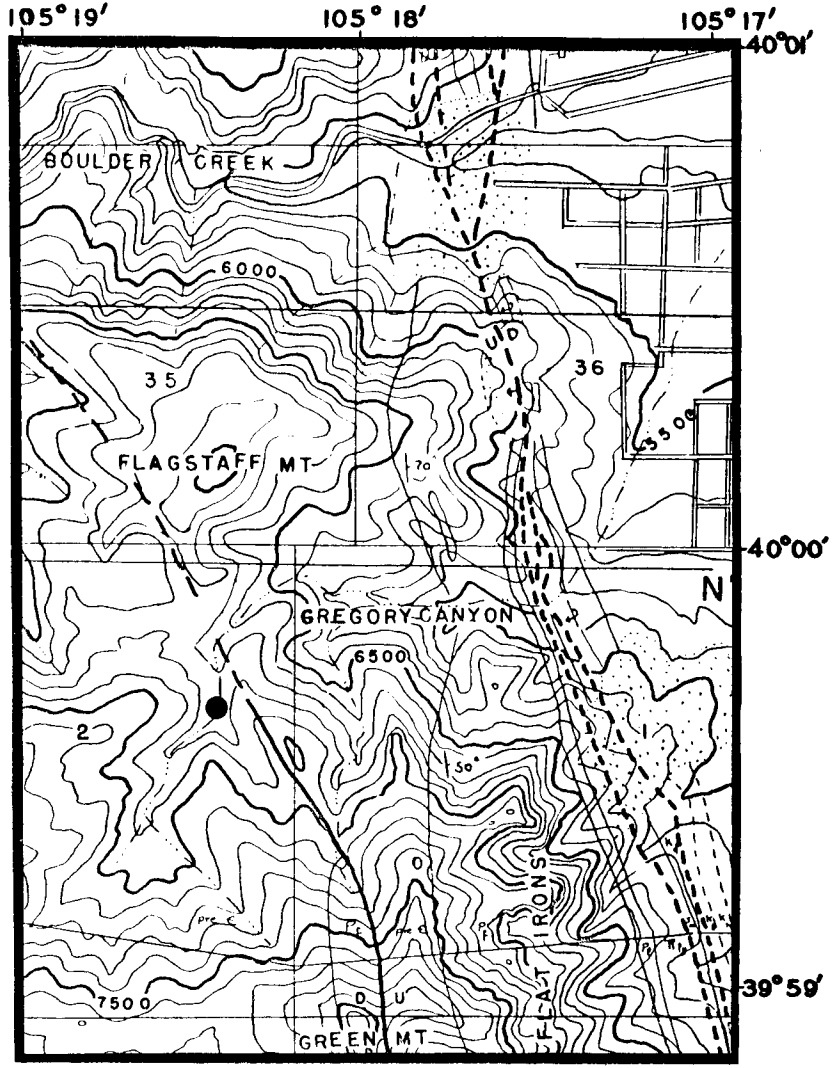
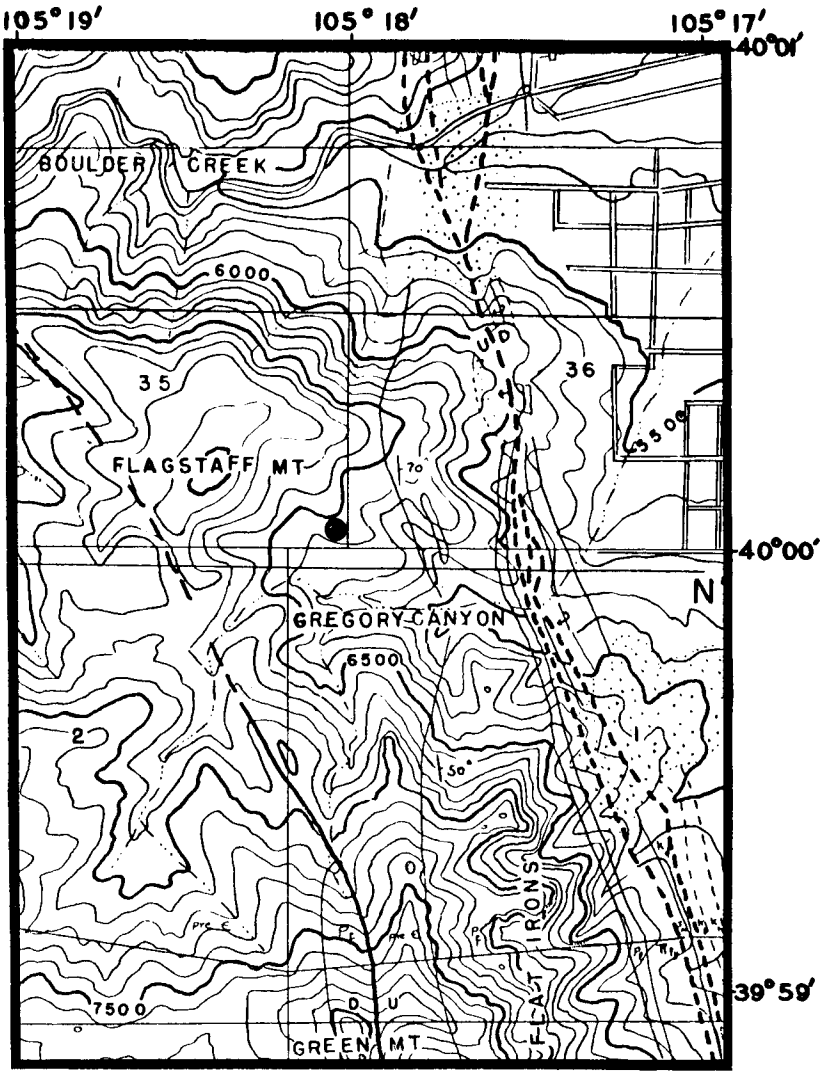


Polyergus lucidus



Polyergus rufescens breviceps

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