

**PARASITISM AND PREDATION IMPACTS ON SENSITIVE
NEOTROPICAL MIGRATORY SONGBIRDS IN PONDEROSA PINE
FORESTS OF COLORADO**

1998 Progress Report

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Summary

Nesting success was evaluated for forest and montane shrub/deciduous passerine species, and Brown-headed Cowbird (*Molothrus ater*) habitat selection and movement were documented at five study sites in the ponderosa pine foothills directly west of Boulder, Colorado. In forested sites, parasitism was focused primarily upon the Plumbeous Vireo (*Vireo plumbeus*) (50%, n = 32), and predation upon the Plumbeous Vireo (33%, n = 32) and Chipping Sparrow (*Spizella passerina*) (40%, n = 15) and to a lesser extent other species, but Western Wood-pewees (*Contopus sordidulus*) were not found to be parasitized and sustained lower predation rates (19%). In the two deciduous riparian drainages which transected our sites, predation was focused upon Black-headed Grosbeaks (*Pheucticus melanocephalus*) (42%); Warbling Vireos (*Vireo gilvus*), Virginia's Warblers (*Vermivora virginiae*), and MacGillivray's Warblers Warbler (*Oporornis tolmiei*) were parasitized at 63%, 100%, and 100% respectively (although sample sizes were low for Macgillivray's and Virginia's Warbler). Preliminary data indicate sensitive and declining species had higher rates of parasitism and depredation than other nesting species and depredation and parasitism rates were not equal across study sites. Point counts revealed that Brown-headed Cowbirds appear to be most abundant in the montane canyons and ponderosa pine forests when they are nest searching. In the afternoon when cowbirds are most often foraging they are found in the residential areas, taking advantage of foraging opportunities at bird feeders and short grass yards. In the evenings cowbirds move back to higher elevations and out to the grasslands. Similar studies have been conducted by other workers, but were set in an agricultural or rural context or related parasitism and predation patterns to various forestry regimes. Our study is one of the few to attempt to elucidate these patterns within the urbanized context of the Front Range of Colorado.

Cowbird Habitat Selection and Movement Landscape Effects and Nesting Success

Background

Foothills ponderosa pine (*Pinus ponderosa*) is fairly common along the eastern slope of the Colorado Front Range, extending north from near Canon City to 150 km south of the Wyoming border (Little 1971, Veblen and Lorenz 1991), and it is one of the most common forest habitats in the western U.S. (Steele 1988, Daubenmire 1978, Oliver and Ryker 1990). Despite the fact that this habitat is widespread, many of the bird species that breed in the ponderosa pine forests are considered sensitive across their southwestern range, including several species that breed along the Colorado Front Range. In Arizona and New Mexico, the Plumbeous Vireo (*Vireo plumbeus*) and Virginia's Warbler (*Vermivora virginiae*) are designated as high priority species in southwestern ponderosa pine forests, and they are species of special concern in Arizona (Hall et al. 1997). In addition, New Mexico lists the Hammond's Flycatcher (*Empidonax hammondii*), Dusky Flycatcher (*E. oberholseri*), Cordilleran Flycatcher (*E. occidentalis*), Broad-tailed Hummingbird (*Selasphorus platycercus*), Townsend's Solitaire (*Myadestes townsendii*), and Warbling Vireo (*Vireo gilvus*) as species of special concern (Hall et al. 1997). New Mexico and Arizona breeding bird survey (BBS) data taken from 1968 to 1990 on managed ponderosa pine forests indicate the following species were undergoing population declines: Mourning Dove (*Zenaida macroura*), Western Wood-pewee (*Contopus sordidulus*), Chipping Sparrow (*Spizella passerina*), and the Black-headed Grosbeak (*Pheucticus melanocephalus*) (Miller 1992), although BBS data indicate a large increase for the Black-headed Grosbeak in Colorado (Levad 1998). In Colorado the Plumbeous Vireo and Virginia's Warbler are of species of concern, as well as the MacGillivray's Warbler (*Oporornis tolmiei*) (Winternitz and Crumpacker 1985). Most recently, the Western Working Group of the Partners-in-Flight program listed the MacGillivray's Warbler, Virginia's Warbler, and Green-tailed Towhee (*Pipilo chlorurus*) as Priority Species in Colorado (Rich and Breadmore 1997). In addition, MacGillivray's Warblers are reported to need careful monitoring because of severe declines reported by BBS data (Carter 1998). Because more species in southwestern ponderosa pine forests are declining rather than increasing (Miller 1992), it has been recently argued by Block et al. (1997) that "Greater effort should be devoted to monitoring bird populations exhibiting these perceived declines. This more intensive monitoring should not be restricted to measures of absolute or relative abundance, but should also include estimates of other population parameters such as survival, reproduction, or turnover rates."

Miller (1992), using BBS data (1968-1990), found that the proportion of bird species declining in ponderosa pine forests in Colorado and Utah were highest among open cup nesters (56%) and migratory birds (81%). These birds are susceptible to population declines because open nests are more likely to be preyed upon or parasitized by cowbirds than cavity nesters (Askins et al. 1990). Migratory birds also have fewer opportunities to breed than residents and have other threats facing them on the wintering grounds: pesticides (Gard and Hooper 1995), habitat loss (Myers 1991), and a lack of a conservation plan by many Neotropical countries (Petit et al. 1995).

Canopy openings can increase the frequency of nest predation and cowbird parasitism on nesting birds (Patton 1994, Chace et al., *in press*). Many nest predators and cowbirds are edge specialists, typically occurring in the highest abundance on the interface of open grassland or disturbed habitat and the forest edge (Gates and Gysel 1978). Fragmentation of the forests increases the amount of edge, while reducing the interior forest area, an area which typically has significantly lower rates of predation and parasitism. The increase in predation and parasitism along edges, (the edge-effect), has been well documented in eastern and midwestern forests (see Faaborg et al. 1995). However, as the recent symposium on the Ecology and Management of the Brown-headed Cowbird in the West addressed, the same rules may not apply to western landscapes where the forests are less continuous than historic forests of the East. What is known, however, is that cowbirds take advantage of canopy openings in ponderosa pine forests, created naturally or by roads, and parasitize Plumbeous Vireo nests closer to those openings than nests farther away (Chace 1995, Chace et al. *in press*). Nest predators increase in abundance in pine forests with or near residential development and subsequently nest predation is significantly higher in these developed forests than in undisturbed ponderosa forests (Craig 1997). Increases in residential development creates canopy openings in the ponderosa pine forest. Residential development also entails the building of roads that also reduce canopy continuity and increases road kill (Marzluff 1997). Road kill, bird feeding, in addition to accessible human garbage and pet food, can provide supplemental food resources to nest predators, e.g., Stellar's Jays (*Cyanocitta stellari*), and feeders can provide food for cowbirds as well (Marzluff 1997). Not only does this type of development reduce the canopy cover, but brings the nest predators and nest parasites closer to breeding birds. In this study we evaluated nesting success at a unique montane/urban interface of the City of Boulder, a growing city with a population of over 90,000 and significant open space acreage. The city growth is contained such that the foothill ponderosa pine forest on the western border of the city has been designated as open space. While many studies have evaluated predation and parasitism in an agricultural setting (see Paton 1994), a rural/agricultural versus forested setting (Tewksberry et al. 1998) or have compared nesting success in forests of varying logging regimes (Fenske-Crawford

and Niemi 1997, Rudnicky and Hunter 1993) our study is one of the few studies conducted in an urban context (but see Soule et al. 1988, Engels and Sexton 1994)

Methods

Study Sites - Nest searching was conducted on 5 sites on Boulder County Open Space and City of Boulder Open Space. Shanahan Ridge (SHRI): Ponderosa pine stand southwest of Boulder on gently rising foothills, understory of mixed grass with rock outcrops. It is bordered on the east by suburban development and a city operated cattle pasture. A single riparian drainage covered with montane scrub transects the site. Several hiking trails transect the site as well. Chautauqua Park (CHTQ): Foothill ponderosa pine-Douglas fir forest transected by a single riparian drainage covered with montane scrub. Due to its proximity to the Flatirons rock formations and downtown Boulder (<5 km), this site received the highest amount of hiking traffic of all of our study sites. The forest is buffered on the east from suburban development by a mixed grass stand. Gregory Canyon (GRCA)/ Long Canyon (LOCA): montane ravines which extend from Chataqua Park to higher elevations, covered with montane scrub and deciduous trees. Walker Ranch (WARA): Montane (elevation 7500 ft) scattered ponderosa pine with understory of mixed grass and shrubs such as kinnikinnik (*Arctostaphylos uva-ursi*), interspersed with large, open mixed grass patches covered with mixed grass. (see attached maps).

Nesting Success - Nests were found through observations of nesting behavior (Ralph et al. 1993). Once found, nests were marked by a small blue flag > 10 m from the nest. The nests were monitored at least once every three days from the day it was found until the nest was inactive. Nest contents were observed directly or with a 6 m mirror pole. Efforts were made to not attract nest predators to the nest site (Picozzi 1975, Westmoreland and Best 1985, Major 1989). Following nest inactivity, vegetative parameters were measured following James and Shugart (1970), and as modified for the standardized protocol developed by Martin and Ropper (1988). In addition, we measured distances from the nest to human impacts: trails, roads, homes, canopy openings, power line right-of-ways, and livestock.

Cowbird Habitat Selection and Movement - We established 160 50m point counts to census cowbirds across the foothills and valley of Boulder County. Eighty-four point counts were established in the foothills: 58 in ponderosa pine (20 > 6500 m, 38 < 6500 m elevation) and 26 in mountain riparian habitats. Eighty-six points were censused in suburban (30 points), rural and agricultural areas (31 points), and lowland riparian habitat (25 points). We attempted to census each point a total of nine times during the breeding season, three times during each of three time periods: morning (sunrise to 1000 h), afternoon (1200-1500 h), and evening (1700-2000 h). These times correspond with known cowbird activities: breeding during the morning and early afternoon, foraging in the afternoon and early evening prior to going to the roost at dusk (Gougen and Matthews 1997). All cowbirds detected within 150 m boundary were recorded during 10

minute censusing, and they are reported as a relative abundance index for each transect of points such that cowbird abundance can be compared between transects and times of day.

Results

1998 Nesting Success - In 1998, we monitored 102 nests of 15 migratory bird species on Boulder County Open Space. Of these, 29 nests of 5 sensitive species in the southwest were monitored: Hammond's Flycatcher (2 nests), Plumbeous Vireo (24), Warbling Vireo (1), MacGillivray's Warbler (1), Broad-tailed Hummingbird (1). In addition, 55 nests of three species considered declining in Arizona and New Mexico ponderosa pine forests were monitored: Chipping Sparrow (5), Black-headed Grosbeak (8), and the Western Wood-pewee (42). Our comprehensive searching efforts enabled us to track the reproductive success of most open cup nesting species present on our Boulder County ponderosa pine forest sites, although we were unable to collect data for all species. We monitored the breeding biology of six species which nested in two deciduous, riparian drainages which transected our study sites. Tables 1 and 2 provide data for the percentage of nests parasitized or depredated for five species sensitive in the southwest and three species considered declining in New Mexico and Arizona. Data for breeding species which are not currently designated as sensitive or declining are also given in these tables.

The 1997 and 1998 data indicate that among nesting passerines in forested sites, parasitism was focused primarily upon the Plumbeous Vireo (50% of nests). Other species nesting but not parasitized were: Hammond's Flycatcher and Western Wood-pewee (note that sample sizes are very low for Hammond's Flycatcher, (Table 3). One out of three (33%) Cedar Waxwing nests found was parasitized. Predation was focused upon the Plumbeous Vireo (35%). Other species either had lower rates of depredation or sample sizes were very low (Table 3). In the two deciduous, riparian drainages which transected our sites, predation was focused upon the Black-headed Grosbeak (42%), Warbling Vireo (36%), and the Virginia's Warbler (100%). MacGillivray's Warbler, Warbling Vireo, and Virginia's Warbler were parasitized at 100%, 36% and 100% respectively (Table 4)

Among the migrants, preliminary data indicate sensitive and declining species had higher rates of parasitism and depredation than other nesting species. For example, parasitism and depredation rates for the Virginia's Warbler, MacGillivray's Warbler, Black-headed Grosbeak and Warbling Vireo were (100, 0, 63, 100%) and (0, 39, 36, 100%) respectively, whereas Grey Catbird, Western Flycatcher and Spotted Towhee nests were not parasitized or predated (Table 4). In addition, for the Plumbeous Vireo a species of which we have larger sample sizes, the data indicate parasitism rates were not equal across sites. Parasitism for the Plumbeous Vireo was 94% at SHRI and 45% at CHTQ.

1997 breeding data showed consistent patterns with 1998 (Tables 3, 4). However, in 1997 we were able to monitor 10 Warbling Vireo nests. In 1997 and 1998, the Warbling Vireo nests we monitored sustained a 63% parasitism rate and 36% depredation rate.

Cowbird Habitat Selection and Movement- Cowbirds were most commonly detected in the morning when they are looking for nests to parasitize in the montane canyons and ponderosa pine forests (Table 7). Interestingly, cowbirds were more common on the lower elevation ponderosa pine transects (Shanahan Ridge and Mesa Trail) than higher elevation transects (Meyer's Gulch and Betasso Preserve). For the lowland areas, cowbirds were more common along the riparian zones than residential or grasslands (both with and without cattle) sites.

In the afternoon, when cowbirds are more likely to be foraging, they were most commonly found in residential areas of Boulder. In the evening, when cowbirds are most likely foraging and looking for roosting locations, they were detected most often in the montane canyons and grasslands. Cowbirds were also observed associating with cattle several miles north of Boulder just west of highway 93 at the base of the foothills.

Discussion

Parasitism and Predation on Nesting Forest and Montane Shrub Species- Parasitism and depredation was focused heavily upon the Plumbeous Vireo in forested habitats. Plumbeous Vireos have a history of being parasitized in Boulder County (Table 5). The average parasitism rate for this species during 1984-1986, 1992-1994, 1997, and 1998 was 51.5%. This long term reproductive study has helped to support the idea that the Boulder population of vireos would soon vanish without immigration from more productive areas (Chace 1995). Behavioral observations conducted during 1998 uncovered some factors which may render this species vulnerable to brood parasitism. Vireos tended to forage at various distances away from their nest (at times > 50m) leaving the nest unattended and hence easier to parasitize. Demarco et al. (*in press*) report in their New Mexico study that the average time nests were attended or adults were within 5 m of their nest during the egg-laying stage was: 44.7 minutes per 60 minutes of observation and 58.7 minutes per 60 minutes of observation during incubation. In addition, we have observed that vireos may be more conspicuous nest builders than species which were not parasitized in Boulder County such as the Western Wood-pewee. This is relevant because cowbirds may key in on the location of a potential host nest by observing nest building behavior (Wiley 1988, Norman and Robertson 1975, Demarco et al. *in review*). Landscape factors are also important. Our past and ongoing research is revealing that vireo nests located near canopy openings, roads, residential areas and other edges suffer higher rates of predation and parasitism (Chace 1995)

Western Wood-pewees were not parasitized and sustained a low rate of predation. This is interesting considering the relatively uncryptic nest placement (a whitish, uncamouflaged nest, placed on top of a usually sparsely foliated ponderosa pine branch) and high nesting density of this species in Boulder. One explanation for the low predation and parasitism witnessed in this species may derive from its clumped nesting behavior. Western-Wood pewees may utilize a small fraction of the available breeding habitat by clumping their nesting territories together which results in a colonial style nesting pattern. Nest guarding and vigilance may benefit as adjacent breeding pairs cooperate in nest defense. In addition, foraging patterns that allow nesting pairs to stay vigilant and in close proximity to their nest may facilitate efficient nest defense. However, cowbirds have been observed as close as 2 m from pewee nests at various stages of incubation (Walsh 1999).

In riparian habitats, predation was focused upon the Black-headed Grosbeak and the Warbling Vireo, and parasitism was focused upon the Warbling Vireo. Grosbeaks, which were nesting primarily at GRCA, may have been preyed upon by squirrels and jays which were abundant at this site. These predator densities may in part be a result of the close proximity of GRCA to residential areas (<100 m) (see Craig 1997). Grosbeaks may be susceptible to predation in other areas as well. Hill (1995) reports that grosbeaks may be predated heavily in some areas of New Mexico by Stellar's jays and western Scrub-Jays, with rates of up to 60% in one study. Warbling Vireos, which were parasitized and predated at even higher rates than Plumbeous Vireos, have shown a history of parasitism in Boulder County (Table 6). The average parasitism rate of for the combined years of 1993, 1994 and 1997 was 51%. One factor contributing to this species vulnerability to parasitism may be the fact that it sings at the nest. Because this species may sing at the nest, predators and parasites may be able to locate their nests with efficiency (Barrett 1998).

Parasitism and Predation of Sensitive and Declining Species - Sensitive and declining species had higher rates of parasitism and predation than other nesting species. For example, parasitism and depredation rates for the MacGillivray's Warbler, Black-headed Grosbeak and Warbling Vireo were respectively; (100, 0, 100) and (0, 42, 0), whereas Grey Catbird and Cordilleran Flycatcher nests were not parasitized or predated. Elsewhere in Colorado, parasitism has been documented in the past for the MacGillivray's Warbler (in southwestern Colorado and in Gunnison County), for the Black-headed Grosbeak (several records for early 1900 exist, but with no locational information) and for the Warbling Vireo (Boulder, Gunnison, San Miguel, Huerfano, Montrose, Archuelta, Fremont, and Eagle Counties) (Chace and Cruz 1996). Although the Cordilleran Flycatcher was not parasitized in our study, Chace and Cruz (1996) document one occurrence of adults feeding a cowbird fledgling in Teller County

Parasitism Across Sites - Parasitism was higher at SHRI than at CHTQ for the Plumbeous Vireo. Although we do not have any sure explanation at this time, the discrepancy in parasitism rate for this species may be related to habitat. The forest is much more patchy sparse at SHRI which could allow cowbirds to find Plumbeous Vireo nests with more efficiency.

Cowbird Habitat Selection and Movement - Brown-headed Cowbirds in Boulder County appear to be most abundant in the montane canyons and ponderosa pine forests when they are nest searching. This is reflected on regional studies of parasitism, where parasitism is higher in these two habitat types than lowland forest or grassland habitats (Miller 1996). In the afternoon when cowbirds are most often foraging they are found in the residential areas, taking advantage of bird feeders and short grass. In the evenings cowbirds move back to higher elevations and out to the grasslands.

Because grasslands were not well sampled in the afternoons and evenings we cannot determine the effects of cattle on cowbirds for 1998, however we did see cowbirds associating with cattle on several occasions. Likewise, because residential areas were not sampled in the evenings we cannot determine the relative importance of these places at this time of day.

Landscape Effects and Nesting Success - Cowbirds can range widely between foraging sites and breeding locations (up to 14 km in New Mexico, Goguen and Curson 1997). Cowbirds appear to move from foraging sites in the foothill residential communities to ponderosa pine forests and montane canyons where they parasitize host species. Earlier work (Chace 1995, Chace et al. *in press*) show that distance to roads, residential areas, and canopy openings create significant negative impacts on nesting Plumbeous Vireos. Our new data support this earlier conclusions and provide a more direct link to cause and effect, radio-telemetry and, possibly, DNA fingerprinting of female cowbirds and eggs could reveal a more direct relationship between suburbanization and nest failure. Similarly, Craig (1997) found the same relationship for corvids and nest predation in Boulder County.

Research Recommendations

Ecological conditions and patterns vary over time, and therefore it is imperative to conduct multi-year studies to remove yearly variation and ecological anomalies, such as El Niño effects. Our work is among the few long-term studies conducted along the Front Range of Colorado, and we plan to continue this line of research in 1999. Initially it appears that cattle grazing on open space is of minor concern as for the potential for attracting cowbirds, residential development appears to have a larger positive impact cowbird abundance. Because of the proximity of homes in the

foothills to areas where migrants nest, ponderosa pine forests and montane canyons, such development may have direct negative impacts on the nesting success of migrants. We recommend further investigation of cowbird habitat selection in the Boulder County area, especially with respect to land-use categories of agriculture-grazing vs. residential development. It will be important to build sample sizes of sensitive species which we currently have little data on (e.g., Warbling Vireo, Virginia's Warbler, MacGillivray's Warbler). Some of these species are either rare in Boulder or take more time to gather reproductive data on because of cryptic nesting behavior. Studies of rare and sensitive species can determine the effects of landscape alteration and the impacts of predation and parasitism on the ability of these species to persist and/or become locally established. It will be important to continue to study the more ubiquitous birds such as the Plumbeous Vireo and Western Wood-pewee. Studies on more common birds are also important because density may be a misleading indicator of success (Van Horne 1983). We suspect that the local population of the Plumbeous Vireo is not able to maintain itself without emigration from other, more successful, populations. It will be important to collect more reproductive data on species which nest in riparian or montane shrub habitats so we will be able to compare the reproductive success, depredation, and parasitism patterns with species nesting in forested habitats. In 1999, we will also sample the vegetation at each point under the BBIRD protocol to determine habitat preference of cowbirds and other migrant species in Boulder County. We will also use multivariate statistics to model species associations, habitat selection, and determine the strength of the cowbird-host community relationship. Finally, given our initial findings of cowbird habitat selection, we recommend future studies to incorporate radio-telemetry to identify foraging and roosting sites, and large-scale vegetation sampling of our point count locations with GIS to accurately determine the influence of landscape features with cowbird habitat selection, movement.

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Literature Cited

- Askins, R. A., J. F. Lynch, and R. S. Greenburg. 1990. Population declines in migratory birds in eastern North America. *Curr. Ornith.* 7:1-57.
- Barrett, N. M. 1998. Warbling Vireo. Pp. 308-309. *in* H. E. Kingery (ed.), Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership and Colorado Division of Wildlife, Denver.
- Block, W. M., D. M. Finch, J. L. Ganey and W. H. Moir. 1997. pgs 145-150 *in* W. M. Block and D. M. Finch. Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Carter, M. F. 1998. MacGillivray's Warbler. Pp. 432-433 *in* H. E. Kingery (ed.), Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership and Colorado Division of Wildlife, Denver.
- Chace, J. F. 1995. The factors affecting the reproductive success of the Solitary Vireo (*Vireo solitarius plumbeus*) in Colorado. M.A. Thesis, University of Colorado, Boulder.
- Chace, J. F., and A. Cruz. 1996. Knowledge of the Colorado host relations of the parasitic Brown-headed Cowbird (*Molothrus ater*). *J. Colo. Field Ornithol.* 30:67-81
- Chace, J. F., A. Cruz, and R. E. Marvil. *in press*. Reproductive interactions of the Brown-headed Cowbird and Solitary Vireo in Colorado. *In* T. L. Cooke, S. I. Rothstein, J. N. M. Smith, S. K. Robinson and A. C. Sealy (eds), Ecology and Management of Cowbirds.
- Craig, D. P. 1997. An experimental analysis of nest predation in western coniferous forests: a focus on the role of corvids. Ph.D. Dissertation, University of Colorado, Boulder.
- Daubenmire, R. 1978. Plant geography with special reference to North America. New York: Academic Press. vi, 338 p.
- DeMarco, T. E., C. B. Goguen, D. R. Curson, and N. E. Mathews. *in review*. Breeding behavior of the Plumbeous Vireo in New Mexico..
- Engels T. M. and C. W. Sexton. 1994. Negative correlation of blue jays and golden-cheeked warblers near an urbanizing area. *Conservation Biology* 8:286-290.
- Faaborg, J., M. Brittingham, T. Donovan, and J. Blake. 1995. Pp. 357-380 *in* , T. E. Martin and D. M. Finch (eds.), Ecology and management of Neotropical migratory birds. Oxford Univ. Press, New York.
- Fenske-Crawford, T. J. and G. J. Niemi. 1997. Predation of artificial ground nests at two types of edges in a forest-dominated landscape. *Condor* 99:14-24.
- Gard, N. W., and M. J. Hooper. 1995. An assessment of potential hazards of pesticides and environmental contaminants. Pp. 294-310 *in* , T. E. Martin and D. M. Finch (eds.),

- Ecology and management of Neotropical migratory birds. Oxford Univ. Press, New York.
- Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. *Ecology* 59:871-883.
- Goguen, C. B., and N. E. Mathews. 1997. Cowbird parasitism and behavior in a grazed and ungrazed landscape in New Mexico. Abstract, Research and Management of the Brown-headed Cowbird in Western and Eastern Landscapes. 23-25 October, Sacramento, CA.
- Hall, L. S., M. L. Morrison, and W. M. Block. 1997. Songbird status and roles. Pp. 69-88 *in*, W. M. Block and D. M. Finch (eds.), *Songbird ecology in southwestern ponderosa pine forests: a literature review*. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Hill, G. E. 1995. Black-headed Grosbeak. *In* *The bird of North America*, no. 143 (A. Poole and F. Gill, eds.). Acad. Nat. Sci., Philadelphia, and Am. Ornithol. Union, Washington, DC.
- James, F.C., Shugart, H.H., Jr. 1970. A quantitative method of habitat description. *Audubon Field Notes* 24:727-736.
- Levad, R. 1998. Black-headed Grosbeak. Pp. 490-491 *in* *Colorado Breeding Bird Atlas* (H. Kingery ed.). Colorado Bird Atlas Partnership, and Colorado Division of Wildlife, Denver CO.
- Little, E.L. 1971. *Atlas of United States Trees. Volume 1. Conifers and important hardwoods.* Misc. Pub. 1146. Washington DC: U.S. Department of Agriculture, Forest Service.
- Major, R. E. 1989. The effect of human observers on the intensity of nest predation. *Ibis* 132:608-612.
- Martin, T. E. and J. J. Roper. 1988. Nest predation and nest-site selection of a western population of the Hermit Thrush. *Condor* 90:51-57.
- Marzluff, J. M. 1997. Effects of urbanization and recreation on songbirds. Pp. 89-102 *in*, W. M. Block and D. M. Finch (eds.), *Songbird ecology in southwestern ponderosa pine forests: a literature review*. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Miller, R. 1992. Preliminary results from breeding bird survey data estimates of trends in bird populations in or near managed ponderosa pine in the southwest. Unpubl. Rep., Arizona Dept. Game and Fish, Flagstaff, AZ.
- Miller, S. G. 1996. Recreation trails and avian communities. M. S. thesis, Colorado State University, Fort Collins, CO.
- Myers, N. 1991. Tropical forests: present status and future outlook. *Clim. Change* 19:3-32.
- Norman, R. F., and R. J. Robertson. 1975. Nest-searching behavior in the Brown-headed Cowbird. *Auk* 92:610-611.

- Oliver, W. W., and R. A. Ryker. 1990 *Pinus ponderosa* Dougl. ex Laws., Ponderosa pine, Pages 413-424 in Burns, R. M.; Honkala, B. H. tech. coords. *Silvics of North America*, Volume 1, Conifers. Washington, DC: U. S. Government Printing Office. vi, 675 p.
- Patton, P. W. C. 1994. The effect of edge on avian nest success: how strong is the evidence? *Cons. Biol.* 8:17-26.
- Petit, D. R., J. F. Lynch, R. L. Hutto, J. G. Blake, and R. B. Wade. 1995. Habitat use and conservation in the Neotropics. Pp. 145-197 in , T. E. Martin and D. M. Finch (eds.), *Ecology and management of Neotropical migratory birds*. Oxford Univ. Press, New York.
- Picozzi, N. 1975. Crow predation on marked nests. *J. Wildlife Manag.* 39:151-155.
- Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. deSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144, Albany, CA, Southwest Research Station, Forest Service, US Dept. Agric.
- Rich, T., and C. Breadmore. 1997. Priority bird species by state in the western US: 1997 status report. Unpubl. Rep., Partners-in-Flight, Western Working Group.
- Rudnicki, T. C., and M. L. Hunter, Jr. 1993 Avian nest predation in clearcuts, forests, and edges in a forests-dominated landscape. *J. Wild. Manage.* 57:358-364.
- Soule', M. E., D. T. Bolger, A. C. Roberts, J. Wright, M. Sorice, and S. Hill. 1988. Reconstructed dynamics of rapid extinction of chaparral-requiring birds in urban habitat islands. *Conservation Biology* 2:75-92.
- Steele, R. W. 1988. Ecological relationships of ponderosa pine. Pages 71-76 in Baumgartner, D. M.; Lotan, J. E., comp. -eds. *Ponderosa pine the species and its management; symposium proceedings; 1987 September 29-October 1; Spokane, Washington*. Pullman, WA: Washington State University, Cooperative Extension. 281 p.
- Tewksbury, J. J., S. J. Heil, and T. E. Martin. 1998. Breeding productivity does not decline with increasing fragmentation in a western landscape. *Ecology* 79: 2890-2903.
- Van Horne, B. 1983. Diversity as a misleading indicator of habitat quality. *J. Wildlife Manage.* 47:893-901.
- Veblen, T. T., and D. C. Lorenz. 1991. *The Colorado Front Range a century of ecological change*. University of Utah Press, Salt Lake City.
- Walsh, J. J. 1999. How do Western Wood-pewees avoid nest parasitism and predation? M. S. Thesis *in prep* . University of Colorado, Boulder Colorado.
- Westmoreland, D. and L. B. Best. 1985. The effect of disturbance on Mourning Dove nesting success. *Auk* 102:774-780.
- Wiley, J. W. 1988. Host selection of the Shiny Cowbird. *Condor* 90:289-303.

Winternitz, B. L., and D. W. Crumpacker (eds.). 1985. Species of special concern. Unpubl. Rep., Colorado Wildlife Workshop.

Appendix 1. Index to species codes

BGGN	Blue-gray Gnatcatcher
BHGR	Black-headed Grosbeak
BTHU	Broad-tailed Hummingbird
CEWA	Cedar Waxwing
CHSP	Chipping Sparrow
COFL	Cordilleran Flycatcher
GRCA	Grey Catbird
HAFL	Hammond's Flycatcher
LEGO	Lesser Goldfinch
MAWA	MacGillivray's Warbler
MODO	Mourning Dove
PLVI	Plumbeous Vireo
SPTO	Spotted Towhee
WAVI	Warbling Vireo
WETA	Western Tanager
WWPE	Western Wood-pewee
YRWA	Yellow-rumped Warbler

Table 1. Parasitism, Predation Frequencies and Mayfield Nest Success Calculations of Forest Species for 1998.

status	species	n*	%parasitized	%depredated	Mayfield
sensitive or declining	HAFL Ψ	1	0	0	**
	PLVI	17	50	35	0.04
	WWPE	36	0	16	0.42
	CHSP	3	0	33	**
stable	LEGO	4	0	0	**
	CEWA	3	33	33	**
	MODO	2	0	0	**
	BGGN	3	0	33	**
	WETA	3	0	0	**

* #nests of known fate

** n<4

Ψ species codes listed in Appendix 1

Table 2. Parasitism, Predation Frequencies and Mayfield Nest Success Calculations of Deciduous/Montane Shrub Species for 1998.

sensitive/ declining	species	n	%parasitized	%depredated	Mayfield
	MAWA Ψ	1	100		**
	BHGR	7	0	42	0.04
	WAVI	1	100	0	**
stable	GRCA	1	0	0	**
	COFL	1	0	0	**
	SPTO	3	0	0	

* # nests of known fate

** n<4

Ψ species codes listed in Appendix 1

Table 3. Parasitism, Predation Frequencies and Mayfield Nest Success Calculations of Forest Species for 1997 and 1998. Data collected during 1990 and 1992 included for WWPE, PLVI and WETA.

sensitive/ declining	species	n*	%parasitized	%depredated	Mayfield '98
	HAFLΨ	2	0	50	**
	PLVI	32	50	33	0.04
	WWPE	97	0	19	0.42
	CHSP	15	7	40	**
	BTHU	9	0	56	**
stable	CEWA	3	33	33	**
	MODO	2	0	0	**
	BGGN	3	0	33	**
	WETA	6	16	0	**
	LEGO	4	0	0	**
	YRWA	1	0	100	**

* #nests of known fate

** n<4

Ψ species codes listed in Appendix 1

Table 4. Parasitism, Predation Frequencies and Mayfield Nest Success Calculations of Deciduous/Montane Shrub Species for 1997 and 1998. Data collected during 1990, 1993-1994 included for WAVI and SPTO.

sensitive/ declining	species	n	%parasitized	%depredated	Mayfield 1998
	MAWA Ψ	1	100		**
	BHGR	11	0	39	0.04
	WAVI	40	53	36	**
	VIWA	3	100	100	
stable	GRCA	1	0	0	**
	COFL	1	0	0	**
	SPTO	5	0	0	**

* #nests of known fate

** n<4

Ψ species codes listed in Appendix 1

Table 5. Frequency of parasitism of Plumbeous Vireo nests in Boulder County, Colorado^a.

	YEAR								
	1984	1985	1986	1992	1993	1994	1997	1998	Total
Unparasitized	11	12	17	5	25	12	7	9	98
Parasitized	9	12	17	3	21	23	11	8	104
% Parasitized	45.0%	50.0%	50.0%	37.5%	45.6%	65.7%	61.1%	47.1%	51.5%

^a Frequency of parasitism is not independent of year (GADJ = 20.5279, df = 7, P < 0.05).

Table 6. Frequency of parasitism of Warbling Vireo nests in Boulder County, Colorado. 1993, 1994, 1997, 1998.

	YEAR				
	1993	1994	1997	1998	Total
Unparasitized	5	10	4	0	19
Parasitized	6	8	6	1	21
% Parasitism	54.5%	44.4%	60.0%	100	52.5

Table 7. Summary of cowbird relative abundance across 18 point count transects in Boulder County, Colorado, 1998.

Transect (No. Stations)	Morning			Afternoon			Evening		
	No. CT	BHCO	RAI	No. CT	BHCO	RAI	No. CT	BHCO	RAI
Montane Canyons									
Skunk Canyon (6)	3	5	27.78	2	0	0			
Bear Canyon (11)	3	8	28.78	2	3	13.64	1	5	45.45
Gregory Canyon (9)	3	7	28.00						
Total		20	28.17		3	8.82		5	45.45
Lowland Riparian									
Boulder Creek Path (10)	3	0	0						
S. Boulder Creek - S (10)	3	11	36.67	2	0	0	2	0	0
S. boulder Creek - N (5)	3	3	20.00						
Total		14	18.67		0	0		0	0
Boulder Residential									
Foothill Residential -S (10)	3	2	6.67	2	9	45.00			
Foothill Residential - N (10)	3	0	0						
30th Street (10)	3	0	0						
Total		2	2.22		9	45.00			
Grasslands									
Cattle North (10)	3	1	3.33						
Cattle South (7)	3	2	9.52						
<u>Subtotal</u>		<u>3</u>	<u>5.88</u>						
No Cattle North (7)	3	1	4.76	1	0	0	2	5	35.71
No Cattle South (7)	3	1	4.76						
<u>Subtotal</u>		<u>2</u>	<u>4.76</u>						
Total		5	5.38		0	0		5	35.71
Montane Ponderosa Pine									
N. Shanahan Ridge (8)	3	10	41.67	1	0	0	1	0	0
S. Shanahan Ridge (10)	3	9	30.00	3	1	3.33	2	0	0
Mesa Trail (10)	3	10	34.48	1	0	0			
<u>Subtotal</u>		<u>29</u>	<u>34.94</u>						
Betasso Preserve (10)	3	5	16.67						
Meyer's Gulch - Walker Ranch (10)	3	1	3.33	1	0	0	2	0	0
<u>Subtotal</u>		<u>6</u>	<u>10.00</u>						
Total		35	24.48		1	1.72		0	0
Grand Total (160)		76	16.10		13	9.35		10	10.75

No. CT = number of counts per transect of all available stations
 BHCO = number of Brown-headed Cowbird detections
 RAI = relative abundance index ([No. CD/Total No. of Counts] * 100)

Table 8. Map Index.

Map 1: North Boulder Point Count Locations.

Map 2: City of Boulder and South Boulder Creek Point Count Locations.

Map 3: Long Canyon, Gregory Canyon, Shanahan Ridge, Bear Canyon , Skunk Canyon, Boulder Residential Nest Search Sites and Point Count Locations.

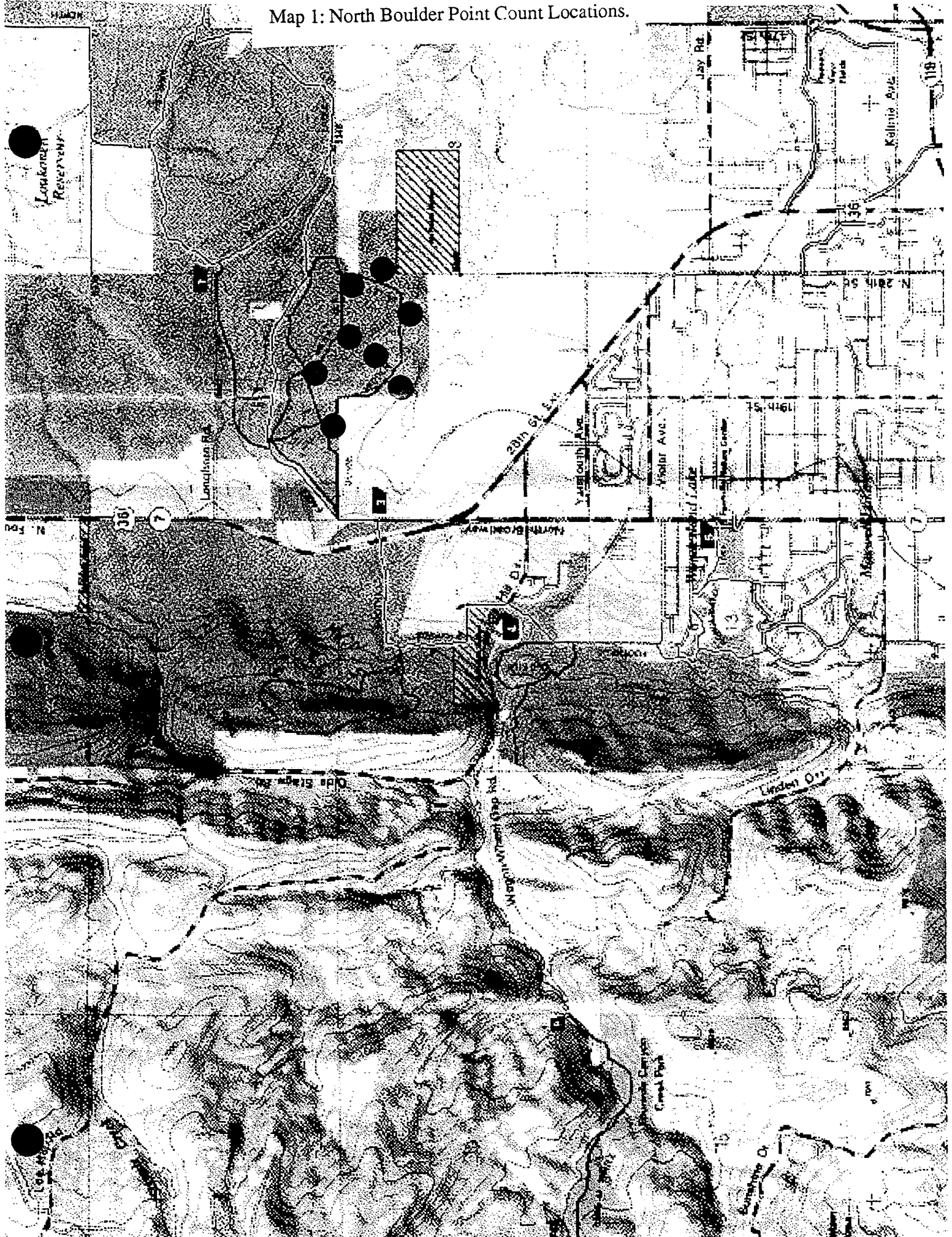
Map 4: South Boulder Point Count Locations.

Map 5: Walker Ranch Nest Search Site and Point Count Locations.

Map 6: North Boulder Residential and City of Boulder Point Count Locations.

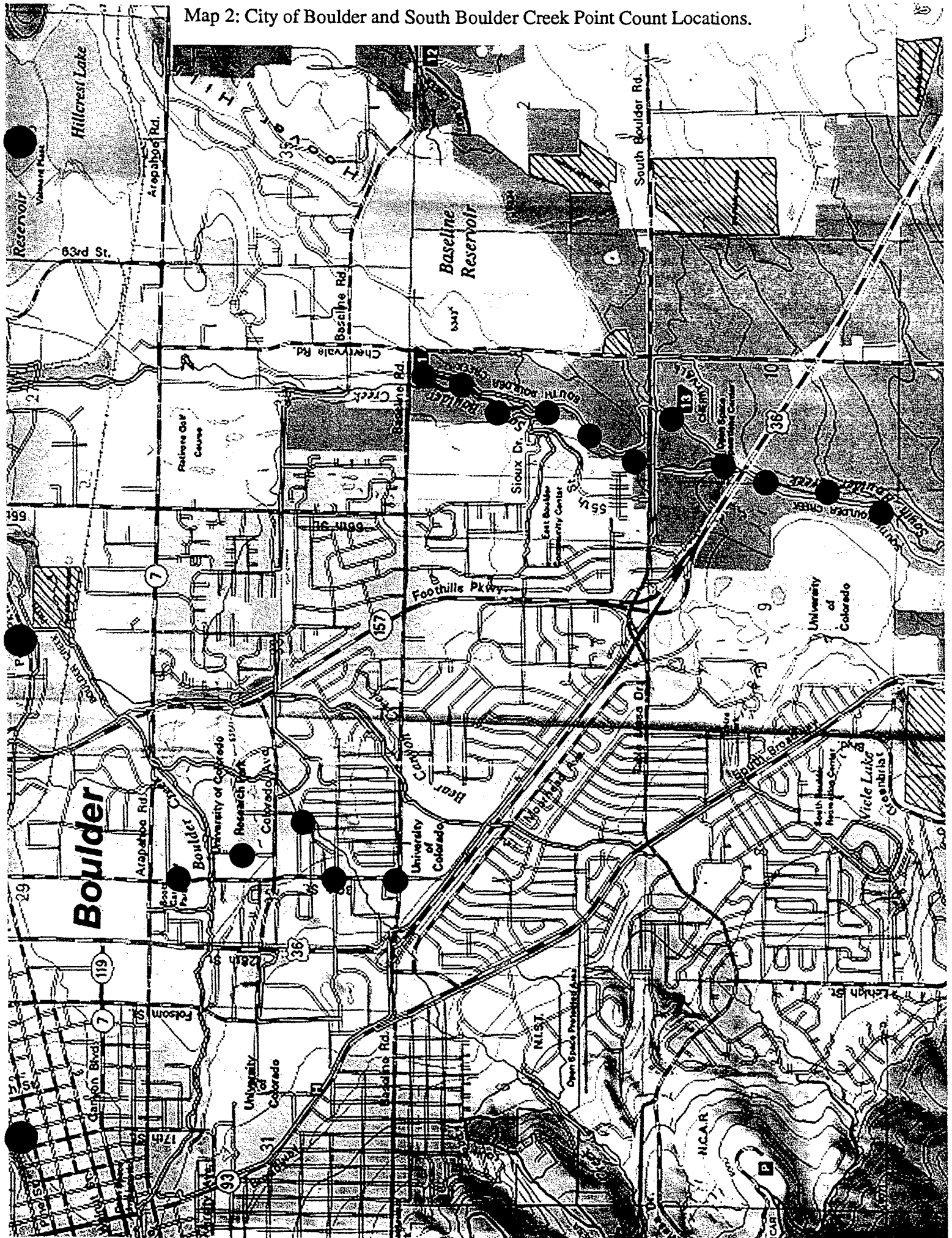
Map 7: Betasso Preserve Point Count Locations, Long Canyon Nest Search Site.

Map 1: North Boulder Point Count Locations.

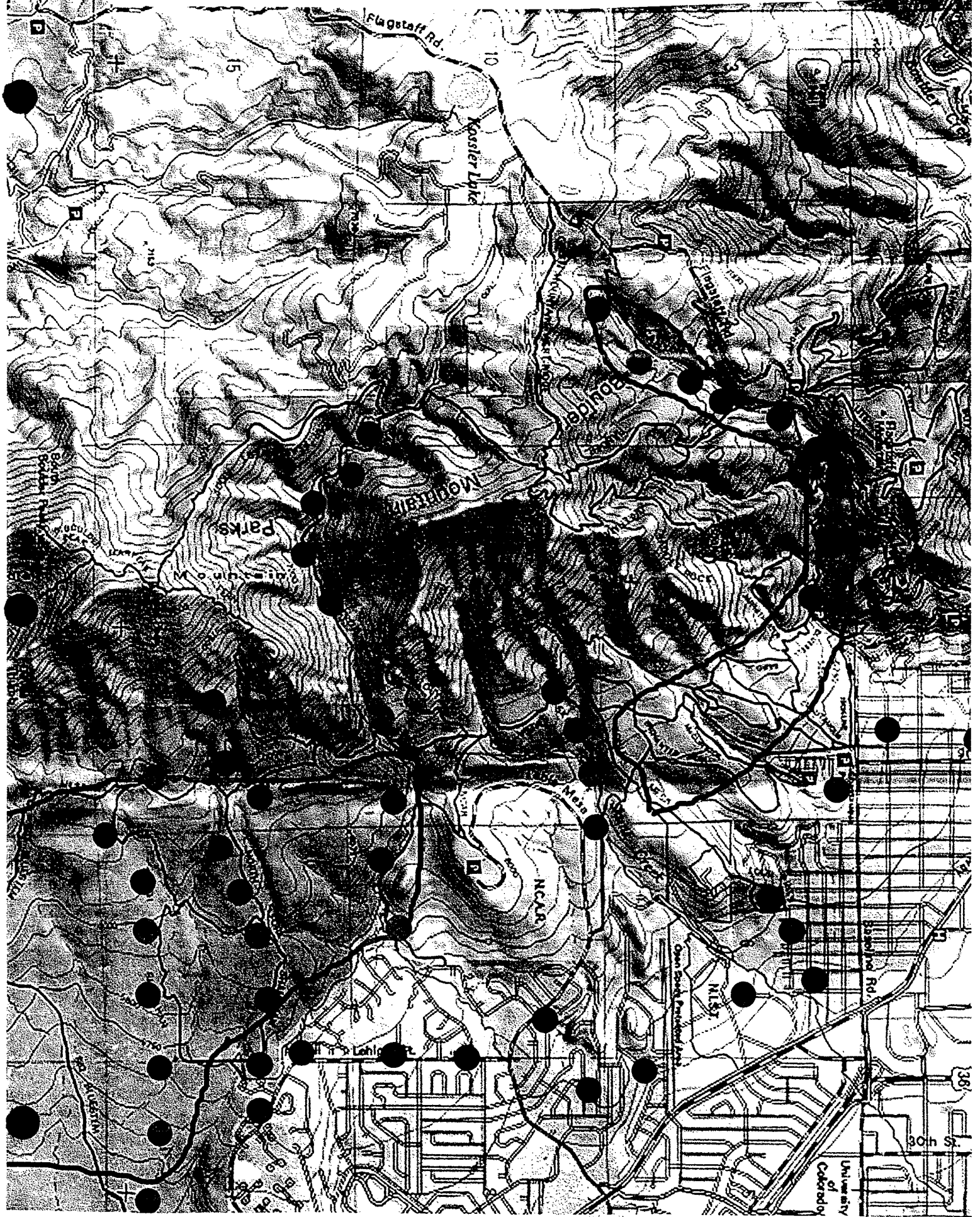


6/17/11

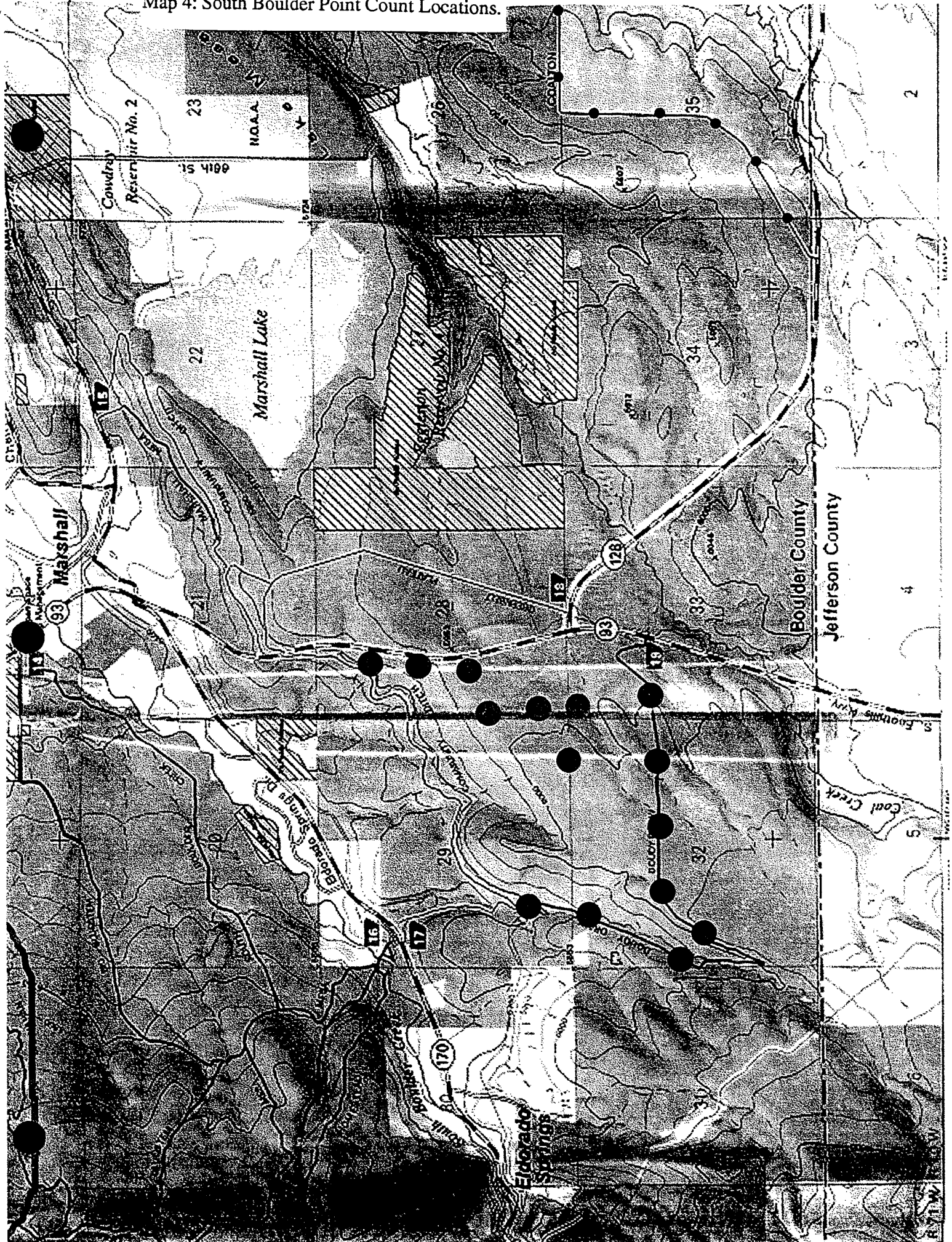
Map 2: City of Boulder and South Boulder Creek Point Count Locations.



Map 3: Long Canyon, Gregory Canyon, Shanahan Ridge, Bear Canyon, Skunk Canyon, Boulder
Residential Nest Search Sites and Point Count Locations



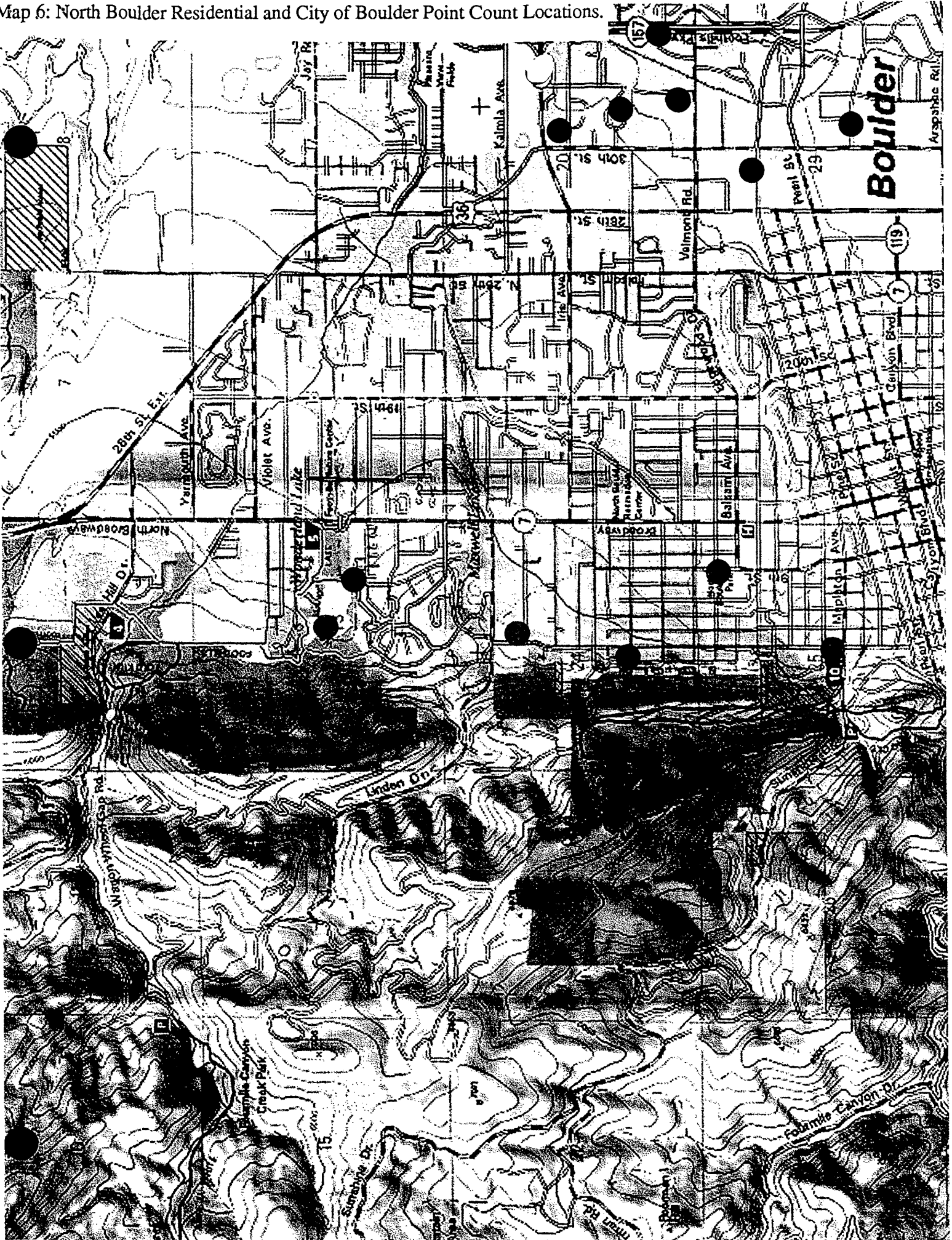
Map 4: South Boulder Point Count Locations.



Map 5. Walker Ranch Point Count Locations



Map 6: North Boulder Residential and City of Boulder Point Count Locations.



Map 7: Betasso Preserve Point Count Locations, Long Canyon Nest Search Site.



Model Egg (size, ground color, maculation)	Number of Differences
Robin size, blue, immaculate (robin egg)	0 – (control)
Robin size, blue, spotted	1
Robin size, white, spotted	2
Robin size, white, immaculate	1
Intermediate size, blue, immaculate	1
Intermediate size, blue, spotted	2
Intermediate size, white, spotted	3
Intermediate size, white, immaculate	2
Cowbird size, blue, immaculate	1
Cowbird size, blue, spotted	2
Cowbird size, white, spotted (cowbird egg)	3
Cowbird size, white, immaculate	2

Table 1. Description of model eggs and the number of differences from an American robin egg.