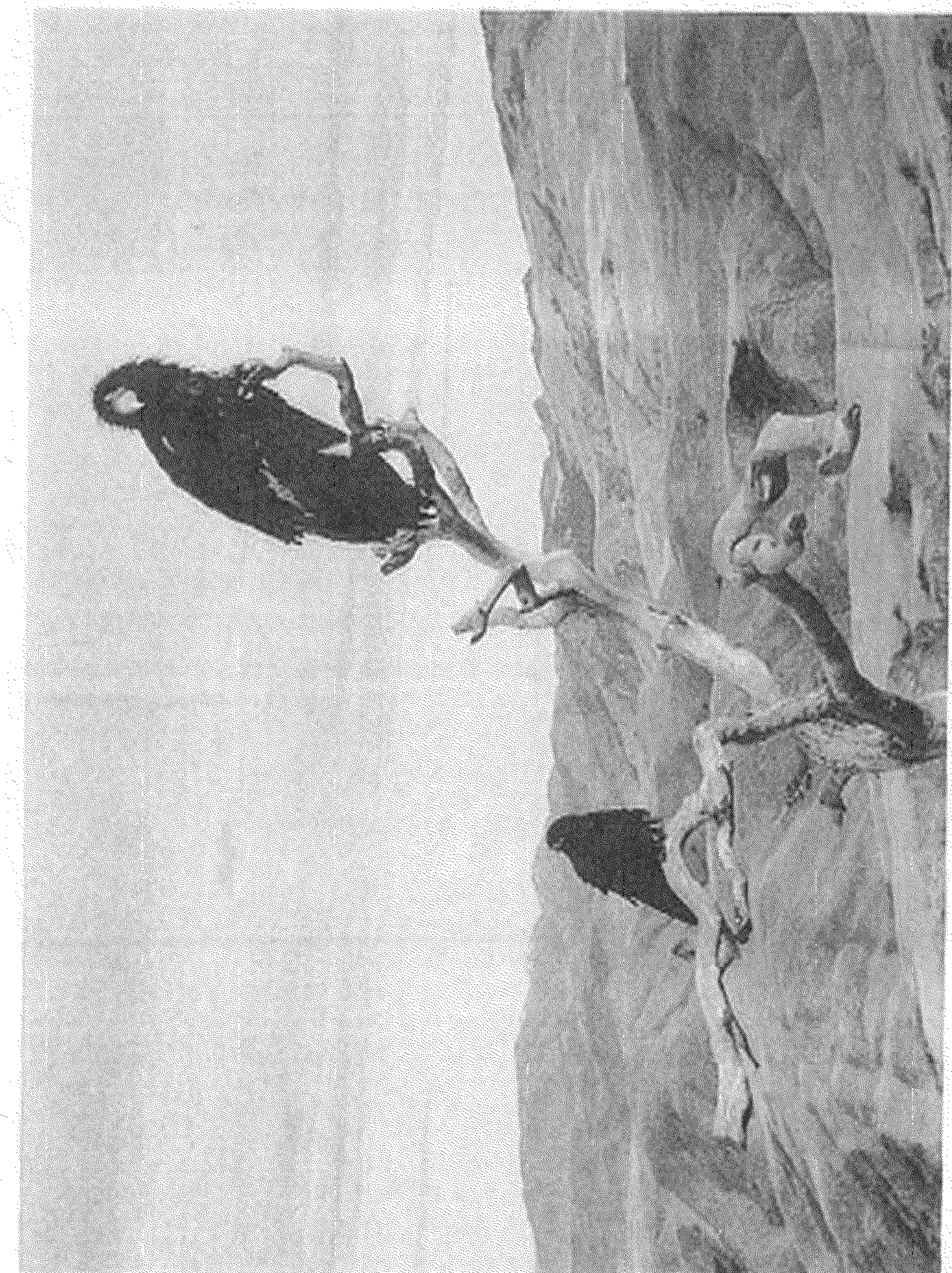

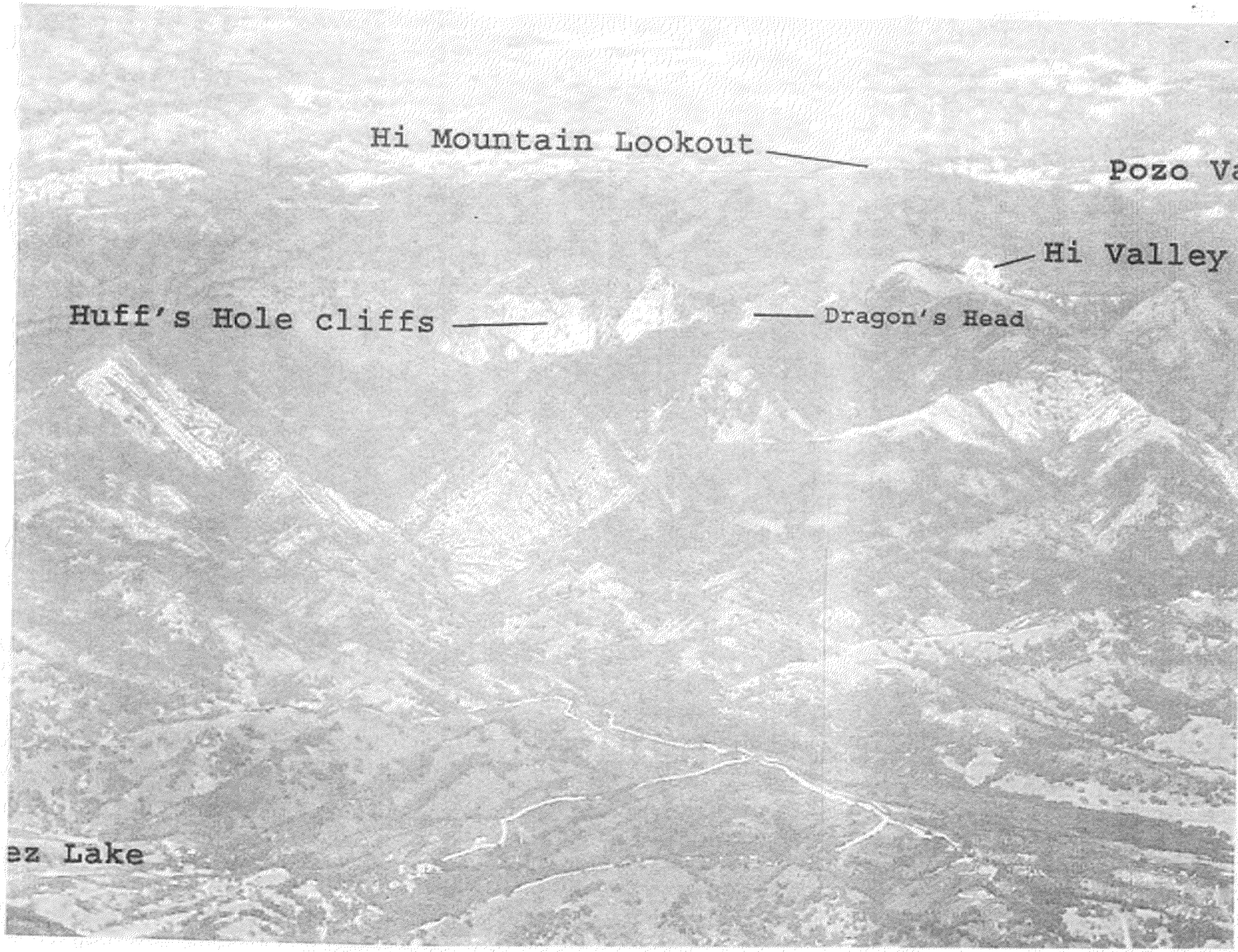
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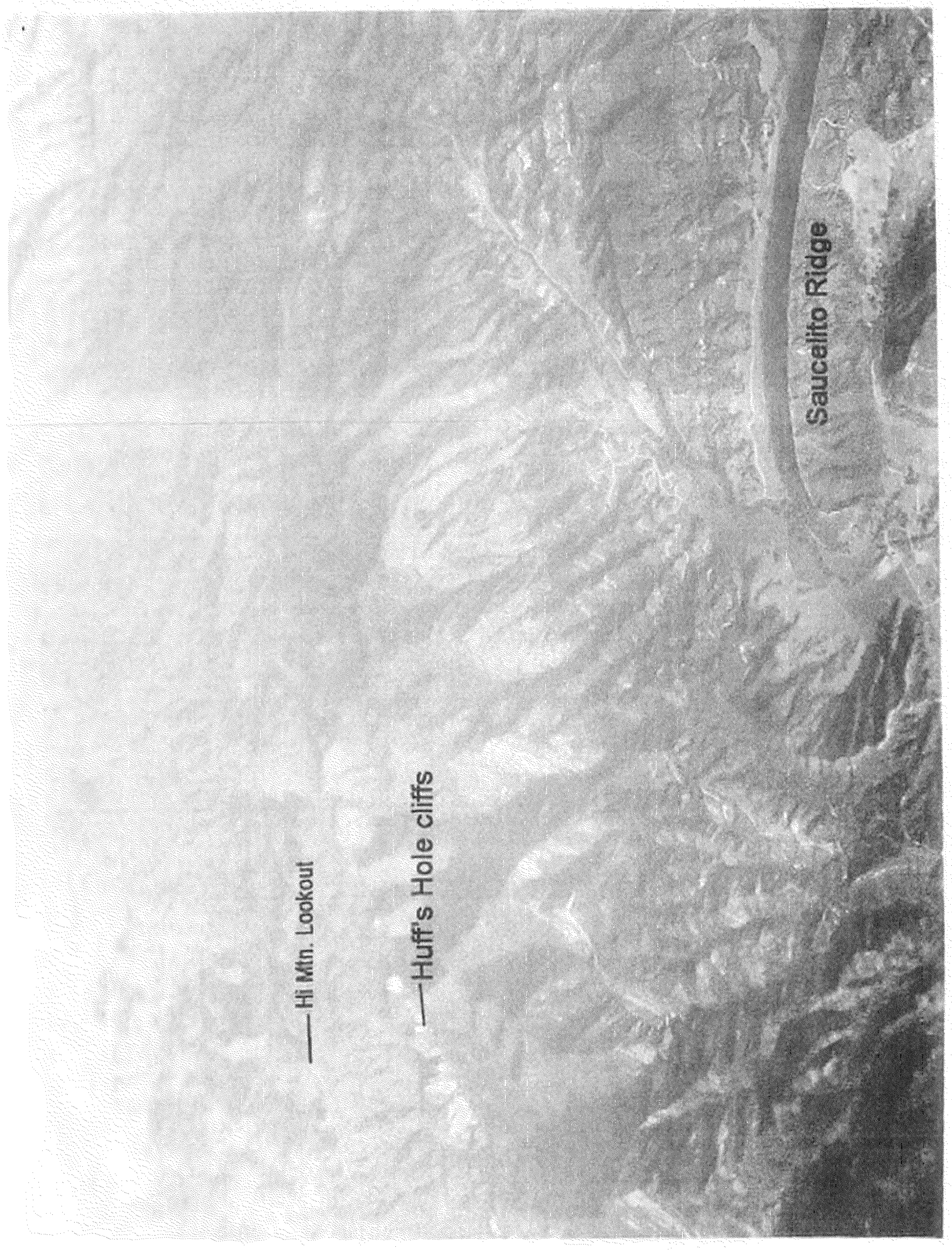
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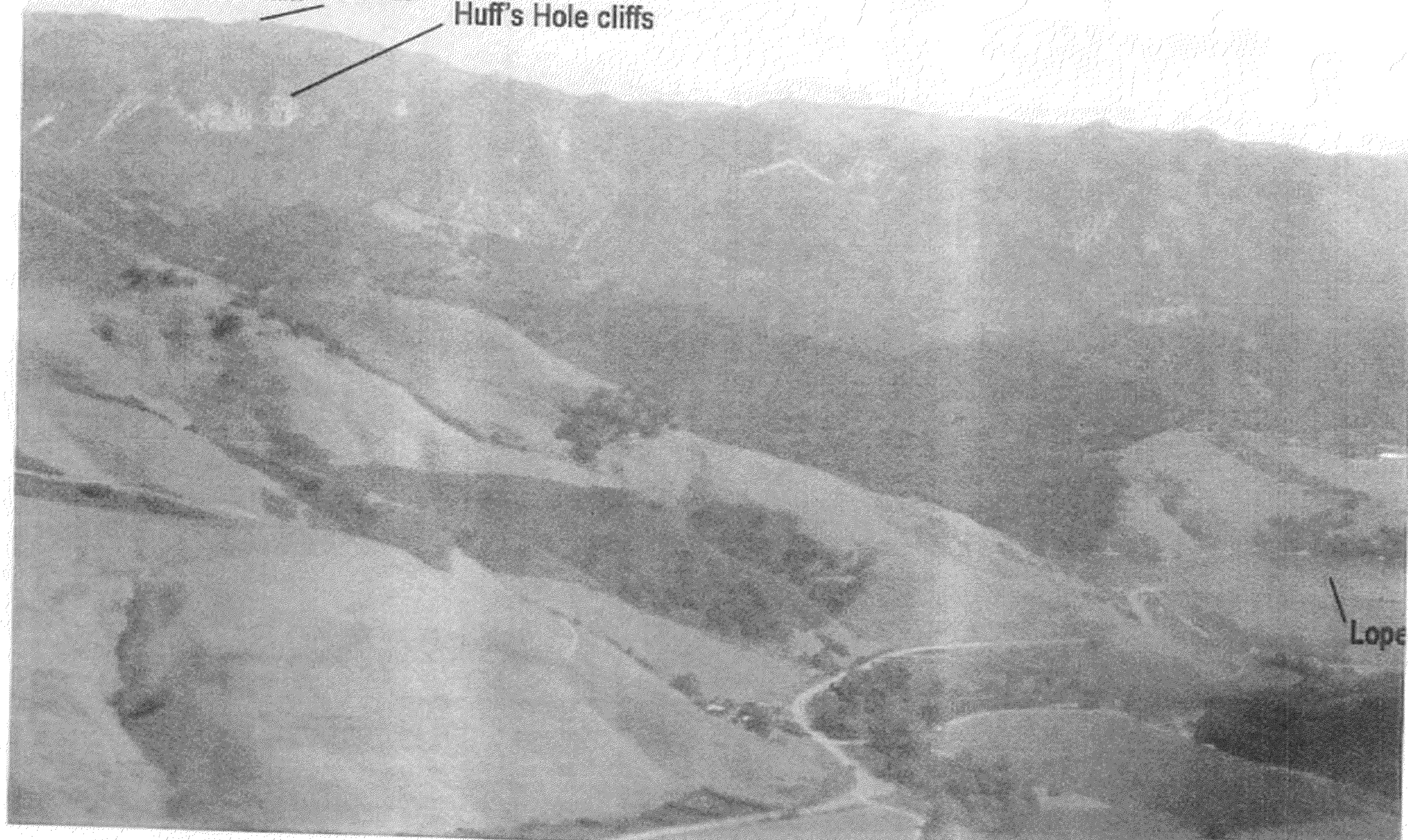
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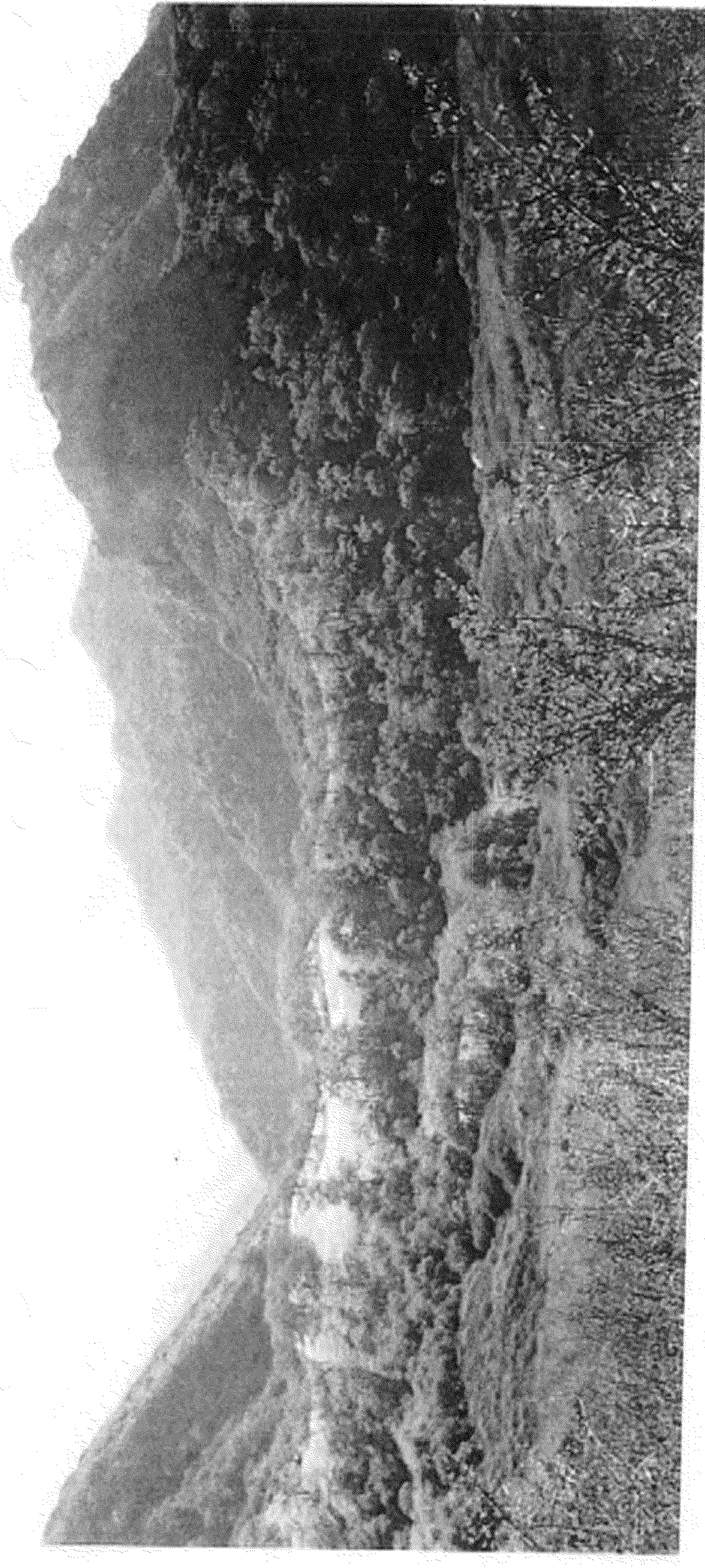

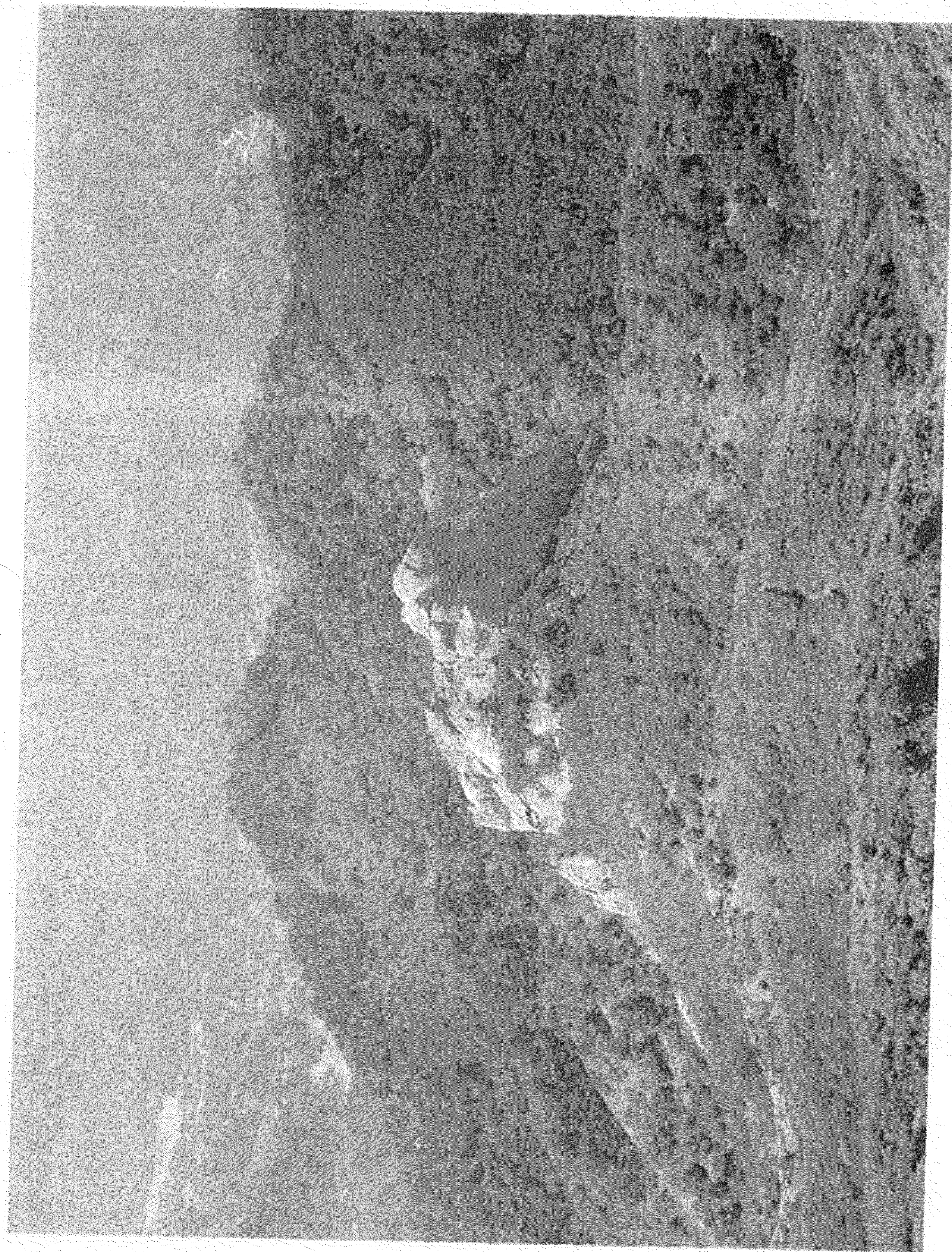

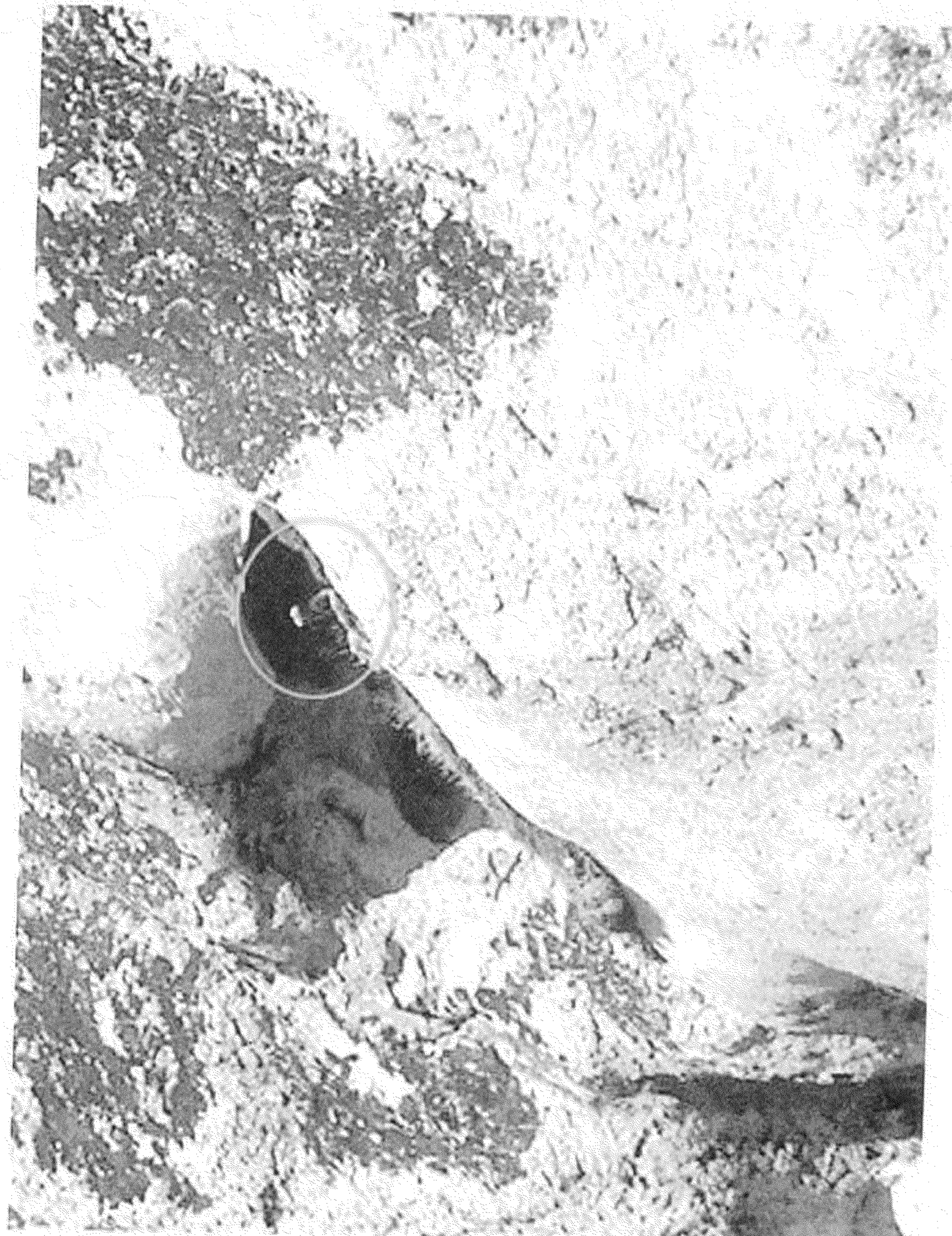

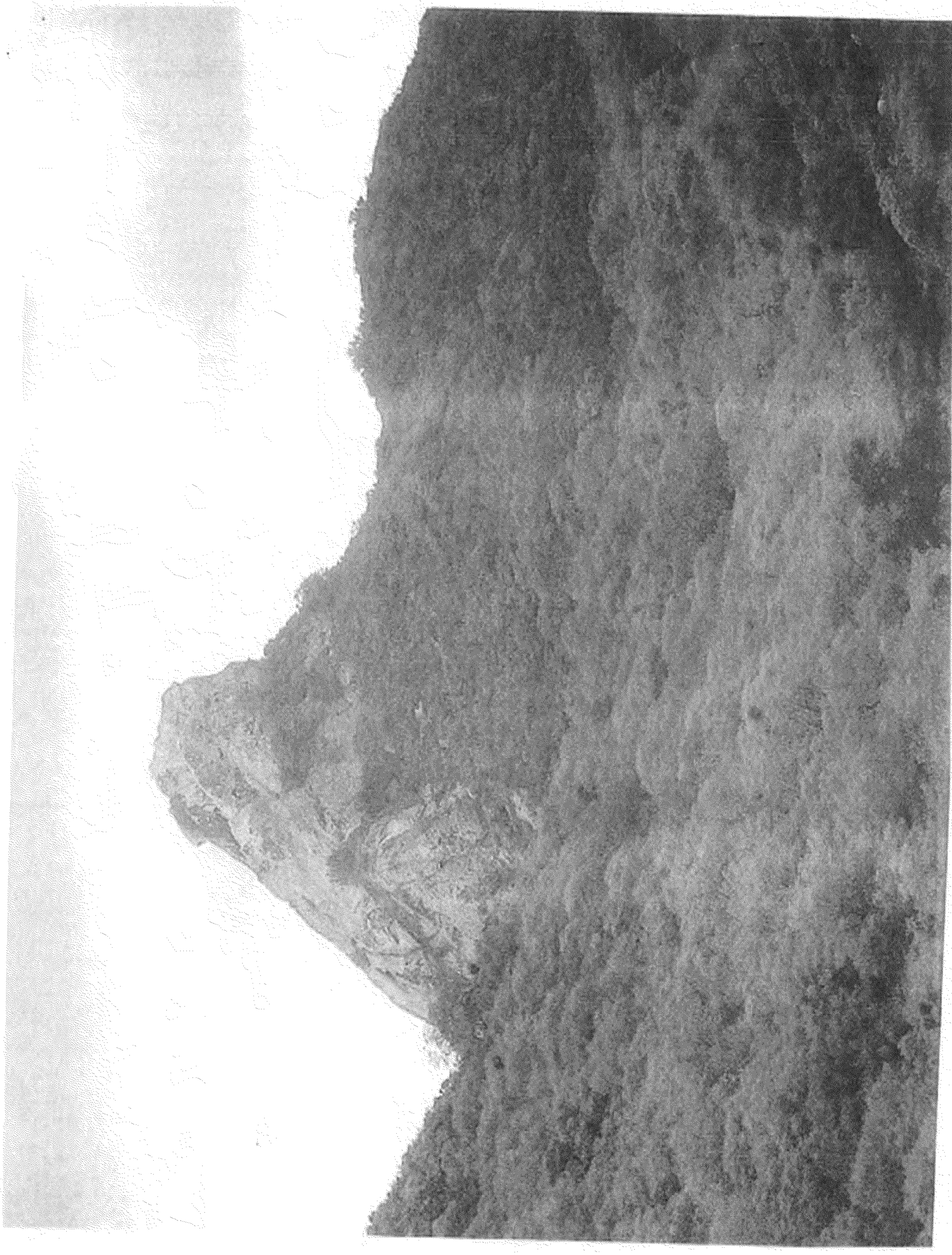

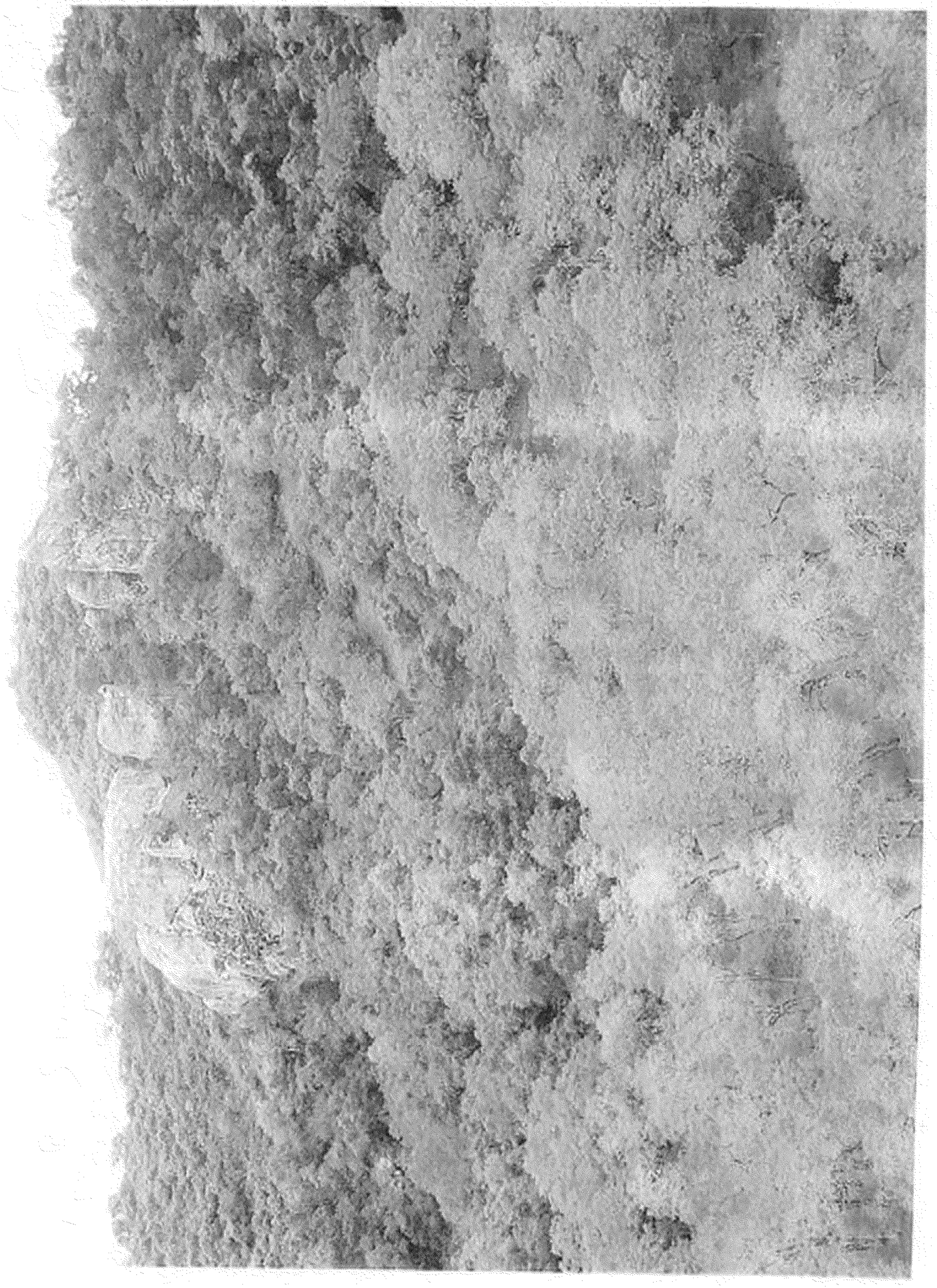

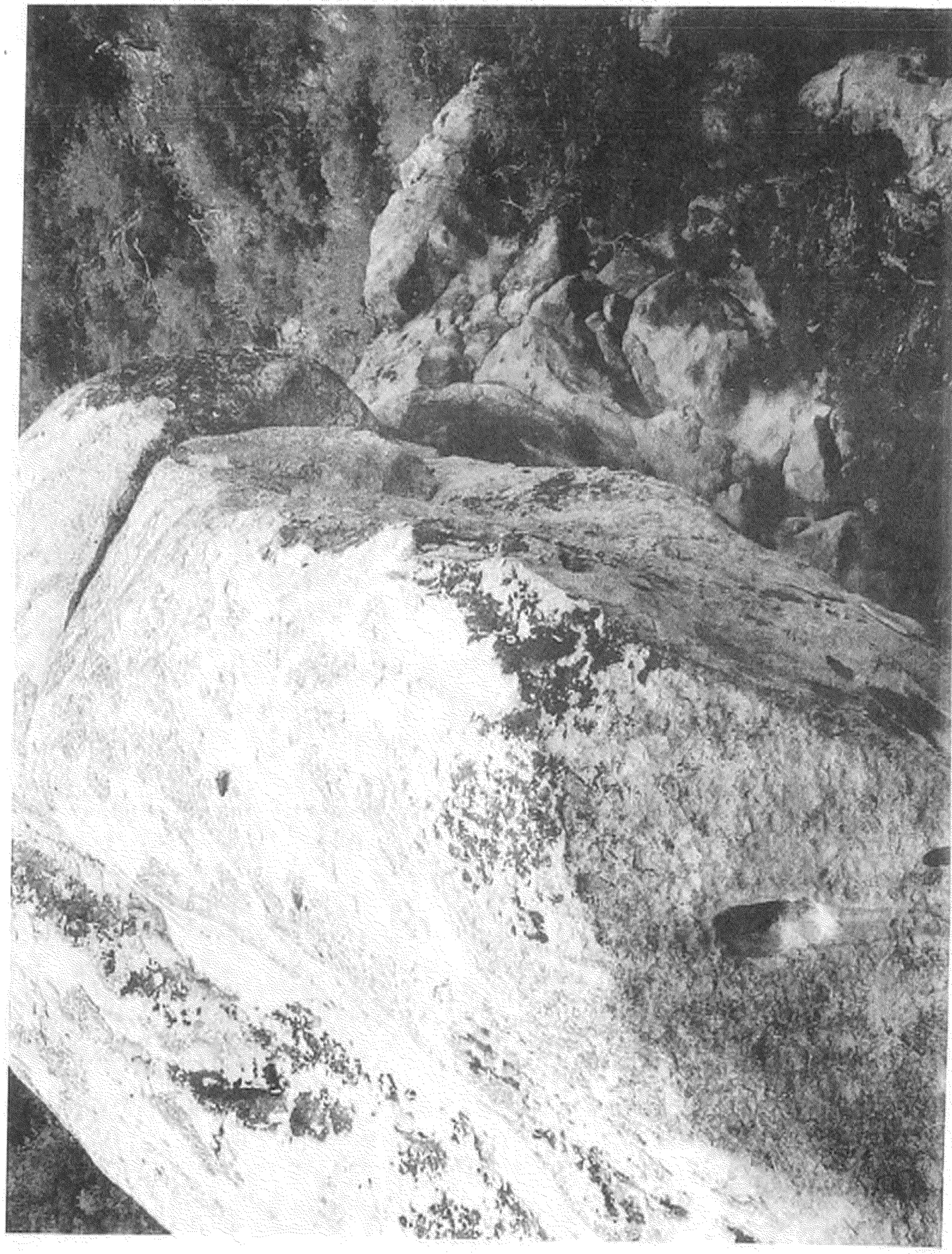

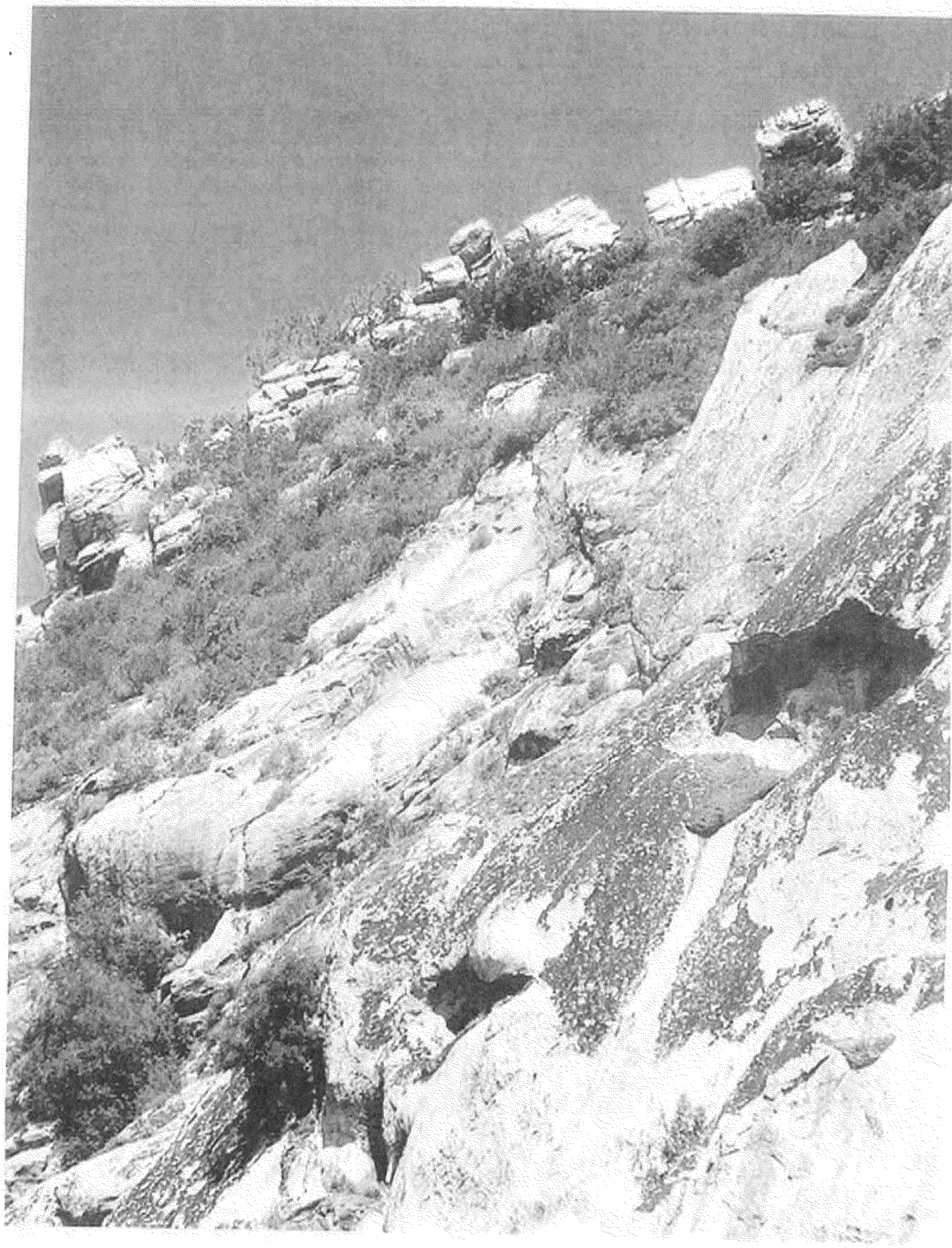

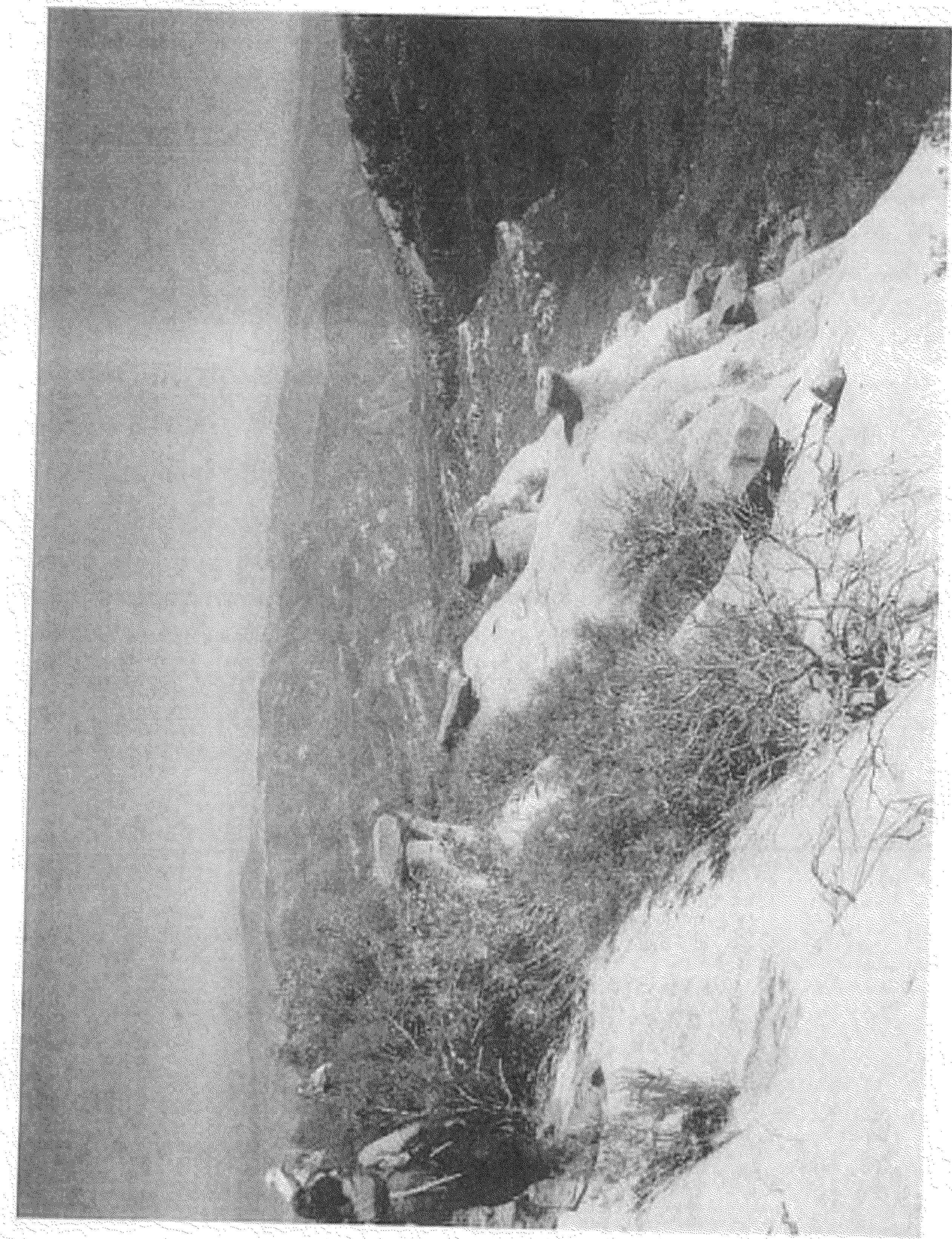

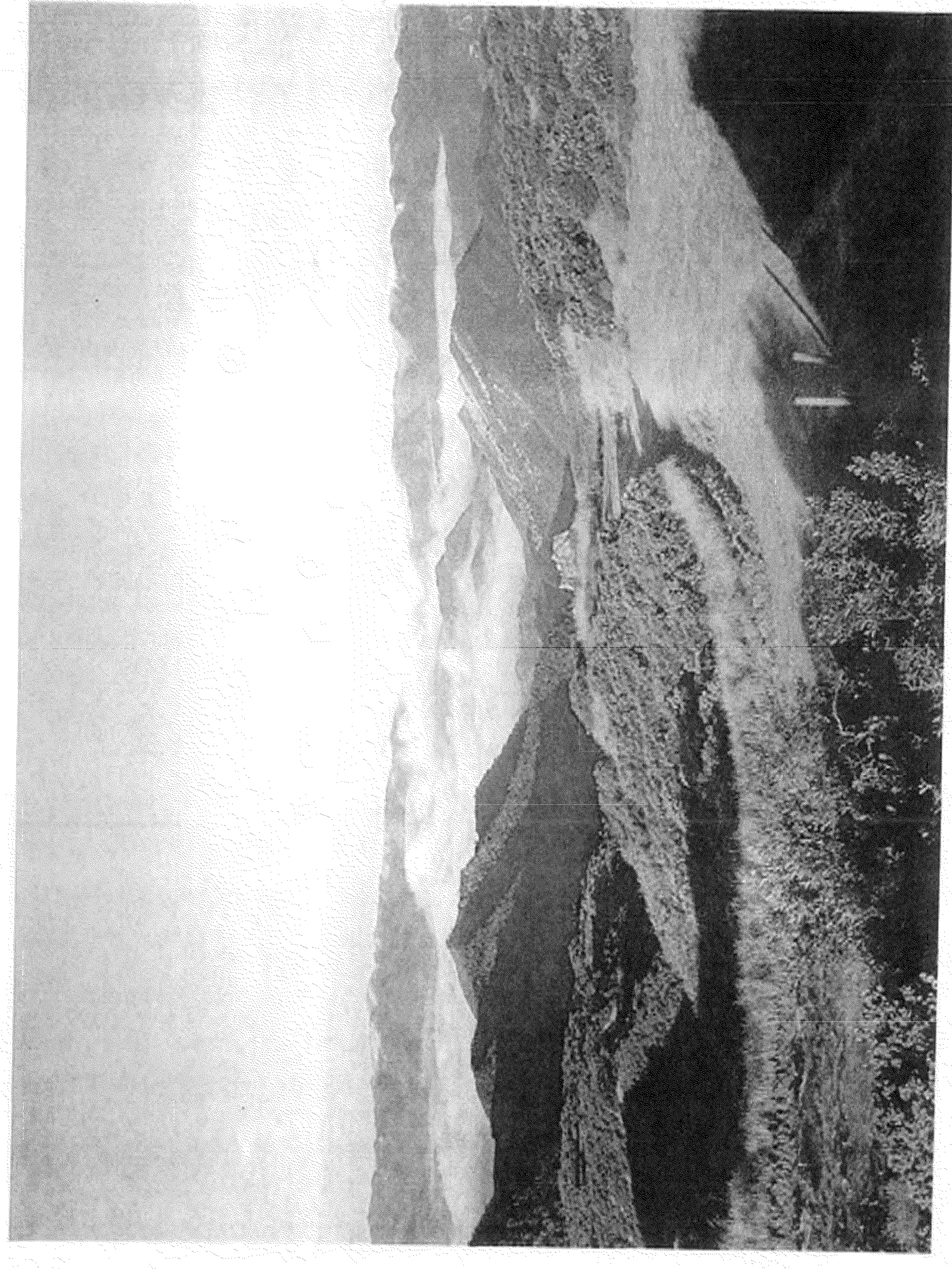

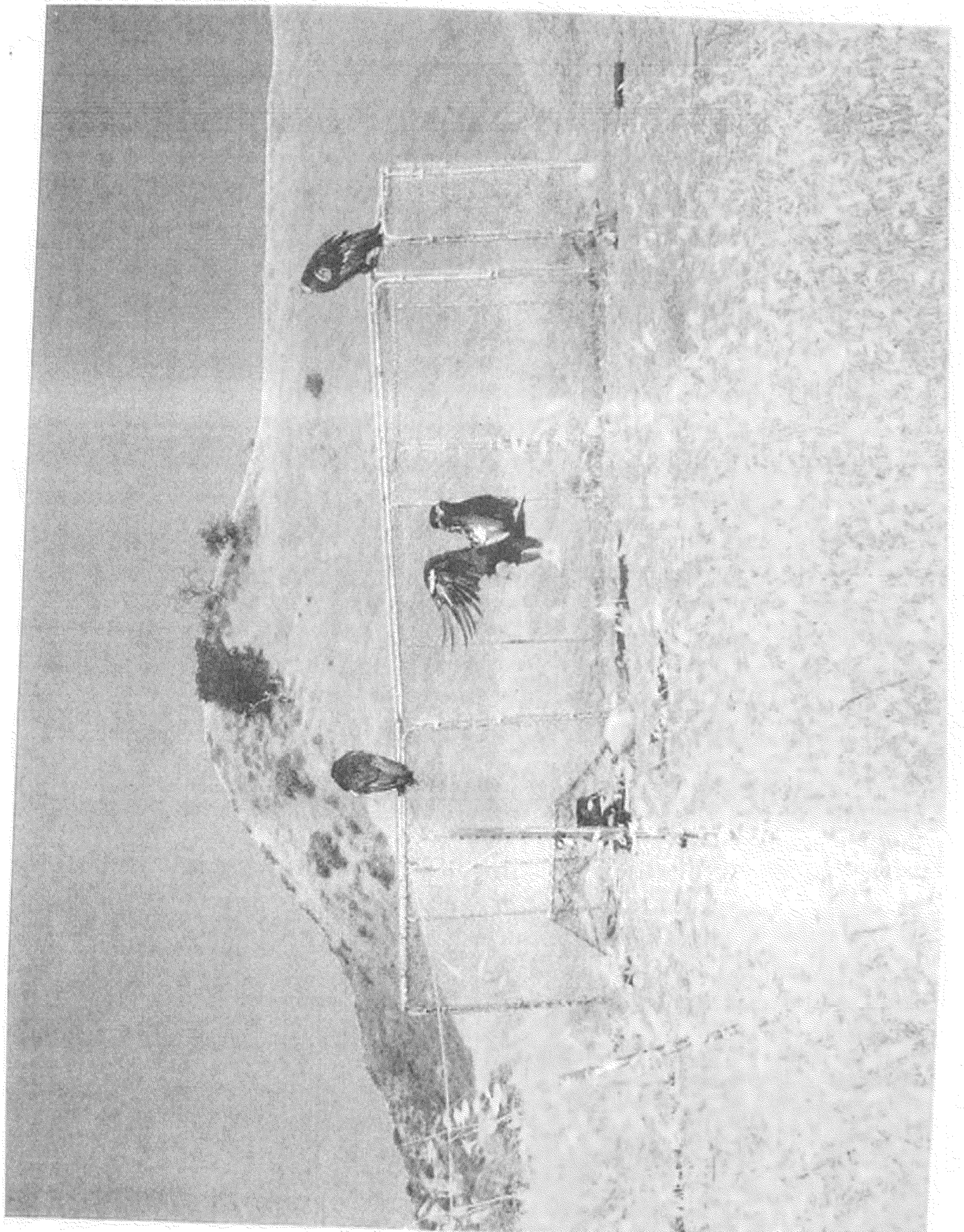

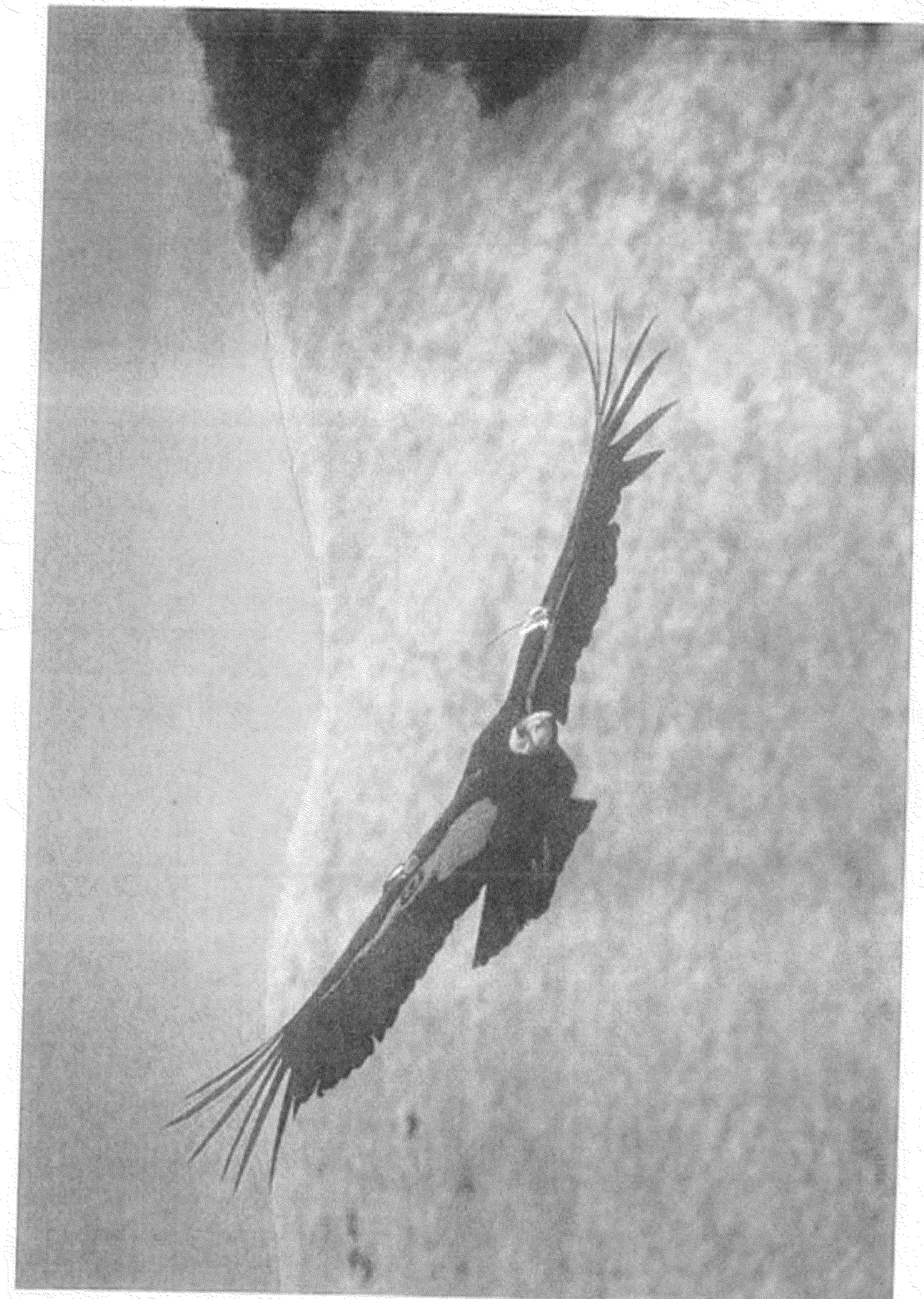

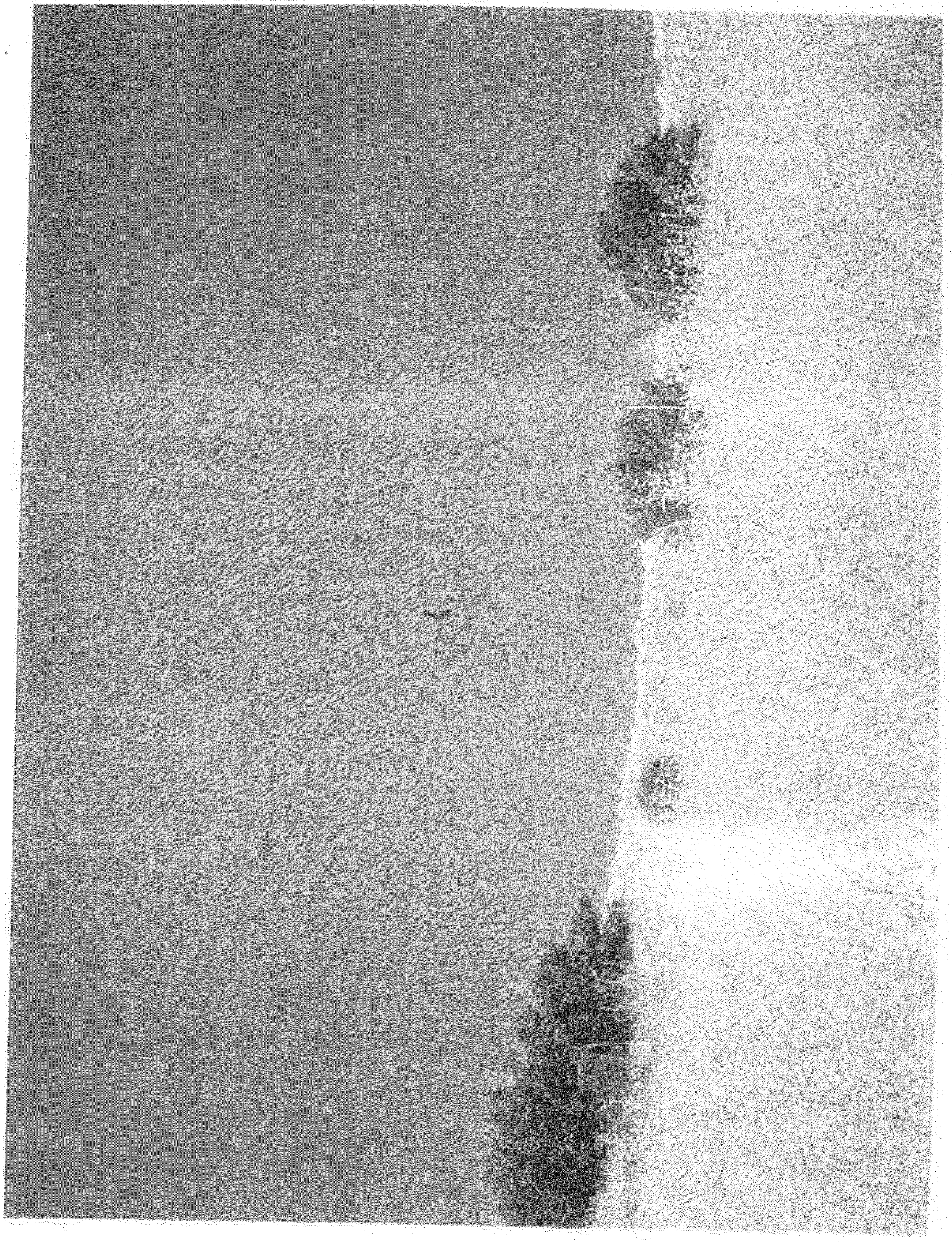

National Wind Coordinating Collaborative

Wind Turbine Interactions with Birds, Bats, and their Habitats:

A Summary of Research Results and Priority Questions

Spring 2010

www.nationalwind.org

This fact sheet summarizes what is known about bird and bat interactions with land-based wind power in North America, including habitat impacts, and what key questions and knowledge gaps remain.

Introduction

Wind energy has gained prominence as a means of generating electricity without emitting air pollutants or greenhouse gases. As the wind spins a wind turbine's blade assembly, known as a rotor, a generator connected to the rotor generates electricity. Large wind turbines generate electricity at a lower cost and higher efficiency than smaller ones, because longer rotor blades capture the energy from a larger cross-section of the wind, known as the rotor-swept area, and because taller towers generally provide access to stronger winds. The greater and more consistent the wind, the more electricity is produced.

Early turbines were mounted on towers 60–80 feet in height and had rotors 50–60 feet in diameter that turned 60–80 revolutions per minute (rpm). Today's land-based wind turbines are mounted on towers 200–260 feet in height with rotors 150–260 feet in diameter, resulting in blade tips that can reach over 425 feet above ground level. Rotor swept areas now exceed 1 acre and are expected to reach nearly 1.5 acres within the next several years. Even though the speed of rotor revolution has significantly decreased to 11–28 rpm, blade tip speeds have remained about the same; under normal operating conditions, blade tip speeds range from 138–182

Photo courtesy of National Renewable Energy Laboratory (NREL), PIX 15223.

Photo courtesy of National Renewable Energy Laboratory (NREL), PIX 15249.

mph. Wider and longer blades produce greater vortices and turbulence in their wake as they rotate, posing a potential problem for bats. Because large turbines are more efficient, most modern wind developments for a given number of megawatts (MW; 1 MW equals 1 million watts) have fewer machines with wider spacing. Still, larger turbines are being developed.

Wind turbines are typically described in terms of their "rated" (or "nameplate") power generating capacity, which can vary from a few hundred watts for home applications to commercial turbines of several MW.[1] A 1.5-MW turbine, a capacity commonly installed in the United States over the past five years, could produce 4.6 million kilowatt-hours (kWh) per year; actual energy generation is dependent upon the wind speeds and wind availability at the site where it is located. Although there are wide regional variations in electricity consumption, a 1.5-MW turbine can generate enough electricity for 300 to 900 households.

Wind energy's ability to generate electricity without many of the environmental impacts associated with other energy sources (e.g., air pollution, water pollution, mercury emissions, climate change) could benefit birds, bats, and many other plant and animal species. However, possible impacts of wind facilities on birds, bats, and their habitats have been documented and continue to be an issue. Populations of many bird and bat species are experiencing long-term declines, due in part to habitat loss and fragmentation, invasive species, and numerous anthropogenic impacts, increasing the concern over the potential effects of energy development.

[1] Nameplate capacity is the maximum rated output of a generator under specific conditions designated by the manufacturer. Installed generator nameplate capacity is commonly expressed in MW.

About the Fact Sheet

This fact sheet summarizes what is known about bird and bat interactions with land-based wind power in North America, including habitat impacts, and what key questions and knowledge gaps remain. It uses a three-tiered classification of wind-wildlife relationships based on the weight of the evidence and agreement, or lack thereof, among researchers in the field on each particular statement contained herein.

"What Studies Have Shown" are conclusions widely supported by peer-reviewed studies and on which there is broad consensus among researchers.

"What Is Less Well Understood" presents ideas reached by some field studies, but either the evidence is too limited to support a firm and broadly applicable conclusion, there is some evidence to the contrary, or there is some controversy regarding the idea among researchers.

"Areas Where Little Is Known" presents questions to which even tentative conclusions cannot yet be reached based on current information and data gaps. These questions are hypotheses yet to be tested or are gaps in current knowledge that have been identified by researchers.

The information presented is restricted to land-based wind facilities. Literature citations supporting the information presented here are denoted in parentheses and found at www.nationalwind.org/publications/bbfactsheet.aspx.

What Studies Have Shown

The number of studies using rigorous methods and research protocols to determine the potential impacts of wind development on birds and bats has increased substantially since the publication of the original NWCC fact sheet in 2004 (NWCC 2004). Impacts on birds and bats have been demonstrated at most facilities, but these impacts vary among facilities and regions.

Studies have indicated that relatively low raptor (e.g., hawks, eagles) fatality rates exist at most wind energy developments with the exception of some facilities in parts of California (Figure 1, page 3). All developments studied have reported fewer than 14 bird (all species combined) fatalities per nameplate MW per year, and most have reported less than 4 fatalities per MW per year (Figure 2, page 3). Although several developments have reported relatively numerous bat fatalities, most studies have reported low rates of such bat fatalities (Figure 3, page 3). However, much uncertainty exists on the geographic distribution and causes of bat fatalities (see discussion under direct mortality).


Photo courtesy of NREL, PIX 16694.

Two general types of local impacts to birds have been demonstrated at existing wind facilities: (1) ***direct mortality*** from collisions and (2) ***indirect impacts*** from avoidance of an area, habitat disruption, reduced nesting/breeding density, habitat abandonment, loss of refugia, habitat unsuitability, and behavioral effects (Stewart et al. 2004, 2007). For bats, only direct mortality resulting from collisions and barotrauma (i.e., experiencing rapid pressure changes that cause severe internal organ damage; Baerwald et al. 2008) has been demonstrated.

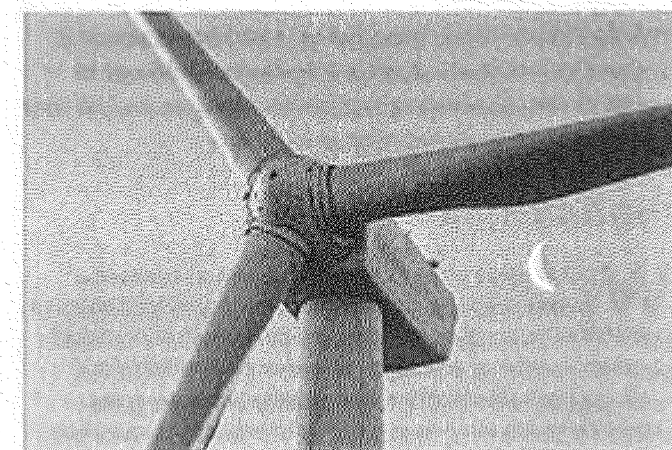
Photo courtesy of NREL PIX 17264.

Direct Mortality

Wind turbines can kill birds and bats.
Birds are sometimes killed in collisions with turbines, meteorological towers, and power transmission lines at land-based wind facilities; turbine-related bat deaths have been reported at each wind facility studied to date (GAO 2005; Kingsley and Whittam 2007; Kunz et al. 2007a; Kuvlesky et al. 2007; NAS 2007; Arnett et al. 2008; see Figures).

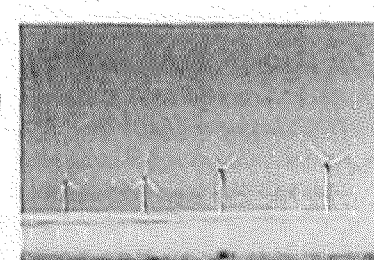
Photo courtesy of NREL PIX 16112.

Fatality rates vary widely regionally across wind resource areas.
Fatalities of birds and bats are highly variable among facilities and regions of the country. For example, more raptors are killed each year at Altamont Pass, California, which has over 5,000 older and smaller turbines and high raptor use, than at other developments where fatality studies have been conducted (GAO 2005; Kingsley and Whittam 2007; Kunz et al. 2007a; Kuvlesky et al. 2007; NAS 2007; Arnett et al. 2008; see Figure 1).

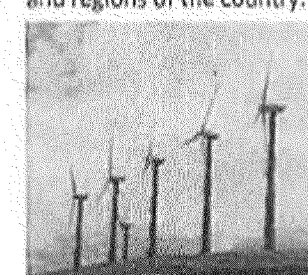
Photo courtesy of Coastergeekperson04, en.wikipedia.

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Figure 1: Summary of Raptor Mortality Rates at Various Wind Energy Facilities*

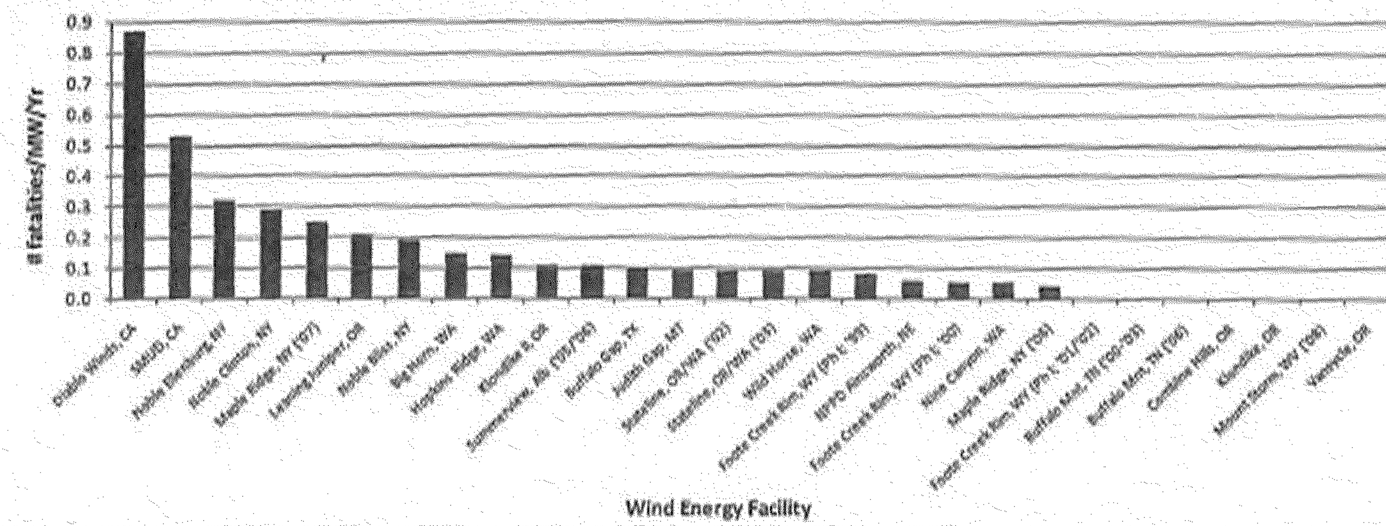


Figure 2: Summary of All Bird Mortality Rates at Various Wind Energy Facilities*

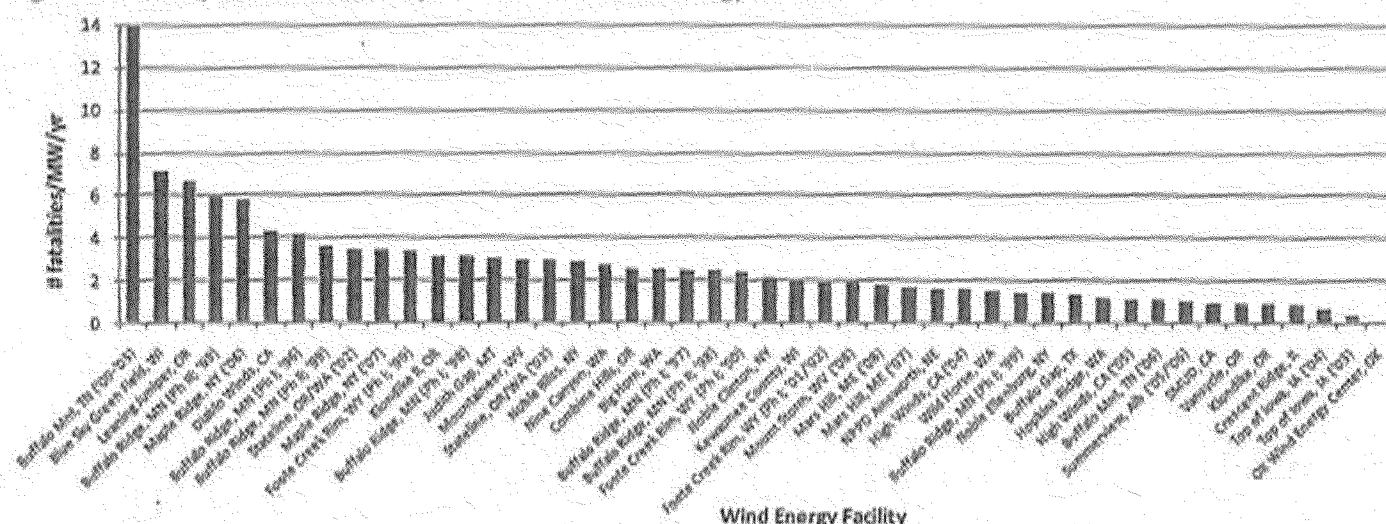
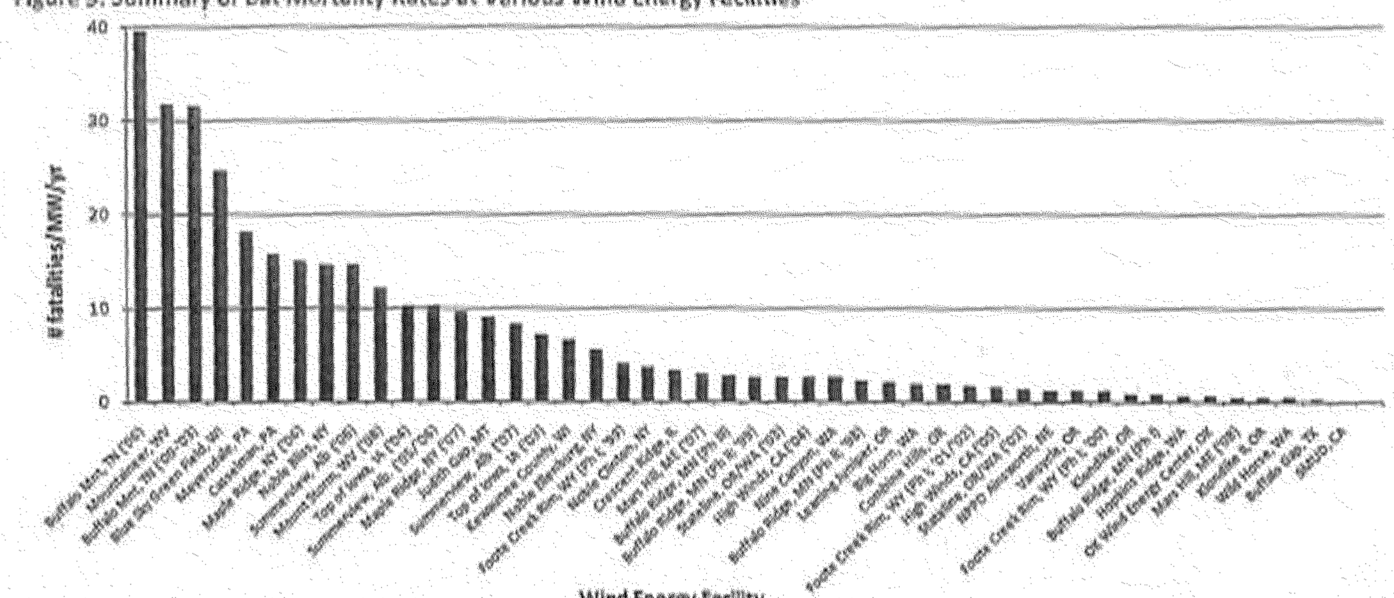


Figure 3: Summary of Bat Mortality Rates at Various Wind Energy Facilities*



*Ph = Phase. References for the data found in the figures can be found at [illegible]. Figures compiled by WEST, Inc., in Spring 2010.

Direct Mortality, cont.

Most birds killed at wind turbines are songbirds.
Most of North America's birds are songbirds, most of these are migratory, and most of the migratory species migrate during the night at altitudes generally above rotor swept areas when weather conditions are favorable. Risk may be greatest during take-off and landing where wind facilities abut stopover sites. Songbirds are vulnerable to colliding with man-made structures such as buildings, communication towers, power lines, or wind turbines during poor weather conditions that force them to lower altitudes (Winkelman 1995; Gill et al. 1996; Erickson et al. 2001; Johnson et al. 2002; Robbins 2002; Kerlinger 2003; Manville 2009). Songbird collisions typically account for roughly three quarters of bird casualties at U.S. wind facilities (Erickson et al. 2001; Johnson et al. 2002) and result in spring and fall peaks of bird casualty rates at most wind facilities (Johnson et al. 2002; Erickson et al. 2004). However, current turbine-related fatalities are unlikely to affect population trends of most North American songbirds (NAS 2007; Kingsley and Whittam 2007; Kuvlesky et al. 2007; Manville 2009).

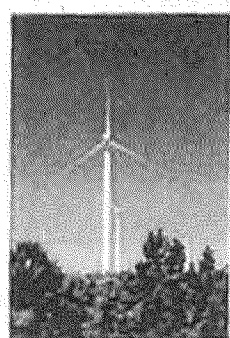


Photo courtesy of NREL, PIX 16708.

The estimated cumulative impact of collisions with wind turbines is several orders of magnitude lower than the estimated impacts from the leading anthropogenic causes of songbird mortality.
Although only general estimates are available, the number of birds killed in wind developments is substantially lower relative to estimated annual bird casualty rates from a variety of other anthropogenic factors including vehicles, buildings and windows, power transmission lines, communication towers, toxic chemicals including pesticides, and feral and domestic cats (Erickson et al. 2001; NAS 2007; Manville 2009). Collisions with wind facility structures will likely increase relative to other anthropogenic structures as the number of wind power facilities increases.

Some migratory tree-roosting bat species appear particularly vulnerable to wind power.
Several species of bats are vulnerable to collisions with turbines. Three migratory tree-roosting species – the Hoary Bat, the Eastern Red Bat, and the Silver-haired Bat – currently compose the majority of bats reported killed at wind facilities in most regions of North America (NAS 2007; Johnson 2005; Kunz et al. 2007a; Arnett et al. 2008). These species are not currently classified as threatened or endangered, but this pattern of higher collisions among certain species may change as more facilities are developed and studied.

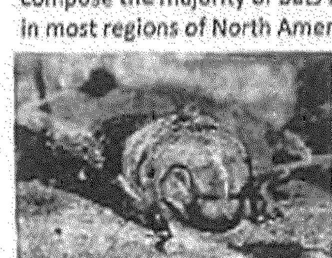


Photo courtesy of William Leonard, NPS.


Photos courtesy of US Fish and Wildlife Service.

Bat fatalities peak at wind facilities during the late summer and early fall migration.
All studies of bat impacts have demonstrated that fatalities peak in late summer and early fall, coinciding with the migration of many species (Johnson 2005; Kunz et al. 2007a; Arnett et al. 2008). A smaller spike in bat fatalities occurs during spring migration for some species at some facilities (Arnett et al. 2008). However, the seasonal fatality peaks noted above may change as more facilities are developed and studied.

There are two significant factors important in assessing fatality risk to birds.
Studies have indicated that the level of bird use at the site and the behavior of the birds at the site are important factors to consider when assessing potential risk. For example, raptor fatalities appear to increase as raptor abundance increases. Certain species (e.g., Red-tailed Hawks and Golden Eagles) that forage for prey in close proximity to turbines appear to have increased fatalities, while others like common ravens appear to avoid collisions with turbines (Erickson et al. 2002; Anderson et al. 2004, 2005; Kingsley and Whittam 2007; Kuvlesky et al. 2007; NAS 2007).

The lighting currently recommended by the Federal Aviation Administration (FAA) for installation on commercial wind turbines does not increase collision risk to bats and migrating songbirds.
The FAA regulates the lighting required on structures of over 199 feet in height above ground level to ensure safe air traffic. The FAA currently recommends strobe or strobe-like lights that produce momentary flashes interspersed with dark periods up to 3 seconds in duration as lighting for commercial wind turbines, and they allow commercial wind facilities to light a proportion of the turbines in a facility (e.g., one in five), firing all lights synchronously (FAA 2007). Red strobe or strobe-like lights are frequently used. Such lighting does not appear to influence bat and songbird fatalities (Avery et al. 1976; Arnett et al. 2008; Longcore et al. 2008; Gehring et al. 2009; Manville 2009).

Indirect Impacts

Siting turbines away from where raptors concentrate may reduce raptor collision rates at wind facilities.
Raptors are known to concentrate along ridge tops, upwind sides of slopes, and canyons to take advantage of wind currents that are favorable for hunting and traveling, as well as for migratory flights (Bednarz et al. 1990; Curry and Kerlinger 1998; Barrios and Rodriguez 2004; Hoover and Morrison 2005; Manville 2009).

What Is Less Well Understood

Pre-development site evaluation may reduce potential negative impacts on wildlife.

A pre-construction evaluation conducted at a potential wind site can help indicate whether a wind power development is likely to cause avian and bat impacts at levels of concern, help determine sites to avoid, and help to design a less impactful project. Such evaluations with respect to the site can include assessments of relevant existing information, physical inspections, and use of direct observation and technological methods designed to document levels of bird and bat use and behavior (Anderson et al. 1999; Kunz et al. 2007b). There is not currently a strong linkage between pre-construction assessment of activities and post-construction fatalities. Therefore, additional work is needed to determine which pre-construction surveys of bird or bat use correlate and better align with post-construction fatalities. It remains unclear on how best to use pre-construction site assessments for siting and development decisions and how best to align these assessments with post-construction monitoring, including the types of data to collect and the duration and intensity of study.

Birds

Siting turbines in areas of low prey density may reduce raptor collision rates at wind facilities.

A high density of small mammal prey and the conditions favorable to high prey densities (Smallwood and Thelander 2004, 2005, 2008) have often been presumed to be the main factors responsible for the high raptor use, and hence high raptor collision rates at the Altamont Pass wind facility (Kingsley and Whittam 2007; Kuvlesky et al. 2007; NAS 2007).

Photo courtesy of NREL, PIX 12704.

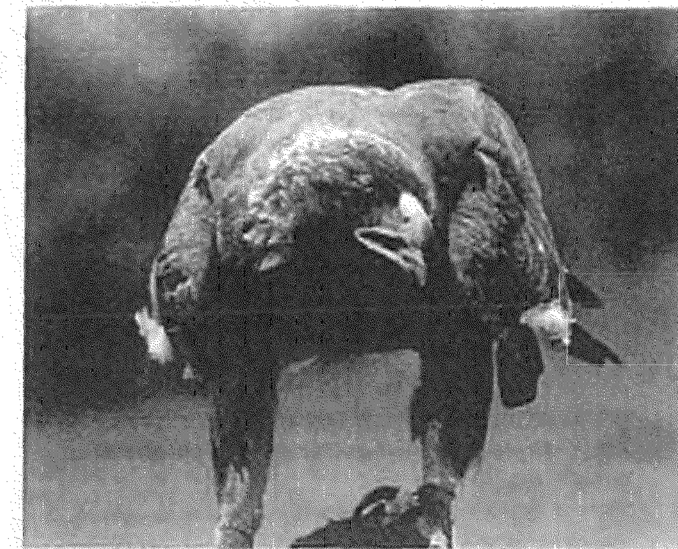


Photo courtesy of J. Glover, Wikimedia commons.

Using newer monopole tubular support towers rather than lattice support towers associated with older designs may reduce raptor collision rates at wind facilities.

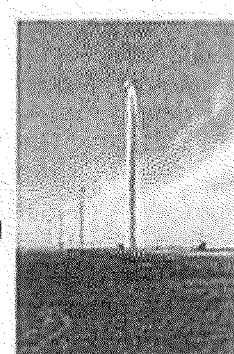


Photo courtesy of NREL, PIX 17015.

Lattice support towers offer many more perching sites for raptors than do monopole towers, and hence may encourage high raptor occupancy in the immediate vicinity, or rotor swept area, of wind turbines (Orloff and Flannery 1992; NAS 2007). Most utility-scale wind turbines installed in North America today have monopole towers. Because the transition to monopole tubular support towers has largely coincided with a number of other transitions in turbine technology and siting practice, it is difficult to separate the individual effects and thereby determine the degree to which the type of support tower affects raptor collision rates. Larger turbines invariably use tubular tower supports.

Newer, larger (≥500 kW) turbines may reduce raptor collision rates at wind facilities compared to older, smaller (40 to 330kW) turbines, but have uncertain effects on songbirds.

Larger turbines have fewer rotations per minute but have similar blade tip speeds compared to the smaller turbines commonly used in older U.S. wind facilities (NAS 2007). This difference may be partly responsible for the lower raptor collision rates observed at most wind facilities where larger turbines have been installed (NAS 2007). Additionally, fatalities could be fewer because fewer larger turbines are needed to produce the same energy as smaller turbines. However, because the transition to larger turbines has largely coincided with a number of other transitions in turbine technology and siting practice, it is difficult to separate the individual effects and thereby determine the degree to which turbine size affects raptor collision rates.

Birds, cont.

Waterbird and waterfowl collision risk at land-based wind facilities is typically low.

Limited information exists on wind turbine collision risk of waterbirds and waterfowl because of limited experience with coastal wind facilities, particularly in the United States (GAO 2005; Kingsley and Whittam 2007; NAS 2007). Most, but not all, bird collision studies at land-based and non-coastal wind facilities to date have reported low rates of waterbird and waterfowl collisions (Everaert 2003; Kingsley and Whittam 2007).

Wind turbines in grassland and shrub-steppe environments may cause some displacement of prairie grouse.

Various species of grassland and shrub-steppe grouse, including Sage Grouse, Sharp-tailed Grouse, Lesser Prairie-chicken, and Greater Prairie-chicken, are of particular concern because they exhibit high site fidelity and require extensive grasslands and open horizons (Giesen 1994; Fuhlendorf et al. 2002). The concern is even greater because of population declines over the past 30 years, and because prairie grouse distributions intersect with some of the continent's prime wind generation regions (Weinberg and Williams 1990). The availability of contiguous unfragmented habitat for prairie grouse is critical in order to provide connectivity among local populations (Woodward et al. 2001). In addition to habitat disruption concerns from wind energy development, prairie grouse may also be displaced by wind turbines; specifically, many of these species are known to avoid displaying, nesting, or brooding within close proximity to roads, utility poles or lines, trees, oil and gas platforms, and/or human habitations. Estimates of this proximity vary; it is less well understood if the impacts that these structures have on prairie grouse also apply to wind developments (Manes et al. 2002; Manville 2004; Robel 2004; Kingsley and Whittam 2007; Kuvlesky et al. 2007). It is commonly assumed that prairie grouse would also avoid wind turbines, although the magnitude of this avoidance is unknown.

Photo courtesy of South Dakota Department of Tourism.

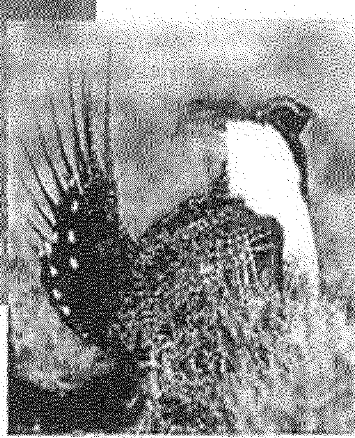


Photo courtesy of US Fish and Wildlife Service.

Bats

Weather patterns may influence bat fatalities.

Some studies demonstrate that bat fatalities occur primarily on nights with low wind speed and typically increase immediately before and after the passage of storm fronts. Weather patterns therefore may be a predictor of bat activity and fatalities, and mitigation efforts that focus on these high-risk periods may reduce bat fatalities substantially (Arnett et al. 2008).

More adults and more male bats tend to be killed by wind turbines.

Photo courtesy of National Park Service (NPS).

Although this pattern has been documented at a number of facilities, it may represent an idiosyncrasy of the three species most commonly killed during their fall migration in North America (see page 4). Furthermore, the pattern of adult fatalities may not necessarily reflect increased susceptibility of adults, but rather a preponderance of adults in the populations. There are notable exceptions, and some studies have reported female and juvenile bias among bat fatalities (e.g., Brown and Hamilton 2004, 2006a, 2006b; Fiedler 2004; Fiedler et al. 2007). It has recently been hypothesized that migratory tree bats (e.g., Hoary and Eastern Red Bats) may exhibit lek mating systems,[2] so that males may be congregating around turbines during autumn in an effort to attract females (Cryan and Brown 2007; Cryan 2008).

Bat fatalities in the southwestern United States are poorly understood but the Brazilian Free-tailed Bat appears to be vulnerable.

Photo courtesy of NPS.

The Brazilian Free-tailed Bat comprised a large proportion (41–86%) of the bats killed at developments within this species' range (Arnett et al. 2008; Miller 2008).

Curtailment of operations during high risk periods may substantially reduce bat fatalities.

Scientists have hypothesized that bat fatalities could be lowered substantially by reducing the amount of turbine operating hours during low wind periods when bats are most active. This can be done by increasing the minimum wind speed, known as the "cut-in" speed, at which the turbine's blades begin rotating to produce electricity. Three studies worldwide (one each in Germany [O. Behr, University of Hanover, unpublished data], Canada [Baerwald et al. 2009], and the United States [Arnett et al. 2009]) have tested whether or not increasing the minimum turbine cut-in speed reduces bat fatalities. These studies demonstrated that bat fatalities were reduced by 50 to 87%. While these studies indicate that reduction in bat fatalities can be achieved with modest reduction in power production, more studies are needed to determine the cost-effectiveness of this mitigation

[2] A lek is a gathering of males, of certain animal species, for the purposes of competitive mating display.

Areas Where Little Is Known

As the wind industry continues to expand, what is the cumulative impact of bird and bat collisions on some species and/or local populations?

The relationship of current fatalities to the demographics of bird and bat populations is poorly understood, but it is unlikely that current fatalities are causing declines in populations (NAS 2007). However, as wind energy facilities become substantially more numerous and as wind development continues to grow, fatalities and thus the potential for biologically-significant impacts to local populations increases (NAS 2007; Erickson et al. 2002; Manville 2009).


Photo courtesy of NREL, PIX 06328.

Current research indicates that wind facilities located in agricultural habitats generally have lower migrant songbird and bat fatality rates than facilities in forested landscapes, but it is unclear if this correlation is caused by the difference in habitat type.

Reduced fatalities in agricultural areas may be related to fewer songbirds being present. However, there are fewer studies in some landscapes (e.g., forests), limiting the ability to make landscape comparisons (Kunz et al. 2007a; Kuvlesky et al. 2007; NAS 2007; Arnett et al. 2008). Bat fatalities in agricultural lands may be relatively high (Jain 2005).

Does turbine height have an impact on the collision rate for songbirds and bats?

Taller turbines reach higher above the ground, have much larger rotor swept areas, and thus further overlap the normal flight heights of nocturnal migrating songbirds and bats (Morrison 2006; Barclay et al. 2007; Johnson et al. 2002; Manville 2009). Larger, taller turbines and their wider and longer blades also produce far greater blade-tip vortices and blade wake turbulence; the potential influence on collisions with birds and bats and barotrauma to bats is uncertain. Collision risk might also increase during inclement weather events that coincide with bird migration (Manville 2009).

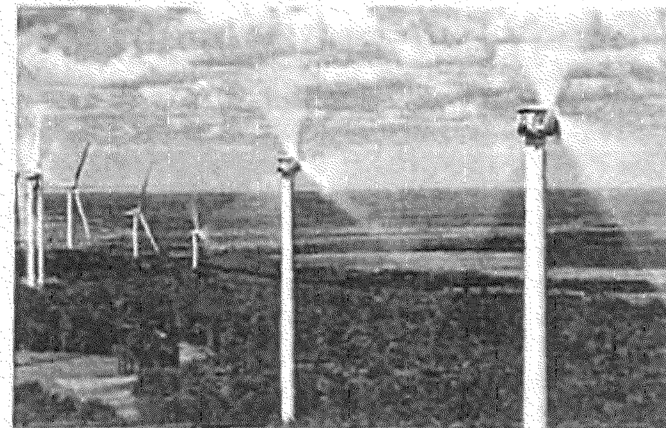


Photo courtesy of NREL, PIX 16051.

Can wind turbines be designed in such a way as to render them easier for birds to see and avoid?

Two hypothetical mitigation methods based on avian vision have been proposed to reduce bird collisions with wind turbines. Motion smear, in which the spinning action of the turbines may render the blades difficult for birds to see and avoid, may be reduced by painting blades with a color pattern that makes them more visible (Hodos et al. 2001; Hodos 2003). It has been hypothesized that towers and blades coated with ultraviolet (UV) paint may be more visible, making them easier to avoid. However, Young et al. (2003) compared fatality rates at turbines with UV coatings to turbines coated with standard paint and found no difference. Few data are available on the effectiveness of these and other potential methods for making turbines more visible to birds.

What is the effect of barotrauma injuries to bats?

While direct collision is thought to be responsible for most of the bat fatalities observed at wind facilities (Horn et al. 2008), recent work by Baerwald et al. (2008) suggests that some of the observed bat fatality may be due to barotrauma (i.e., injury resulting from suddenly altered air pressure). Fast-moving wind turbine blades create vortices and turbulence in their wakes, and bats may experience rapid pressure changes as they pass through this disturbed air, potentially causing internal injuries leading to death. The occurrence of barotrauma in bats, the proportion of individuals that succumb immediately versus those that fly away injured, and the associated influences on the estimation of bat fatalities are uncertain.


Photo courtesy of US Fish and Wildlife Service.

To what extent will wildlife become habituated to wind facilities?

Kerlinger (2000) reported that prairie songbirds increased in abundance within a wind facility in years following construction, suggesting habituation,[3] but there is no other empirical evidence currently to support the habituation hypothesis. Additional research is needed to confirm whether habituation results in a long-term reduction in the displacement of birds by wind facilities.

[3]Habituation describes a decrease in response to a stimulus after repeated exposure.

Areas Where Little Is Known, cont.

Do topography, geography, land cover type, and proximity to key resources influence bat fatality rates?
There is a need to better relate bat fatalities among wind facilities to landscape characteristics (e.g., geology, topography, habitat types, proximity of facilities to features such as mountain ranges or riparian systems). Relating fatalities to features within the immediate area of a turbine (e.g., proximity to water or forest edge) will help with designing future facilities and locating turbines to avoid higher risk areas within a site. (Kunz et al. 2007a; Kuvlesky et al. 2007; NAS 2007; Arnett et al. 2008)

The significance of bat fatalities is poorly understood.
Bats are long-lived and have low reproductive rates, making populations susceptible to localized extinction (Barclay and Harder 2003; Jones et al. 2003). Some have suggested that bat populations may not be able to withstand the existing rate of wind turbine fatalities (Kunz et al. 2007a; NAS 2007; Arnett et al. 2008) and/or increased fatalities as the wind industry continues to grow. Because population sizes are poorly known, it is difficult to determine whether bat fatalities at wind facilities represent a significant threat to North American bat populations, although cumulative impacts raise concern and more studies are needed to assess population impacts (NAS 2007; Kunz et al. 2007a; Arnett et al. 2008).

Federal laws applicable to wildlife and wind developments include the following:

- Migratory Bird Treaty Act (16 U.S.C. 703-712) as amended
- Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d) as amended
- Endangered Species Act (16 U.S.C. 1531-1544)

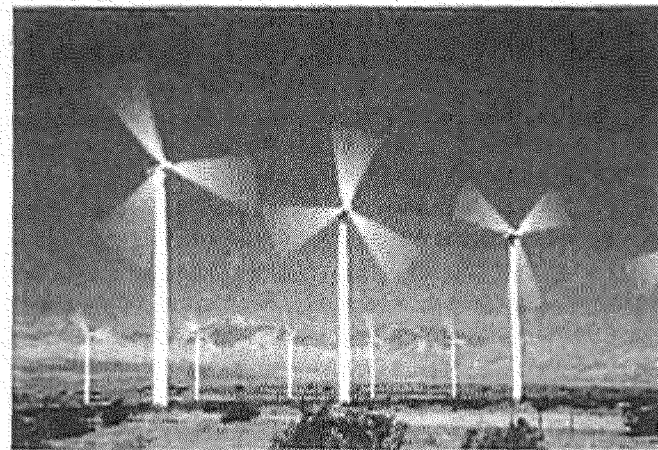


Photo courtesy of NREL, PIX 16110.

Are bats attracted to wind turbines, and if so, what are the primary attraction factors?
Bats appear to be attracted to wind turbines (Horn et al. 2008), and there are several plausible hypotheses that warrant testing as to how and why bats may be attracted to turbines (Kunz et al. 2007a), which may prove useful for developing new solutions to prevent collisions. Reasons for apparent attraction may include sounds produced by turbines, a concentration of insects near turbines, and bats attempting to find roost locations. For Hoary and Eastern Red Bats, additional studies need to be performed to better understand lek mating systems in these two species, especially regarding attraction to turbines.

To what degree does siting of wind facilities within migratory routes of birds and bats contribute to collision risk?
There is a need to conduct studies to identify migratory pathways, congregation areas such as staging and stopover habitats, and other areas of high concentration to aid in risk assessment and avoidance of high risk sites when developing wind power. Species such as Golden Eagles tend to migrate at or below ridge lines, potentially putting these species at risk if turbines are built in these ridge areas (Manville 2009).

About the National Wind Coordinating Collaborative

The National Wind Coordinating Collaborative (NWCC) is a consensus-based network of stakeholders formed in 1994 to support the development of environmentally, economically, and politically sustainable commercial markets for wind power. The mission of the NWCC Wildlife Workgroup is to identify, define, discuss, and through collaboration address wind-wildlife and wind-habitat interaction issues by seeking broad stakeholder involvement on scientific and public policy questions. In addition to convening biennial meetings on the state of the art in wind-wildlife research, the workgroup seeks to provide reference documents as a resource to stakeholders.

Literature Cited and Other Bibliographic Materials

Please go to www.nationalwind.org/publications/bbfactsheet.aspx to access the literature that supports information presented herein and obtain other background information.

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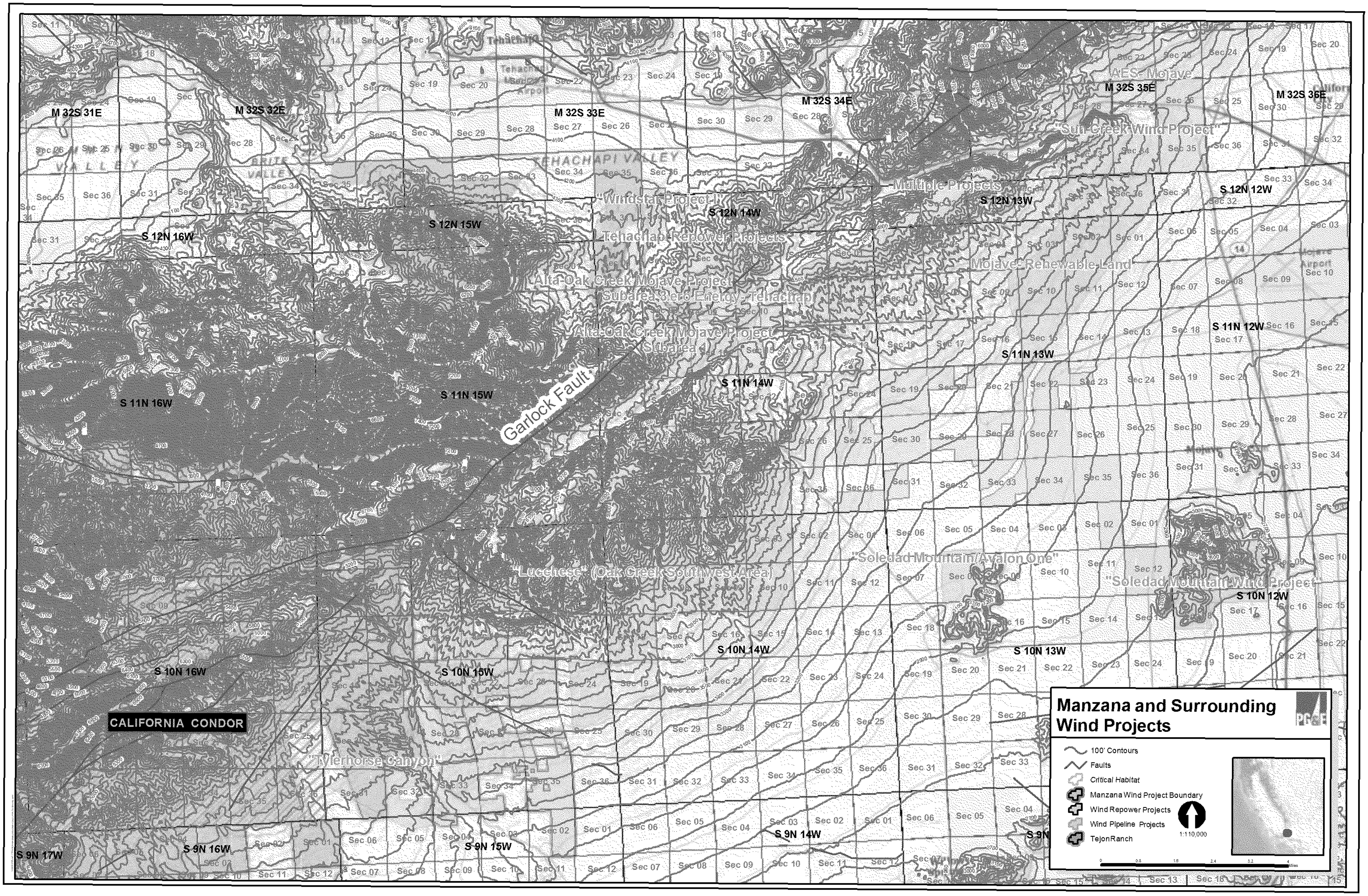
Manzana and Surrounding Wind Projects
100' Contours
Faults
Critical Habitat
Manzana Wind Project Boundary
Wind Repower Projects
Wind Pipeline Projects
TejonRanch
1:110,000
CALIFORNIA CONDOR
Garlock Fault
TEHACHAPI VALLEY
"Windstar Project I"
Tehachapi Repower Projects
Alta Oak Creek Mojave Project
Subarea 3ero Energy - Tehachapi
Alta Oak Creek Mojave Project
Subarea
"Lucchese" (Oak Creek Southwest Area)
"Tylerhorse Canyon"
"Soledad Mountain/Avalon One"
"Soledad Mountain Wind Project"
Mojave Renewable Land
Multiple Projects
"Sun Creek Wind Project"
AES-Mojave
M 32S 31E
M 32S 32E
M 32S 33E
M 32S 34E
M 32S 35E
M 32S 36E
S 12N 16W
S 12N 15W
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