FINAL

ENVIRONMENTAL ASSESSMENT

RESERVE MILITARY OPERATIONS AREA

NEW MEXICO

Prepared For:

TACTICAL AIR COMMAND

December 1989

Air Force
Environmental Planning Division
(HQ USAF/CEVP)

Room 5B269
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16 JUL 93

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FINDING OF NO SIGNIFICANT IMPACT

The U.S. Air Force proposes to continue using the Reserve Military Operations Area (MOA) in Catron County of west New Mexico for supersonic operations. The 49th Tactical Fighter Wing (TFW) at Holloman Air Force Base (AFB), New Mexico, has been flying supersonic operations above 15,000 feet (ft) mean sea level (MSL) in the MOA since January 1985. The majority of the operations will continue to be conducted in the F-15 aircraft. Occasionally, other fighter aircraft may use the airspace but their usage is negligible in comparison to the F-15s, and consequently, would result in no appreciable change from the evaluation and analysis for the F-15 aircraft.

The Air Force also proposes to grant permanent authority for supersonic operations in the Reserve MOA and to periodic reviews of three years or less if any significant changes in operations and environmental conditions occur in the MOA.

The Record of Decision (ROD) allowing supersonic operations in the Reserve MOA stipulated: (1) Supersonic flight be limited to weekday, daylight operations of the 49th TFW and selected adversaries above 15,000 feet MSL, not to exceed 300 sorties per month in each MOA, (2) WSMR be first priority for supersonic training with the overflow equally divided between the Valentine and Reserve MOAs, (3) supersonic operations be confined to 22 X 28 mile elliptical areas, (4) supersonic flight not be conducted within five miles of the specific population centers, and (5) complaints and damage claims be resolved promptly. These operational restrictions resulted from a lack of definitive data to describe impacts of sonic booms. To this extent the research was conducted and the supersonic model used for predicting overpressures was validated as part of this environmental document.

The WSMR data shows the Oceana analysis, of data collected in the Warning Area 72 (Oceana MOA) off the coast of North Carolina, had over predicted noise impacts by ten decibels or more.

The mission of the 49th TFW is to maintain a state of readiness of personnel and equipment in order to conduct worldwide air superiority operations against enemy aircraft. The majority of the operations will be conducted in the F-15 aircraft although small numbers of other aircraft may participate in the exercises as well. An essential element in the effective accomplishment of this mission is realistic air combat training. Recent military experience indicates that combat crew effectiveness and the ability to survive hostile environments are directly related to the quality and quantity of previous training received.

Airspace requirements for the F-15 aircraft dictate the use of large supersonic operating areas to realistically employ the aircraft in the role for which it was designed and procured. To accomplish Tactical Air Command directed mission requirements and maintain a high level of unit combat capability, approximately 85 percent of the F-15 sorties need airspace set aside for supersonic flight. The F-15 missions require training in areas set aside for supersonic flight so that the aircraft can utilize the supersonic flight capabilities during training. Supersonic flight regime is characterized by decreased maneuverability and high closure rates. By eliminating speed restrictions, pilots are able to concentrate on the tactical situation of actual encounters and mission effectiveness is greatly enhanced.

It is the policy of the U.S. Air Force, as specified in Air Force Regulation 55-34, Reducing Flight Disturbances, that supersonic operations be conducted over open water areas above 10,000 ft. MSL, to the maximum extent practicable. Overland supersonic flight is normally conducted above flight level 300 (30,000 ft. MSL). Deviations from the above supersonic flight policy, as in the case of the Reserve MOA requires exception to this policy.

There are numerous alternatives to the proposed action, most of which either (1) utilize existing MOAs within 150 NM of Holloman AFB, (2) utilize existing supersonic airspace outside 150 NM of Holloman AFB by the refueling or temporarily deploying aircraft to another base, (3) create a new MOA capable of handling supersonic operations within 150 NM of Holloman AFB, and (4) invoke the no action alternative. Population concentration, conflicts with other operations (including commercial traffic), size and availability negate using existing MOAs within 150 NM of Holloman AFB. Time, cost, personnel relocation, availability, and quick reaction deployment posture are all factors which diminish the viability of utilizing existing airspace outside 150 NM of Holloman AFB. The feasibility for establishing a new MOA for T-38 and/or F-15 operations is very unlikely due to the number of existing MOAs, restricted areas, and high/low altitude airways. The no action alternative would result in a jeopardized mission for the 49th TFW with reduced and degraded training accommodations.

The total requirements of the 49th TFW is 1200 supersonic sorties per month. Only 300 such sorties are proposed at the Reserve MOA. The shortfall of 900 sorties per month are proposed for WSMR and Valentine MOA. Each of these operations is addressed in individual environmental documents.

The preferred alternative is the proposed action of conducting 300 supersonic sorties per month at the Reserve MOA. Implementing the proposed action contributes to fulfillment of the 49th TFW mission without serious adverse impact to the public, federal or state environmentally sensitive areas; natural resources; or any threatened or endangered species. In addition, the proposed action will not have a significant effect upon the natural or manmade environment, nor will it constitute a major federal action of significant magnitude to warrant preparation of an Environmental Impact Statement.

SUMMARY

1. Description of Proposed Action:

The 49th Tactical Fighter Wing (TFW) at Holloman AFB, New Mexico, proposes to continue to conduct approximately 300 supersonic sorties per month in the Reserve Military Operating Area/Air Traffic Control Assigned Airspace Area (MOA/ATCAA). The Reserve MOA is located in Catron County in west New Mexico.

The Air Force also proposes to grant permanent authority for supersonic operations in the Valentine MOA but with periodic reviews of three years or less as operations and environmental conditions change.

The Record of Decision (ROD) allowing supersonic operations stipulated: (1) Supersonic flight be limited to weekday, daylight operations of the 49th TFW and selected adversaries above 15,000 feet MSL, not to exceed 300 sorties per month in each MOA, (2) WSMR be first priority for supersonic training with the overflow equally divided between the Valentine and Reserve MOAs, (3) supersonic operations be confined to 22 X 28 mile elliptical areas, (4) supersonic flight not be conducted within five miles of the certain population centers, and (5) complaints and damage claims be resolved promptly. These operational restrictions were imposed because of a lack of definitive data to describe impacts of sonic booms. To this extent research was conducted and the supersonic model used for predicting overpressures was validated.

2. Purpose and Need:

The mission of the 49th TFW is to maintain a state of readiness of personnel and equipment in order to conduct worldwide air superiority operations against enemy aircraft. The majority of the operations will be conducted in the F-15 aircraft although small numbers of other aircraft may participate in the exercises as well. An essential element in the effective accomplishment of this mission is realistic air combat training. Recent military experience indicates that combat crew effectiveness and the ability to survive hostile environments are directly related to the quality and quantity of previous training received.

Airspace requirements for the F-15 aircraft dictate the use of large supersonic operating areas to realistically employ the aircraft in the role for which it was designed and procured. To accomplish Tactical Air Command directed mission requirements and maintain a high level of unit combat capability, approximately 85 percent of the F-15 sorties need airspace set aside for supersonic flight. The F-15 missions require supersonic airspace so that the aircraft can utilize the supersonic flight regime capabilities during training. Supersonic flight regime is characterized by decreased maneuverability and high closure rates. By eliminating speed restrictions, pilots are able to concentrate on the tactical situation of actual encounters and mission effectiveness is greatly enhanced.

It is the policy of the U.S. Air Force, as specified in Air Force Regulation 55-34, Reducing Flight Disturbances, that supersonic operations be conducted over open water areas above 10,000 ft. MSL, to the maximum extent practicable. Overland supersonic flight is normally conducted above flight level 300 (30,000 ft. MSL). Deviations from the above supersonic flight policy, as in the case of the Reserve MOA, require exception from this policy.

3. Environmental Impacts:

The environmental impacts associated with the proposed action are a result of the aircraft flying greater than the speed of sound. The amount of time the aircraft would be supersonic is about one-half minute per sortie and is about two percent of the time currently spent in the MOA. The pollutants produced from aircraft operation would be emitted at a relatively high altitude and spread over a large area; consequently, the impact on local ambient air quality would be minor.

The primary impact and concern of local residents are the effects of sonic booms on people, domestic animals and wildlife, archeological sites, structures, and local economics. The Air Force had previously performed an intensive literature review on these various sonic boom effects. As stipulated, a sonic boom study was conducted and model developed in conjunction with this document to assess the magnitude of the impacts to the various environmental attributes.

The sonic boom study and analytical model was developed at White Sands Missile Range and applied to the Reserve MOA. Sorties during the study averaged 550 per month. At WSMR the average peak overpressure was less than 1.0 pounds per square foot (psf). The number of sonic booms experienced per day ranged from 0.6 near the center of the airspace to 0.2 at the fringes. C-weighted day-night noise levels (CDNL) ranged from 50 dB at the center of the airspace to 40 dB along the fringes. For 300 sorties as proposed at the Reserve MOA, the number of sonic booms heard at any location would decrease by about a factor of two while the CDNL levels would decrease by 0.3 dB. This resulting CDNL value (47.0 dB) is well within the EPA acceptability criteria for human annoyance. The average person outside the MOA would be expected to hear one sonic boom every ten days.

Sonic boom effects on domestic animals and wildlife has been evaluated. Species of special concern are the Peregrine falcon and bald eagle (both endangered), sheep, horses, and beef cattle. Review of available literature, information obtained on species response to sonic booms in other areas and special studies conducted for coordination under the Endangered Species Act indicate supersonic flight in the Reserve MOA will not significantly impact domestic animals or wildlife in the area. The Fish and Wildlife Service has concluded the proposed action will not jeopardize the continued existence of the Peregrine falcon. While the bald eagle is known to winter in the Centerfire Bog area, the area is remote from the supersonic maneuvering ellipse and consequently should not be affected.

Bighorn sheep on the Luke and Nellis AF Ranges have been exposed to sonic booms for a number of years. No noticeable effects in the population age structure, longevity, or reproduction success has been found for the sheep on the Nellis AF Range.

Domestic animals such as cattle, horses, sheep, and poultry show very little behavioral effect from exposure to sonic booms. Available literature and special studies reviewed support the fact that animals and wildlife can and do flourish in the presence of military aircraft operations, both subsonic and supersonic. Fletcher concludes if subsonic aircraft noise (excluding sonic booms) were an adverse impact areas around large airports would be devoid of wildlife. This is also true for military operating areas and it should be noted that noise levels in MOAs are normally less than that at busy commercial airports and military airfield with jet activity.

Previously collected data related to the impact of sound induced vibrations on both modern and historical structures indicate that overpressures of 1 to 3 psf are significantly lower than the levels generally accepted as capable of damaging modern structures. Recent studies both in Europe and the American southwest have recommended 2.0 mm/sec. particle velocity to be the upper limit for induced motions in historic structures. Other studies indicate that sonic boom overpressures of less than 5 psf will result in particle velocities within this safe range. Consequently, if the overpressures resulting from Air Tactical Maneuvering are within the 1-3 psf range as indicated by the recent White Sands Boom Monitoring Project (average peak overpressure = 0.673 psf; maximum peak overpressure = 3.523 psf), there will be no impact to any of the classes of historic and archeological resources within the Reserve MOA.

The potential for sonic boom impact on the local economy has been evaluated and determined not to be significant. The evaluation included a review of population, employment, personal income retail trade, assessed valuation, real estate development, tourism, ranching, farming, mining, and forestry. In no case did any of the areas economic attributes indicate sonic booms would result in significant impact.

4. Alternatives:

There are numerous alternatives to the proposed action, most of which either (1) utilize existing MOAs within 150 NM of Holloman AFB, (2) utilize existing supersonic airspace outside 150 NM of Holloman AFB by the refueling or temporarily deploying aircraft to another base, (3) create a new MOA capable of handling supersonic operations within 150 NM of Holloman AFB, or (4) invoke the no action alternative. Population concentration, conflicts with other operations (including commercial traffic), size and availability negate using existing MOAs within 150 NM of Holloman AFB. Time, cost, personnel relocation, availability, and quick reaction deployment posture are all factors which diminish the viability of utilizing existing airspace outside 150 NM of Holloman AFB. The feasibility for establishing a new MOA for T-38 and/or F-15 operations is very unlikely due to the number of existing MOAs, restricted areas, and high/low altitude airways. The no action alternative would result in a jeopardized mission for the 49th TFW with reduced and degraded training accommodations and readiness.

The preferred alternative is the proposed action of conducting 300 supersonic sorties per month at the Reserve MOA. Implementing the proposed action contributes to fulfillment of the 49th TFW mission without serious adverse impact to the public, federal or state environmentally sensitive areas; natural resources; or any threatened or endangered species. In addition, the proposed action will not have a significant effect upon the natural or manmade environment.

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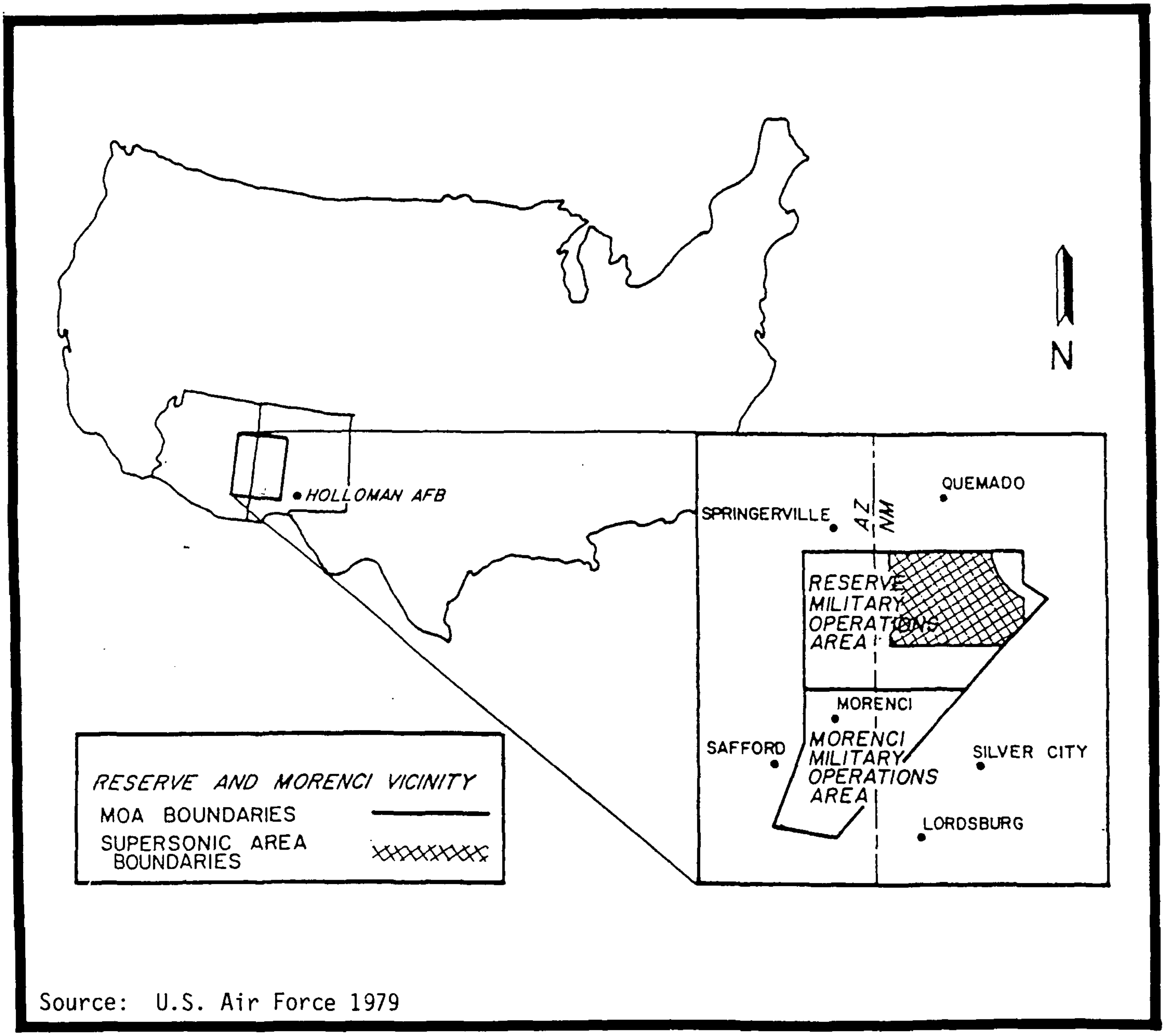
I. PROJECT DESCRIPTION

A. Purpose

The U S Air Force proposes to continue using the Reserve Military Operations Area (MOA) in west central New Mexico for supersonic operations. Figure I-1 shows the general location of the Reserve MOA. The 49th Tactical Fighter Wing (TFW) at Holloman Air Force Base (AFB), New Mexico, has been flying supersonic operations above 15,000 feet (ft) mean sea level (MSL) in the MOA since January 1985. The majority of the operations will continue to be conducted in the F-15 aircraft. Occasionally, other fighter aircraft may use the airspace but their usage is negligible in comparison to the F-15s, and consequently, would result in no appreciable change from the evaluation and analysis for the F-15 aircraft.

The Air Force also proposes to grant permanent authority for supersonic operations in the Reserve MOA. In granting the permanent authority, the Air Force commits to periodic reviews (minimum of three years or sooner if required) of operations and changing environmental conditions in the MOA. When there are proposed operational changes that could result in increased noise levels of one decibel C-weighted day-night noise level (types of aircraft, number of sorties, and etc.) and reconfiguration of the airspace (vertically or horizontally), or changes to the environmental resources of the MOA, the Air Force will initiate an environmental analysis to evaluate the potential environmental consequences of the proposals or continued operations.

The Record of Decision (ROD) allowing supersonic operations in the Reserve MOA, was signed by the Deputy Assistant Secretary for Installations on September 12, 1984. The ROD stipulated: (1) Supersonic flight be limited to weekday, daylight operations of the 49th TFW and selected adversaries above 15,000 feet MSL, not to exceed 300 sorties per month in each MOA, (2) WSMR be first priority for supersonic training with the overflow equally divided between the Reserve and Valentine MOAs, (3) supersonic operations be confined to 22 X 28 mile elliptical areas, (4) supersonic flight not be conducted within five miles of the the towns of Reserve, Apache Creek, Horse Springs, and Aragon in the Reserve



Source: U.S. Air Force 1979

FIGURE I-1. General Location of Reserve MOA.

MOA, and the towns Valentine, Ruidosa and Candelaria in the Valentine MOA and (5) complaints and damage claims be resolved promptly. These operational restrictions were imposed by the Secretariat because of a lack of definitive data to describe impacts of sonic booms. To this extent the secretariat directed research be conducted and the supersonic model used for predecting overpressures be validated. This study was conducted within the WSMR from July 1988 to January 1989.

In addition to facilitating continued approval for supersonic operations in the MOA, this environmental assessment provides an updated noise analysis based on the results of the sonic boom model validation. The previous analysis of sonic boom impacts was based on the sonic boom model developed from operational data collected in the Warning Area 72 (Oceana MOA) off the coast of North Carolina. The WSMR data shows the Oceana analysis over predicted noise impacts by ten decibels or more.

The Air Force proposes to allow supersonic operations throughout the Reserve MOA except within five miles of the town of Reserve, New Mexico. Supersonic flight would continue to be limited to weekday, daylight operations of the 49th TFW and selected adversaries at an altitude not below 15,000 feet MSL. Sorties would not exceed 300 per month, and priority consideration for scheduling would be given to WSMR; however, the Reserve and Valentine MOAs could be scheduled directly when WSMR is known not to be immediately available (operations would continue to be equally divided between the Reserve and Valentine MOAs).

B. Mission

The mission of the 49th TFW is to maintain a state of readiness of personnel and equipment in order to conduct worldwide air superiority operations against enemy aircraft, if the need arises.

An essential element in the effective accomplishment of this mission is realistic air combat training to insure that in time of conflict, tactical forces are prepared and capable of defeating the adversary. Recent military experience indicates that combat crew effectiveness and their ability to survive hostile environments are directly related to the quality and quantity of previous training received.

Airspace requirements for the F-15 aircraft dictate the use of large supersonic operating areas to realistically employ the aircraft in the role for which it was designed and procured. To accomplish Tactical Air Command (TAC) directed mission requirements and maintain a high level of unit combat capability, approximately 85 percent of the F-15 sorties require supersonic airspace. Through out this document, the term "supersonic airspace" means airspace approved for supersonic flights. The F-15 missions require training in the areas set aside for supersonic flight to utilize the aircraft in the supersonic flight regime. This flight regime is characterized by decreased maneuverability, lower G-loads, and high closure rates. By eliminating speed restrictions, pilots are able to concentrate on realistic tactical situation and mission effectiveness is, thus, greatly enhanced.

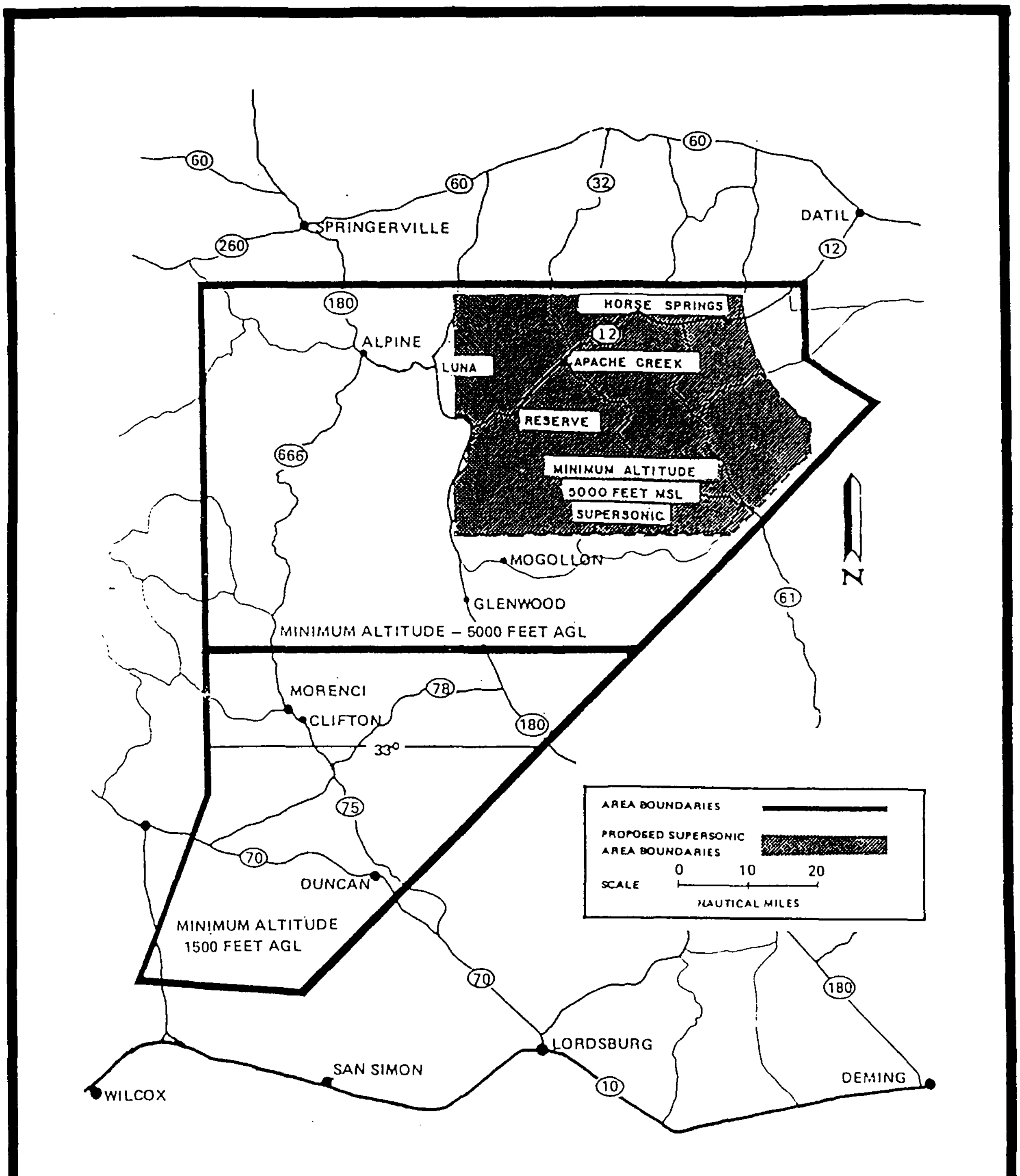
The Tactical Air Command's flying hour program directives dictate that the 49th TFW at Holloman AFB needs to accomplish 1,200 supersonic sorties per month in order to meet proficiency objectives of the mission. Over the course of the past couple of years, the Commanders at the 49th TFW and White Sands Missile Range (WSMR) have given close attention to operational requirements and have adjusted airspace/range management policies to better utilize the WSMR assets. In an attempt to meet sortie requirements, the 49th TFW has divided the available WSMR airspace into smaller parcels (limiting full capability of radar use and intercept operations), reduced individual sortie time (limiting actual number of battle engagements), and provide closer scheduling of sorties. These arrangements allow the 49th TFW to fly from 600 to 900 sorties per month at WSMR. Although these steps have been necessary in order to increase the wing's overall mission capabilities, the necessary compromises have resulted in a degradation of the individual air crew rate of achieving combat proficiency.

The 49th TFW would prefer to conduct all supersonic sorties over the adjacent U.S. Army White Sands Missile Range since its proximity would facilitate coordination and oversight activities as well as reducing the costs associated with flying the F-15 aircraft. However, the Army's research and development operations at WSMR have priority over the 49th TFWs mission and consequently, WSMR cannot commit to support any set number of supersonic sorties. Although the 49th TFW has been able at times to conduct up to 900 sorties per month at WSMR, many of these have been degraded sorties (reduced time, altitude, or geographic constraints). Over the long-term historical range perspective, the Air Force believes 600 supersonic sorties per month can be accommodated at WSMR. The higher rate (900 sorties per month) is not a realistic expectation on a long-term basis, thus, WSMR alone could never provide for needed combat aircrew readiness.

An additional limitation is the WSMR airspace requirements of the 479th Tactical Training Wing (TTW), which is also stationed at Holloman AFB. The 479th TTW is charged with indoctrinating all new fighter aircrews to the basic concepts of fighter operations in the T-38 Talon aircraft. Due to the short operating range of the T-38 aircraft, the suitable airspace is required in proximity (90 nautical miles) to Holloman AFB. Approximately 150 to 160 T-38 sorties are scheduled daily to operating airspaces located within 90 nautical miles (NM) of Holloman AFB.

The 49th TFW proposes to continue supersonic air combat operations in two additional sparsely populated areas: the Valentine MOA in southwest Texas and that part of the Reserve MOA located in west central New Mexico (Figure I-2). At WSMR approximately 600 air combat operations per month can be achieved. To fulfill the 1200 sorties per month, the Valentine and Reserve MOAs must contribute a total of 600. It should be noted that the 49 TFW will attempt to fly all sorties that have a reasonable probability of supersonic flight occurrence at WSMR, and Reserve will be used as an overflow area for those that WSMR cannot accommadate.

Because of the lack of permanent population underneath a large portion of the WSMR area currently approved for supersonic operations, the 49 TFW proposes to continue using WSMR as its primary airspace for conduction training that requires



Source: U.S. Air Force 1979

FIGURE I-2. Reserve and Morenci Subsonic and Supersonic Airspace Boundaries.

airspace approved for supersonic flights. The Reserve and Valentine MOA's will be used as backups in the event WSMR cannot accommodate the 49 TFW sorties.

C. Description of the Action

The Reserve MOA was originally a part of the Morenci MOA, which was established as a subsonic MOA/ATCAA in 1975 by the Arizona Air National Guard. The original area was divided into two separate subsonic MOAs in August 1979, as depicted in Figure I-2. The 49th TFW proposes continuation of supersonic flight operations in the Reserve MOA. Flight operations will be conducted during daylight hours only, at altitudes ranging from 15,000 ft. MSL (approximately 6,000 ft. above the mountain peaks within the area and 9,000 ft. above any populated area beneath the airspace) up to the top of the MOA at 51,000 ft. MSL. A maximum of 300 sorties per month are projected to be flown in the area.

II. AIR FORCE FLYING ACTIVITIES

A. General

All the military flying areas in the vicinity of Holloman AFB are depicted in Figure II-1. These areas must accommodate approximately 160 T-38 and 50 to 70 F-15 training sorties per day. WSMR, Valentine, and Reserve areas are currently the only supersonic areas within 400 NM of Holloman AFB. The F-15 and T-38 aircraft share available WSMR training time when the airspace is not being used for WSMR research and development projects. Because of the short operating range of the T-38 aircraft and the shared use of WSMR, all other areas within 90 NM of Holloman AFB (Beak MOA, Talon MOA, and the McGregor Range) must be used for T-38 operations. The majority of the F-15 sorties are flown within WSMR and the outlying MOAs of Pecos, Reserve and Valentine. The subsonic Pecos MOA is used by other USAF bases and cannot provide the training time required for Holloman AFB aircraft.

B. F-15 Operations in the Reserve MOA

The Reserve area is presently utilized for up to 130 subsonic sorties per month. The F-15 flying profiles have been developed after careful analysis of previous experiences with known and postulated adversaries during combat simulations. The flight programs are designed to provide participating pilots with the most demanding and realistic combat experience possible.

Pilots in the 49th TFW are not students as in the Air Training Command. Most F-15 pilots are qualified in the aircrafts, before arriving at Holloman AFB. The few pilots who complete their transition flying at Holloman AFB are already highly experienced in fighters. Operations in the Reserve MOA will be oriented toward simulating combat maneuvers, not student training. These operations are divided into four basic phases, as described in the following paragraphs.

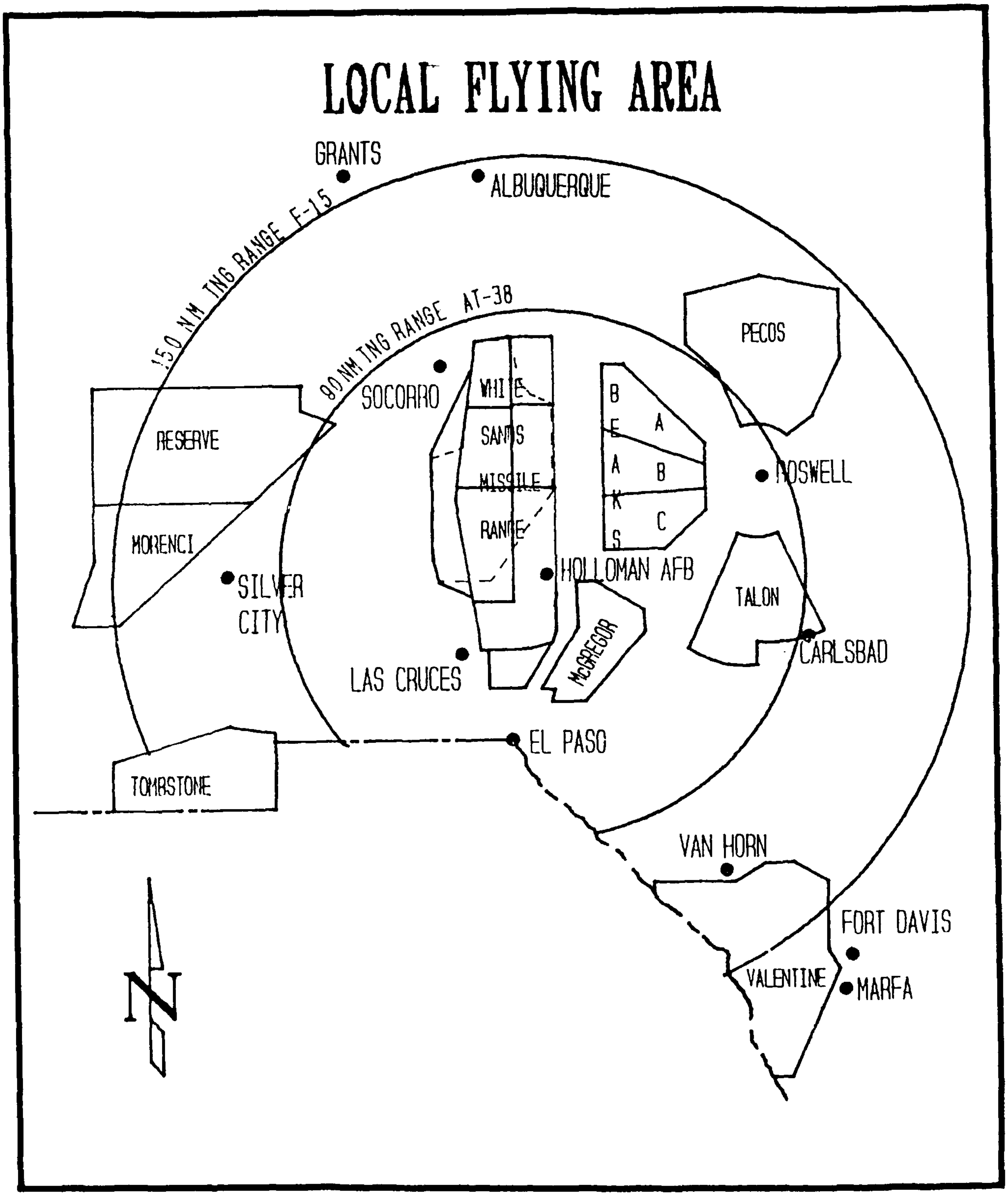


FIGURE II-1. Flying Areas near Holloman AFB.

1. Transition Phase

This phase is the initial aircraft familiarization phase for pilots transferring from other aircraft such as the F-4 to the F-15. It is the first phase of tactical operations and provides the pilot with basic skills, proficiency and knowledge in the operations and handling characteristics of the new aircraft. Some transition operations are presently conducted in the Reserve MOA with flights consisting of two aircraft and if outside the current ellipses, they are restricted to subsonic airspeeds.

By operating in the subsonic flight regime only, pilots are denied valuable experience in the vastly different performance and handling characteristics of the aircraft in the flight envelope at speeds above Mach 1.0 (speed of sound).

2. Basic Fighter Maneuver Phase

After completing the transition phase, pilots enter the basic fighter maneuver phase of air-to-air combat. Flights, consisting of two aircraft, practice standardized offensive and defensive maneuvers both singularly and in combination. Pilots develop the aerial skills, judgement and weapon systems knowledge to effectively fly their aircraft in the three dimensions relative to an airborne adversary--the objective being to maneuver the aircraft efficiently to negate a potential threat while achieving a position of advantage for simulated weapons launch. This phase of the operation is the pilot's first exposure to the three dimensional aerial arena.

3. Air Combat Tactics Phase

In this advanced phase of flying, pilots sharpen their tactical employment skills while developing new and innovative combat tactics. Air combat tactics require a comprehensive flight profile designed to insure the best possible tactical employment of flights consisting of more than one aircraft.

Basic Fighter Maneuver training pits the individual pilot against a designated adversary. Air Combat Tactics, however, concentrates effective employment of up to four aircraft as tactical partners or as a team to maintain offensive and defensive mutual support. Sophisticated radar and visual identification systems are employed at long-range to arrive at a visual close-in, three dimensional air-to-air engagement (dogfight). Realistic and tactically sound Air Combat Tactics experience requires a flight with unrestricted airspeed.

4. Dissimilar Air Combat Tactics Phase

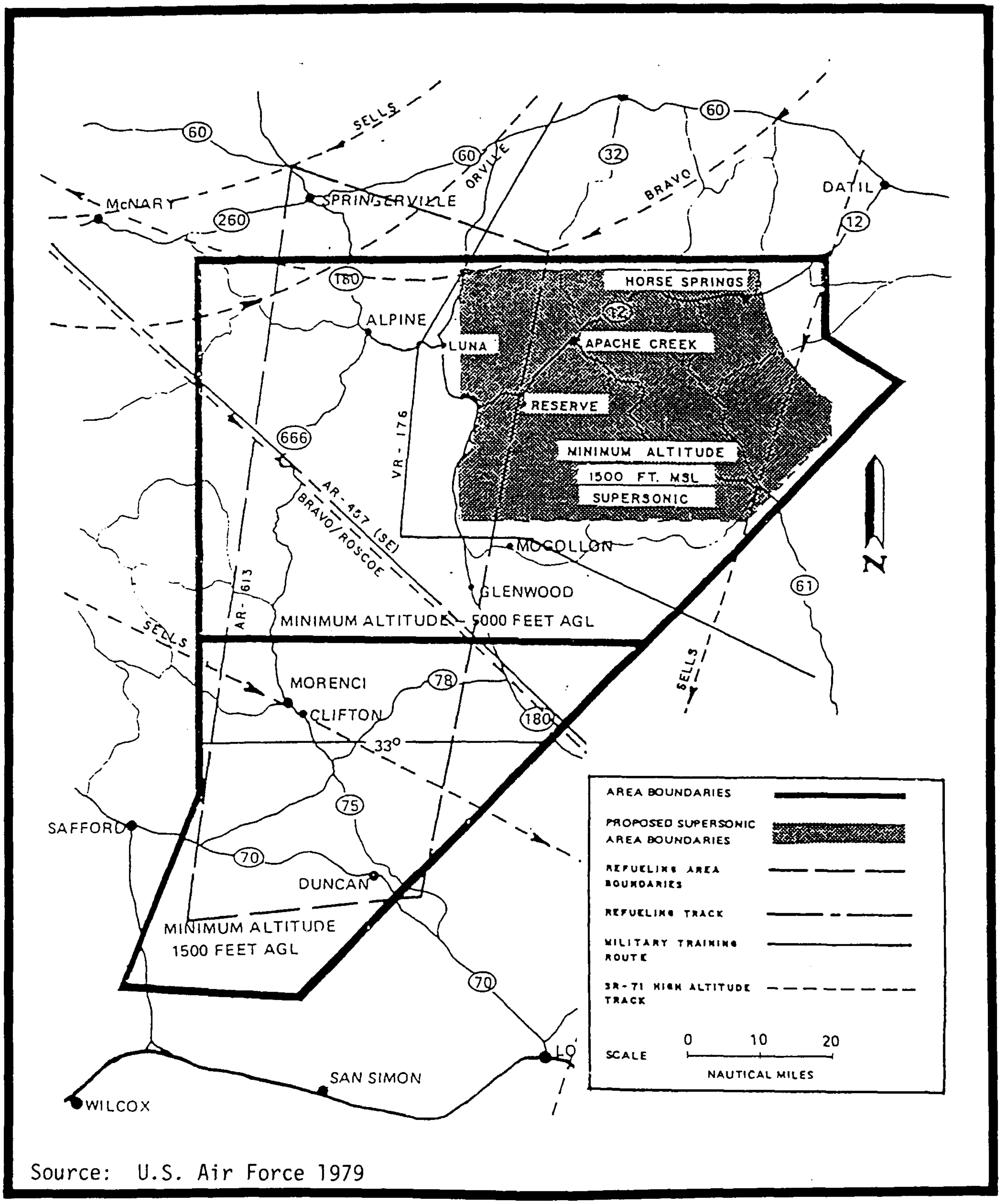
Pilots at this level of proficiency employ air combat tactics against simulated adversaries in different types of aircraft, such as the F-15, F-4, or F-16. The objective of the mission is to provide each pilot with experience against Navy and other Air Force fighter aircraft to simulate foreign aircraft in size, performance, and tactical capabilities. Flight size varies from four to eight aircraft with airspeed and altitude parameters the same as Air Combat Tactics phase.

C. Other Airspace Users

The airspace within the geographic boundaries of the Reserve MOA may be used at different times for various types of training, in-flight aerial refueling, and transition training for other types of military aircraft also take place (Figure II-2).

1. Military Training Route

Military Training Routes (MTRs) are specially designated routes where aircrews can practice and upgrade low altitude visual navigation and low altitude threat awareness skills. These skills are necessary to allow aircraft to penetrate into a hostile target area below radar coverage.



Source: U.S. Air Force 1979

FIGURE II-2. Air Uses at Reserve/Morenci MOAs.

Airspeeds averaged 270 NM per hour while aircraft altitudes may vary as low as 100 ft. AGL. However, most training is accomplished between 500 ft. AGL and 1500 ft. AGL.

Although several MTRs cross the Reserve MOA, only one approaches the supersonic training area. VR-176 was established by the 150th TFG, New Mexico Air National Guard, located in Albuquerque, New Mexico. The route is used primarily by A-7D fighter-bomber aircraft to practice low altitude navigational skills. The route is flown at altitudes between 100 ft. AGL and 5000 ft. AGL. The route is specified generally as 15 NM to the left of the centerline and 10 NM to the right of the centerline.

Other military aircraft may use the route for training, but must obtain permission from the 150th TFG before flying the route to avoid scheduling conflicts.

2. Refueling Tracks/Anchors

In-flight refueling of aircraft is practiced to maintain aircrew proficiency in 2aerial refueling operations. Aerial refueling of aircraft allows aircraft to increase their range or increase 'loiter' time in a target area. Most military fighter or reconnaissance type aircraft have the capability to refuel in-flight.

The AR-457 refueling track crosses the Reserve MOA west of the supersonic area and refueling operations are conducted between 25,000 and 27,000 ft. MSL. This route is used extensively by the SR-71 strategic reconnaissance aircraft operating out of Beale AFB, California. Refueling is accomplished to increase the range of the Mach 3.0+ aircraft.

3. Transition Training

The area was originally established by the 162nd TFG, Arizona Air National Guard for transition training. Aircraft from Davis-Monthan AFB (A-10s), Kirtland AFB (A-7s), Tucson Air National Guard (A-7s), and Holloman AFB (F-15s) continue to use the area for transition training. Supersonic training will take place only in the area proposed and only by F-15 aircraft from Holloman AFB, and aircraft actively engaged in training with these F-15's.

III. Affected Environment

A. Climate

Reserve, New Mexico is the county seat for Catron County, and is located in west-central Catron County approximately 20 miles from the Arizona border (NOAA 1987). Reserve has a mild, semi-arid continental climate. The elevation (5,832 ft. MSL) results in moderately cool summers. Only July has an average maximum temperature above 90°F, although there are normally 50 days of highs at least 90°F. In an average year, one or two days may approach highs of 100°F. Sundown brings cool summer nights, with substantial cooling. Midsummer night temperatures normally drop to the low 50s, and occasionally approach freezing. The rainy season occurs during the summer, with frequent thunderstorms from July through October, producing more than half the annual precipitation. In general, these showers are brief, and prolonged rainy periods are practically unknown.

Winter days are normally mild, with shade temperatures reaching the low 50s on most days. The night time cooling makes winter nights cold, with minima below freezing as the rule from mid-October until early May. On average, only on three days a year will winter temperatures fall below 0°F. Part of the winter precipitation is snowfall, which seldom remains on the ground for more than a day or two. Generally, there is little wind accompanying these snowstorms, and consequently, little drifting of snow.

Relative humidity averages about 55 percent, ranging from about 75 percent in the cooler morning hours to less than 30 percent during spring afternoons. Hot, humid weather does not normally occur in the area. The location experiences generally light winds, and tornadoes have never been reported in this section of New Mexico. The growing season averages somewhat less than four months, beginning June 4 (the average date of the last freezing temperature in the spring) and ending September 29 (the average date for the first freeze in the fall).

B. Geology

The geology of the Reserve MOA is complex (Dane and Bachman 1965). The major geologic structures now evident in southwestern New Mexico and adjacent areas date mainly from the Laramide orogeny of Late Cretaceous and early Tertiary age (USGS 1979). During this period widespread faulting and folding, igneous intrusion, and volcanism took place throughout the Cordilleran region of the western United States. These events were followed by renewed volcanism and tensional faulting starting in middle Tertiary time.

Western portions of the MOA consist of mountainous, forested terrain. Eastern portions of the MOA are represented by the San Augustine Plains. Stream valley alluvium and bolson fill in the Gila and San Francisco drainages consist of generally poor sorted and locally derived clay, silt, sand, and gravel.

Marine and continental sediments consist mainly of limestone, dolomite, marine shale, sandstone, coal, "red beds", local deposits of evaporites and conglomerate. The limestone and dolomite are mostly dense and the sandstone deposits are massive. The shale commonly contains much sandy material, disseminated gypsum, and local beds of good grade coal.

The marine sediments, particularly the limestone and dolomite, provide local ore mineralization in some mining districts within the MOA. Alterations and mineral deposition most commonly occur where the carbonate rock has been intruded by igneous rocks.

Igneous rocks of various composition are found throughout Catron and Grant Counties, New Mexico. They are concentrated in areas of higher elevation within both counties. The basalt, andesite, rhyolite, and associated rock varieties of volcanic origin make up a section estimated to be more than 8,000 ft. thick. These rocks constitute the Datal formation.

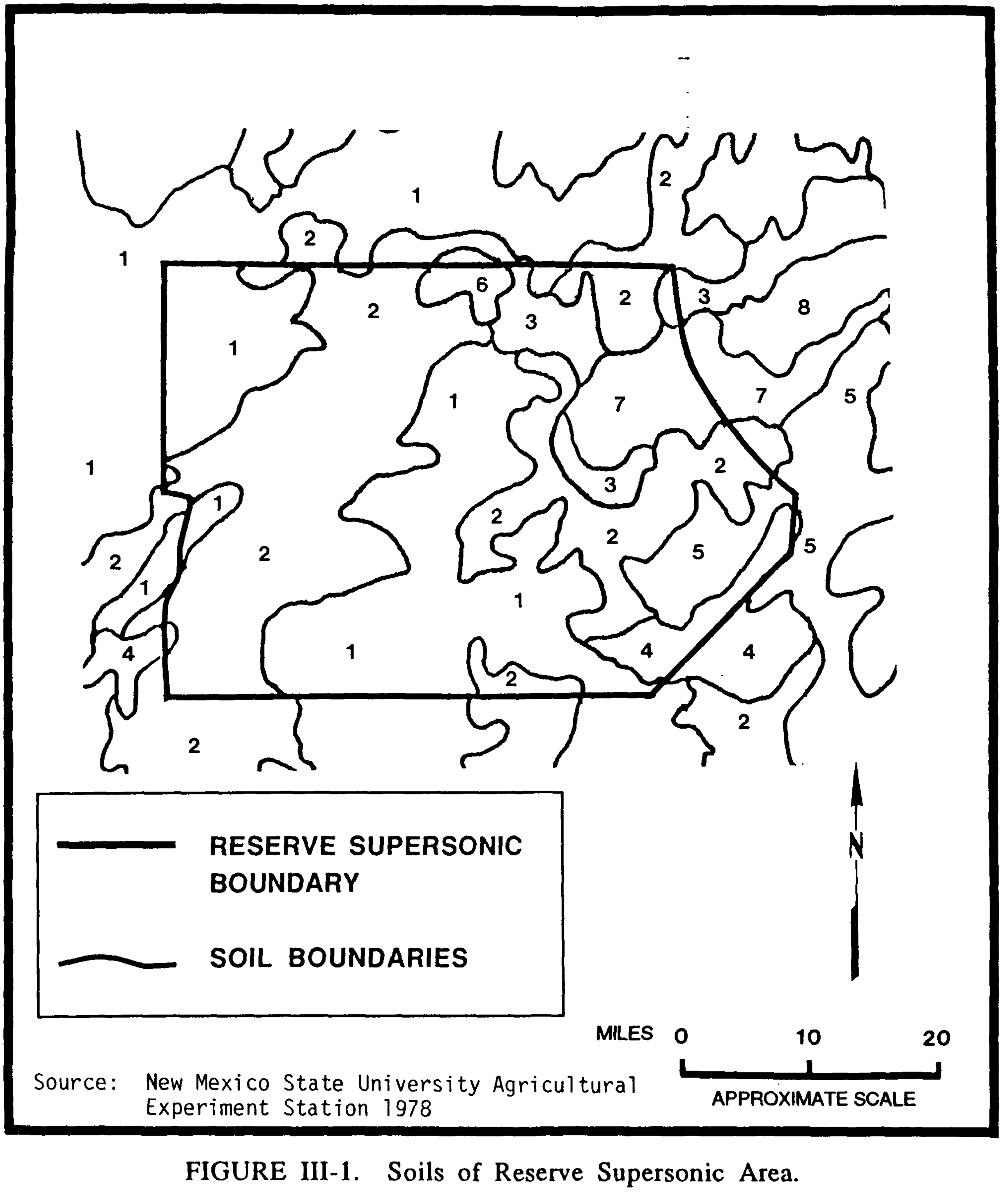
Sedimentary rocks are essentially absent on the San Augustine Plains except for Quaternary sediments consisting of bolson, pediment, wind blown sand, and high-level terrace deposits. The plains are underlain by more than 2,000 ft. of these alluvial sediments as indicated by a 2,000 ft. core hole that failed to reach the base of the deposit (Foreman et al. 1959). The highlands around the San Augustine Plains consist of volcanic rocks of Tertiary and Quaternary ages. The Tertiary rocks belong to the Datal formation. Rock types include andesite, basaltic andesite, rhyolite, latite, and pumiceous tuff and breccia. Quaternary basalt and basaltic andesite flows overlie thick sequences of the Tertiary volcanics, particularly on the south and west sides of the basin.

Mineral deposits of economic value have been found at many places within or near the MOA. They occur mainly in the mountainous areas. Though now totally inactive, one of the better known mining districts is that of Mogollon located in Southwestern Catron County. The district was discovered about 1875, and has produced gold, silver, copper, and lead. Mining on a large scale ceased in the early thirties. Only minor amounts of minerals of economic value are known to occur near the San Augustine Plains. Several oil test wells have been drilled in the North Plains basin, north of the San Augustine Plains, and all were unsuccessful as petroleum producers.

C. Soils

The soils in the Reserve Supersonic Boundary in Catron County have yet to be surveyed by soil series. They have, however, been surveyed using the Soil Taxonomy Classification System adopted by the U.S. Department of Agriculture in 1965 (Figure III-1 and Table III-1). Soils are classified on the basis of observable or measurable properties with this procedure.

The soils in the Supersonic Boundary of the Reserve MOA vary greatly. They range from flood plain soils to mountainous soils. The mountain soils make up approximately 80 percent of the area. They are dominated by two associations: (1) Argiborstolis-Cryobordlls-Usorthents Association and (2) Hapustolls-Argiustolls-Rock Land. The Mountain soils are generally shallow soils. They are gravelly or stoney and are usually underlain by large formations by bedrock.



Source: New Mexico State University Agricultural Experiment Station 1978

FIGURE III-1. Soils of Reserve Supersonic Area.

TABLE III-1

Soils Legend - Reserve Supersonic Boundary Area

1 ARGIBOROLLS - CRYOBOROLLS - USORTHENTS: This association includes an extensive area of mountainous land with altitude ranges from 6,000 to 10,000 feet. It ranges from gently sloping in the valleys to very steep on mountain sides. This typically dark colored soil consists of about 80% of the association. It is generally anywhere from 6 to 20 inches thick in the surface layer, but its depth can range up to 40 inches. The surface layers textures range from a gravelly loam to a clay loam. They are usually underlain by bedrock. These soils are moderately productive to native vegetation. This association includes the principle timber producing soils in the southwest. Its main use is for grazing and wildlife.

2 HAPLUSTOLLS - ARGIUSTOLLS - ROCKLAND: This generally gravelly and shallow association is the largest in the Mountainous regions. The topography varies extremely, from gently sloping to very steep. Approximately 65% of the area consists of Haplustolls and Argiustolls. These are generally light colored soils with a surface depth of about 10 to 20 inches. Rockland makes up the other 35% of this association. It is characterized by outcrops of bedrock. These soils support a wide variety of native vegetation. They have many uses including recreation, livestock and wildlife grazing, woodland, and watershed.

3 HAPLARGIDS - TORRIORTHENTS: This association which is dominated by a gently to strongly sloping terrain is usually located at the base of mountain ranges. The Haplargids comprise about 75% of this association. This soil type is usually dark colored with a sandy loam or gravelly loam surface about 10 to 20 inches thick. The Torriorthents, which are generally light colored, sandy loams consist of about 15% of the association. Rock outcrops make up the remainder of the association. The production potential is fair to moderate for native vegetation. Its main use is for grazing and wildlife.

4 HAPLARGIDS - ROUGH BROKEN LAND: The Haplargids comprise about 50% of this association. These soils occur on gently to strongly sloping areas. This generally dark colored, gravelly loam soil has a surface layer of about 30 inches. The Rough Lands make up approximately 30% of the association. It usually consists of shallow gravelly soils ranging from loamy to sandy. The rest of the association is made up of small acreages of riverwash and gullies. The dominant use of this land is grazing. Production is moderate for native vegetation.

5 ARGIUSTOLLS - HAPLARGIDS - ROCKLAND: This generally light colored, gently to strongly sloping, cobbly association is generally located over old lava flows. The Argiustolls, which are generally dark colored with a clay loam to a clay texture, comprise about 50% of the association. Their surface layers range from 10 to 40 inches thick. The Haplargids account for about 25% of the association.

TABLE III-1
(cont'd)

Soils Legend - Reserve Supersonic Boundary Area

These soils are typically dark colored and shallow with a surface depth of just a few inches. Texture ranges from loam to clay. Rock outcrops make up the remainder of the association. In certain areas, production is very high for native grasses.

6 TORRIFLUVENTS - HAPLARGIDS - HAPLUSTOLLS: These generally deep, well drained soils occur on nearly level to gently sloping flood plains along intermittent drainages. The Torrifluvents, which comprise approximately 35% of this association, are mainly light colored with a deep surface layer. Textures range from silty clay loam on the surface to coarse clay loams in the subsoils. Haplargids, which have a light colored thin surface layer of fine sandy loams to light clay loams, comprise about 25% of the association. Haplustolls, which comprise about 15% of the association, are generally light colored clay loams with surface layers around 30 inches thick. These soils are used for grazing and are moderately productive for native grasses.

7 TORRERTS - TORRIORTHENTS: This association occurs generally on nearly level basin floors where flooding from high periods of runoff occurs. Torrerts comprise about 45% of the area. They are generally light colored with a thin surface layer. Textures range from silty clays to clay. Torriorthents, which comprise about 30% of the association, are light colored with a surface layer of 60 to 10 inches thick. Textures range from silty clay to clay. The remaining 25% consist of deep fine-textured soils. The soils are moderately productive for salt tolerant vegetation.

8 HAPLARGIDS - TORRIPSAMMENTS: This association is located primarily on nearly level to gently sloping landscapes. Haplargids constitute approximately 50% of this association. These generally deep, well drained soils have a thin light colored surface layer with textures ranging from fine sandy loam in the surface to a heavy clay loam subsoil. The Torripsamments, account for about 20% of this association. These soils also have a thin, light colored surface layer, but are characterized by their sandy soils. The remaining 30% is made up of shallow soils underlain by sandstone. These soils are mainly used for rangeland although some dry-farming has been done. Production is moderate for native vegetation.

Source: New Mexico State University Agricultural Experiment Station 1978

Also, in the mountain regions, there are large amounts of exposed rock outcrop. These mountainous soils usually support pine trees and various shrubs.

The other 20 percent is generally plains and drainageways. The plains are generally a deeper soil which range in textures from sandy to clayey. These areas are generally level, producing moderate amounts of native vegetation.

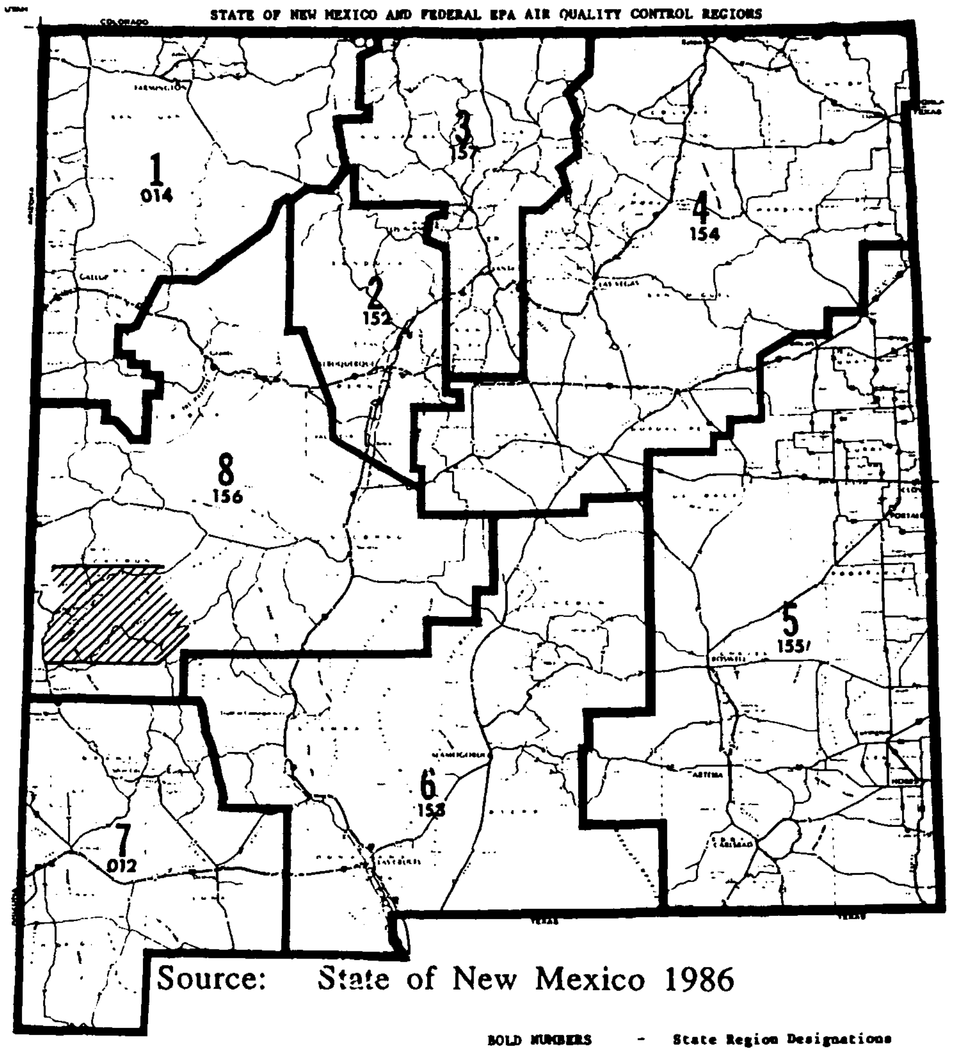
D. Air Quality

The Reserve MOA lies entirely within Air Quality Control Region 8 in New Mexico, as designated by the United States Environmental Protection Agency (Figure III-2). Catron County is in attainment, meaning the area meets or exceeds the National Ambient Air Quality Standards (NAAQS) (State of New Mexico 1986). These standards are presented in Table III-2. Historically, the air quality in Catron County is excellent. Point source emissions are listed in Table III-3.

The Prevention of Significant Deterioration (PSD) program has identified nine Mandatory Class 1 areas (Figure III-3), having air that is pristine and allowing very limited increases in air contaminants. The Gila Wilderness, Number 5, is the largest of these areas in the state and is the closest area to the Reserve MOA.

E. Noise

Rural noise levels have typically a Day-Night Average Noise Level (DNL) of 40 to 47 decibels (dB). DNL is the long-term day-night average noise level averaged over a twenty-four hour period. DNL's below 55 dB are considered to have no significant effect on public health by the Environmental Protection Agency. DNL's below 65 dB are considered acceptable for residential purposes without the need of noise attenuation as proposed by the U.S. Department of Housing and Urban Development. Noise levels from subsonic flight activity would be typical of a rural community with a DNL of approximately 31.6 dB.



Source: State of New Mexico 1986

BOLD NUMBERS - State Region Designations

SMALL NUMBERS - EPA Region Designations

FIGURE III-2. State of New Mexico and Federal EPA Air Quality Control Regions.

TABLE III-2

Ambient Air Quality Standards

	New Mexico Standard	Federal Primary Standard	Federal Secondary Standard
Total Suspended Particulate (TSP)			
1. 24-Hour Average	150 ug/m^3	260 ug/m^3	150 ug/m^3
2. Annual Geometric Mean	60 ug/m^3	75 ug/m^3	60 ug/m^3
Sulfur Dioxide (SO2)			
1. 24-Hour Average	0.10 ppm**	0.14 ppm	--
2. Annual Arithmetic Mean	0.02 ppm	0.03 ppm	--
3. 3-Hour Average	--	--	0.50 ppm
Carbon Monoxide (CO)			
1. 8-Hour Average	8.7 ppm	9.0 ppm	9.0 ppm
2. 1-Hour Average	13.1 ppm	35.0 ppm	35.0 ppm
Ozone ($_3$)			
1. 1-Hour Average	0.06 ppm	0.12 ppm	0.12 ppm
Nitrogen Dioxide (NO$_2$)			
1. 24-Hour Average	0.10 ppm	--	--
2. Annual Arithmetic Mean	0.05 ppm	0.05 ppm	0.05 ppm
Lead (Pb)			
1. Calendar Quarterly Arithmetic Average		1.50 ug/m^3	1.50 ug/m^3

#ug/m^3 - data in micrograms per cubic meter
**ppm - data in parts per million by volume

Source: Office of Federal Register 1976

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1 Primary standards define levels of air quality which the U.S. Environmental Protection Agency's Administrator judges necessary to protect the public health with an adequate margin of safety.

2 Secondary standards define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

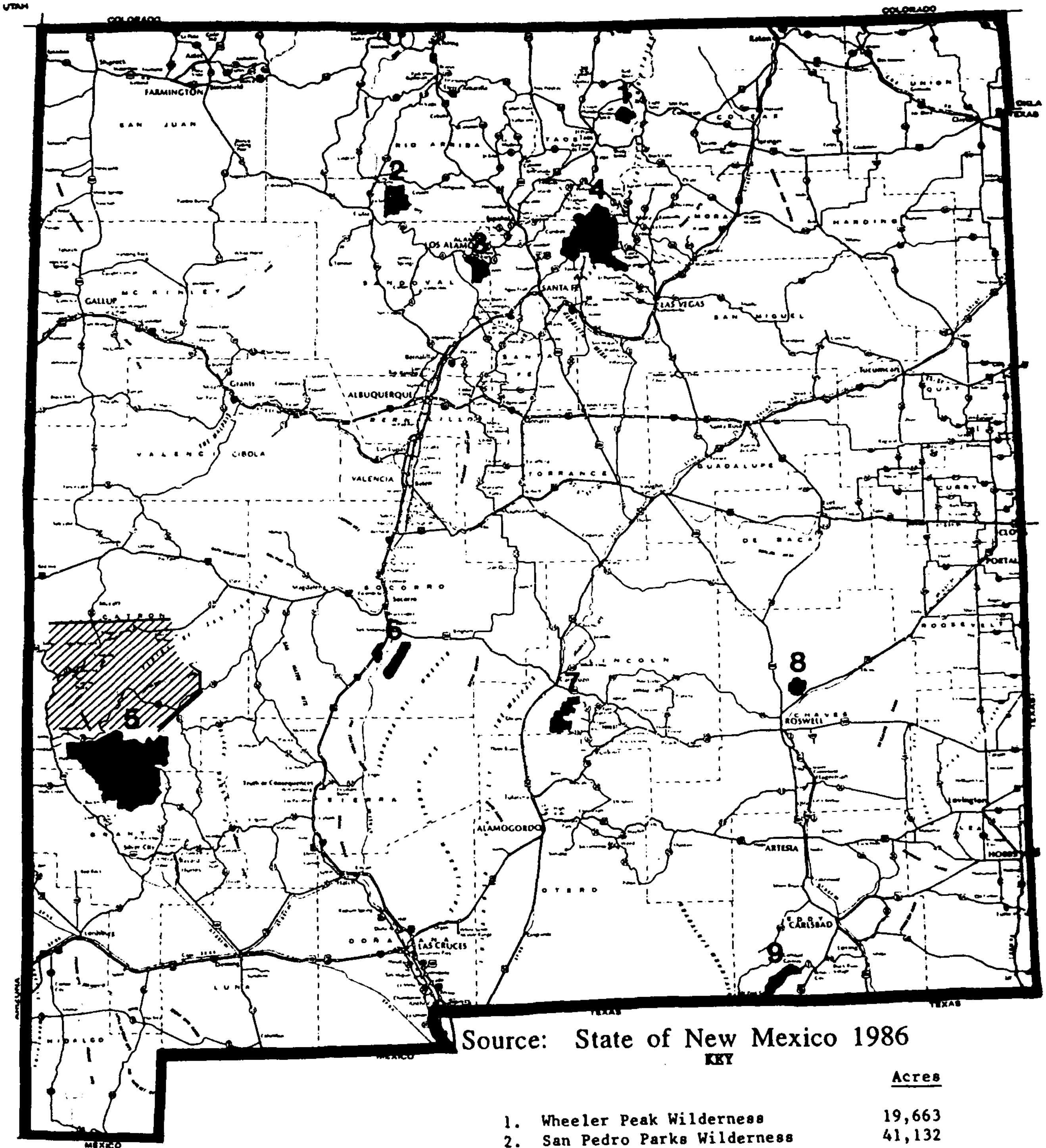
ppm -- parts per million
mg/m^3 -- milligrams per cubic meter
ug/m^3 -- micrograms per cubic meter

TABLE III-3

Point Source Emission Inventory

Parameter	Tons/Yr
Particulates	42
SO_2	---
NO_x	6
HC	66
CO	780

Source: New Mexico Air Quality
Control Board 1986



Source: State of New Mexico 1986

KEY

		Acres
1.	Wheeler Peak Wilderness	19,663
2.	San Pedro Parks Wilderness	41,132
3.	Bandelier Wilderness	23,267
4.	Pecos Wilderness	223,333
5.	Gila Wilderness	569,792
6.	Bosque del Apache Wilderness	40,948
7.	White Mountain Wilderness	48,873
8.	Salt Creek Wilderness	9,621
9.	Carlsbad Caverns National Park	46,435

FIGURE III-3. Mandatory Class I Areas in New Mexico.

As discussed earlier, the ROD directed that research be conducted and the supersonic model used for predicting overpressures be validated. The noise study and WSMR model was initiated to satisfy this requirement. The original CDNL predictions for supersonic operations at the Reserve MOA utilized the Oceana model. That model was never calibrated with actual data.

The basic concept of the Oceana model (elliptical contours centered between setup points) is entirely reasonable. Original application of the model employed limited data and the best sonic boom modeling tools available at that time.

A comparison between the Oceana model and WSMR model based on 300 sorties per month, shows a substantial decrease in CDNL number of sonic booms heard and overpressure. The WSMR model showed a maximum CDNL value of 51 dB (10 dB less than the original Oceana). It resulted in 0.4 sonic booms heard at any given location per day as opposed to 2.5 from Oceana. Average peak overpressure from the WSMR model was 0.7 psf, down substantially from 2.5 psf predicted by Oceana.

F. Biological Resources

The Reserve MOA contains one of the most biologically diverse areas in New Mexico. Four of the New Mexico life zones described by Bailey (1913) are located within the MOA boundaries. Represented life zones are lower and upper Sonaran, and the Transition and Canadian life zones. The diversity of habitats encountered within the MOA is extensive. In general, habitats range from the aquatic and associated riparian zones to high, montane areas. The San Augustine Plain is a grassland. Higher elevations within the mountains contain the pinyon-juniper association, that grades into ponderosa pine forest. New Mexico shares the flora and fauna of several different areas including the Rocky Mountains, Great Plains, Chihuahuan Desert, Sonoran Desert, and the Mexican Plateau. The Reserve MOA is reflective of this mixing, providing an area rich in biological resources.

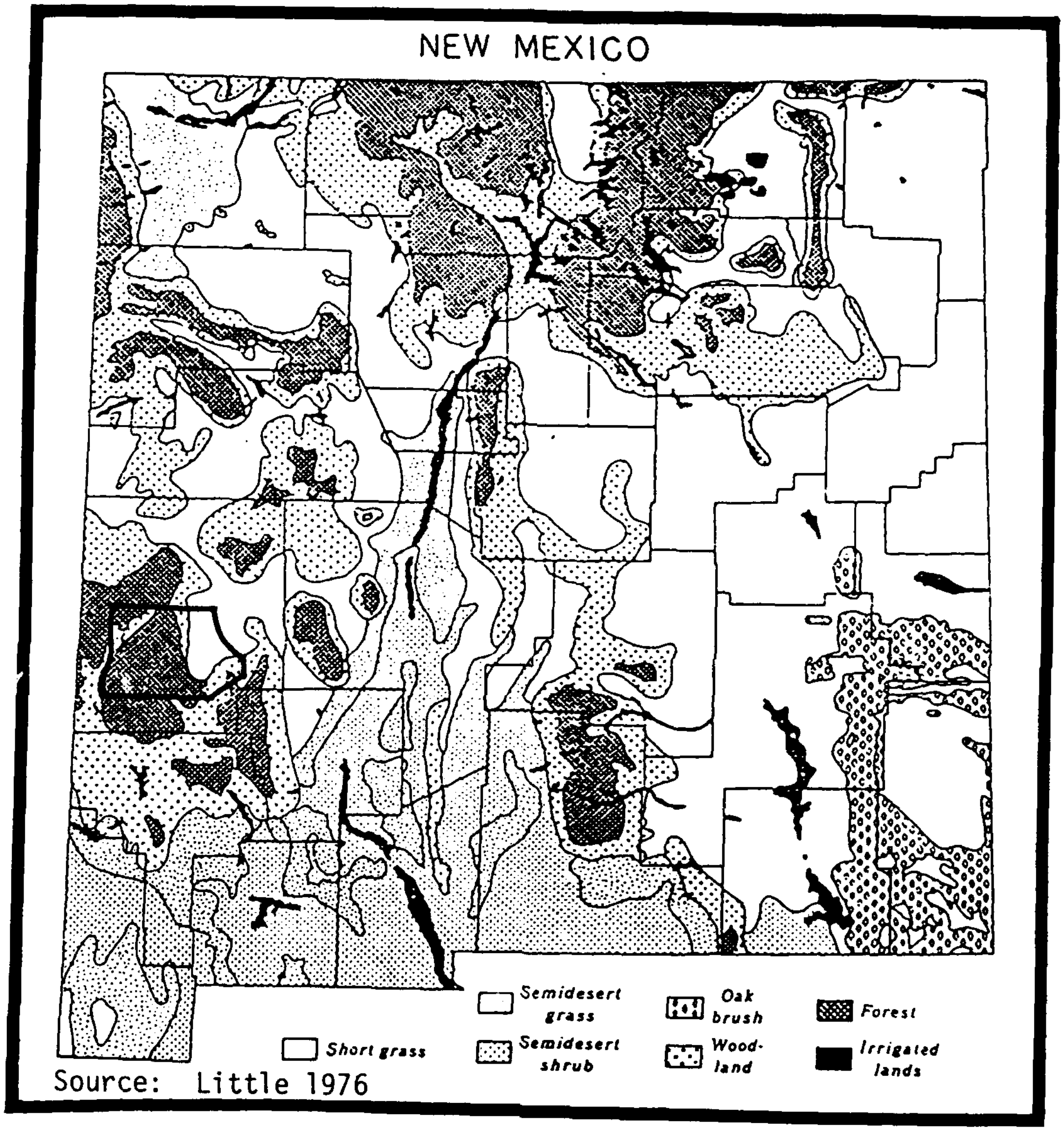
1. Vegetation

The complex composition of the flora within the Reserve MOA is a function of climatic, geologic and topographic diversity (Martin and Hutchins 1980). The vegetation has been further modified by long term human habitation. The more obvious manifestations of human effects include overgrazing, timber removal, mining, and access roads. In irrigated river valleys, native flora has been replaced by cultivated plants, and in some non-agricultural areas, introduced plants have replaced the native flora. The principal vegetation types in New Mexico and Catron County are presented in Figure III-4.

The principal vegetation types that are encountered within the MOA have been described by Little (1976). The desert type (semi-desert shrub, Lower Sonoran Life Zone) has characteristic plants consisting of creosotebush (Larrea tridentata), mesquite (Prosopis glandulosa), catclaw acacia (Acacia gregii), four wing saltbrush (Atriplex canescens), and pricklypear cacti (Opuntia spp.). Desert grass type (semidesert grassland, lower Sonoran Life Zone) has the characteristic plants black grama (Bouteloua eriopoda), tolosa (Hilaria mutica), and dropseeds (Sporobolus spp.). The short grass type (plains grassland, upper Sonoran Life Zone) is represented by blue grama (Bouteloua gracilis), hairy grama (Bouteloua hirsuta), and galleta (Hilaria jamesii).

The oak woodland type (Upper Sonoran Life Zone) is represented by emory oak (Quercus emoryi), gray oak (Quercus grisea), Arizona white oak (Quercus arizonica), and cliffrose (Cowani stansburiana). The pinyon juniper woodland type (upper Sonoran Life Zone) has the very characteristic plants pinyon pine (Pinus edulis), Utah juniper (Juniperus osteosperma), one seed juniper (Juniperus monosperma), Alligator juniper (Juniperus deppeana), and Rocky Mountain juniper (Juniperus scopulorum).

The ponderosa pine forest type (Transition Life Zone) is predominated by ponderosa pine (Pinus ponderosa). Where the forest canopy is open, herbaceous forage plants are common. Included are Arizona fescue (Festuca arizonica) and mountain muhly (Muhlenbergia montana). The Douglas-fir forest type (montane



Source: Little 1976

FIGURE III-4. Principle Vegetation Types in New Mexico.

forest, Canadian life zone) features the Douglas-fir (*Pseudotsuga taxifolia*), white fir (*Abies concolor*), quaking aspen (*Populus tremuloides*), and limber pine (*Pinus flexilis*). Spruce-fir forest type vegetation (sub-alpine forest, Hudsonian and Canadian Life Zones) characteristicly includes Engelmann spruce (*Picea engelmanni*) and alpine fir (*Abies lasiocarpa*).

2. Vertebrates

a. Reptiles and Amphibians

Reptiles in this area are common. The terrain of plains and foothills provide ample habitat for numerous species of lizards, turtles, and snakes. Amphibians are plentiful around creeks and riverbeds in or near the Reserve Supersonic Boundary Area. A list of these amphibians and reptiles have been compiled in Table III-4. This list includes the lowland leopard frog (*Rama yazataiensis*) which is on the Group 1 endangered species list of New Mexico (New Mexico Department of Game and Fish 1985).

b. Fishes

Excellent aquatic habitat occur within Catron County, offering some recreational value as well. The MOA includes portions of the Tularosa and San Francisco Rivers and associated tributaries. Table III-5 lists the fish that may be encountered in the Reserve MOA. Game fishes include rainbow trout (*Salmo gairdneri*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fantinalis*), channel catfish (*Ictalurus punctatus*), and sunfishes including (*Lepomis*, *Micropterus* and *Pomoxis* species (Lee et al. 1980). Introduced non-game species include the goldfish (*Carrassius auratus*), common carp (*Cyprinus carpio*), and the fathead minnow (*Pimephales promelas*). Native non-game fish include the roundtail chub (*Gila ralusta*), spike dace (*Meda fulgida*), speckled dace (*Rhinichthys osculus*), loach minnow (*Tiaroga cobitis*), desert sucker (*Catostomus clarksi*), Samona sucker (*Catostomus insignis*), and the Gila topminnow (*Poeciliopsis occidentalis*). The Gila trout (*Salmo gilae*), a native salmonid, remains endangered, and has been reintroduced to some streams within its

TABLE III-4

Amphibians and Reptiles Known or Presumed to Occur in the Reserve MOA

Amphibians
Tiger salamander (*Ambystoma tigrinum*)
Plains spadefoot toad (*Scaphiopus bombifrons*)
Couch's spadefoot toad (*Scaphiopus couchi*)
Western spadefoot (*Scaphiopus hammondi*)
Bullfrog (*Rana catesbeiana*)
Lowland leopard frog (*Rana yazataiensis*)
Northern leopard frog (*Rana pipiens*)
Great Plains toad (*Bufo cognatus*)
Green toad (*Bufo debilis*)
Southwestern toad (*Bufo microscaphus*)
Redspotted toad (*Bufo punctatus*)
Woodhouses toad (*Bufo woodhousei*)
Canyon tree frog (*Hyla arenicolor*)
Mountain tree frog (*Hyla eximia*)
Charous frog (*Pseudacris triseriata*)

Reptiles
Western box turtle (*Terrapene ornata*)
Sonora mud turtle (*Kinosternon sonoriense*)
Spiny softshell (*Trionyx spiniferus*)
Greater earless lizard (*Cophosaurus texanus scitulus*)
Collared lizard (*Crotaphytus collaris fuscus*)
Leopard lizard (*Gambelia wislizenii*)
Lesser earless lizard (*Holbrookia maculata approximans*)
Shorthorned lizard (*Phrynosoma douglassi ornatissimum*)
Clarks spiny lizard (*Sceloporus clarki clarki*)
Desert spiny lizard (*Sceloporus magister bimaculosus*)
Crevice spiny lizard (*Sceloporus poinsetti*)
Eastern fence lizard (*Sceloporus undulatus tristichus*)
Common tree lizard (*Urosaurus ornatus linearis*)
Side-blotched lizard (*Uta stansburiana stejnegeri*)
Chihuahuan spotted whiptail (*Cnemidophorus exsanguis*)
Gila whiptail (*Cnemidophorus flagellicaudus*)
Little striped whiptail (*Cnemidophorus inornatus arizonae*)
Checkered whiptail (*Cnemidophorus tesselatus*)
Western whiptail (*Cnemidophorus tigris*)
Desert-grassland whiptail (*Cnemidophorus uniparens*)
Many-linked skink (*Eumeces multivirgatus*)
Great Plains skink (*Eumeces obsoletus*)
Texas blind snake (*Leptotyphlops dulcis dissectus*)
Glossy snake (*Arizona elegans philipi*)
Ringneck snake (*Diadophis punctatus regalis*)
Western hooknosed snake (*Gyalopion canum*)
Western hognose snake (*Heterodon nasicus*)
Night snake (*Hypsiglena torguata*)
Common kingsnake (*Lampropeltis getulus splendilda*)
Coachwhip (*Masticophis flagellum*)
Striped whip snake (*Masticophis taeniatus taeniatus*)

TABLE III-4
(cont'd)

Amphibians and Reptiles Known or Presumed to Occur in the Reserve MOA

Pine gopher snake (Pituophis melanolencus affinis)
Longnosed snake (Rhinocheilus lecontei tessellatus)
Big Bend patchnosed snake (Salvadora deserticola)
Mountain patchnosed snake (Salvadora grahamiae)
Ground snake (Sonora semiannulata)
Mexican blackheaded snake (Tantilla atricepes)
Plains blackheaded snake (Tantilla nigriceps)
Blacknecked garter snake (Thamnophis cyrtopsis)
Western terrestrial garter snake (Thamnophis elegans)
Narrowheaded garter snake (Thamnophis rufipunctatus)
Lyre snake (Trimorphodon biscutatus vilkinsoni)
Western diamondback rattlesnake (Crotalus atrox)
Rock rattlesnake (Crotalus lepidus)
Blacktailed rattlesnake (Crotalus molossus)
Western rattlesnake (Crotalus viridis)

Source: Behler et al. 1979

TABLE III-5

Fishes That May Be Encountered In Catron County, New Mexico

Gila trout, *Salmo gilae*
Rainbow trout, *Salmo gairdneri*
Brown trout, *Salmo trutta*
Brook trout, *Salvelinus fontinalis*
Longfin dace, *Agosia chrysogaster*
Goldfish, *Carassius auratus*
Common carp, *Cyprinus carpio*
Roundtail chub, *Gila robusta*
Spike dace, *Meda fulgida*
Fathead minnow, *Pimephales promelas*
Speckled dace, *Rhinichthys osculus*
Coach minnow, *Tiaroga cobitis*
Desert sucker, *Catostomus clarki*
Channel catfish, *Ictalurus punctatus*
Gila topminnow, *Poeciliopsis occidentalis*
Green sunfish, *Lepomis cyanellus*
Bluegill, *Lepomis macrochirus*
Smallmouth bass, *Micropterus dolomieui*
Largemouth bass, *Micropterus salmoides*
White crappie, *Pomoxis annualaris*
Black crappie, *Pomoxis nigromaculatus*

Source: Lee et al. 1980

historical distribution. Of the native fish, the Gila trout is protected at the state and federal levels, and the roundtail chub, spike dace, and loach minnow are protected at the state level. The Gila chub (Gila intermedia) is endemic to the Gila Basin of Arizona and New Mexico. It presently occurs only in southeastern Arizona (Minckley 1973) and has not been collected in New Mexico waters since 1923 (New Mexico Department of Game and Fish 1985)

c. Birds

Numerous species of birds utilize the Reserve MOA. The main residences of birds are in the Gila National Forest and the Apache National Forest. Although there are many locally resident birds, even a larger number are migrant through the area. Table III-6 lists the species of birds native and transient that have been or could be observed in the MOA. The list includes the threatened or endangered species of New Mexico such as the common black hawk, the bald eagle, the Mississippi kite, Baird's sparrow, McCown's longspur, varied bunting, peregrine falcon, least tern, Gila woodpecker, Bell's vireo, and Gray's vireo.

d. Mammals

There are 149 species of native mammals in New Mexico, seven of which reside in New Mexico from intentional or accidental human introduction. Seventy-eight species of mammals could be encountered in Catron County. Four species have been recently eradicated from Catron County: the black-tailed prairie dog (Cynomys ludovicianus), gray wolf (Canis lupus), grizzly bear (Ursus arctos), and the black-footed ferret (Mustela nigripes). Of the extant species, one insectivore, 20 bats, three rabbits, 35 rodents, 13 carnivores, and 6 ungulates have been collected and/or observed in Catron County (Findley 1987; Findley et al. 1975). A listing of the mammals is provided in Table III-7. The diversity of mammalian fauna in Catron County is due to the variety of habitats encountered in the MOA. Findley et al. (1975) divides New Mexico mammals into montane forest, woodland, and desert-grassland categories, all of which are present in Catron County.

TABLE III-6

List of Birds That Maybe Encountered in Catron County, New Mexico

LEGEND:
R- Resident
W- Winter Resident
S- Summer Resident
T- Transient

COMMON NAME	STATUS
FAMILY GAVIIDAE - Loons	
Common loon	T
FAMILY PODICIPEDIDAE - Grebes	
Horned grebe	T
Eared-grebe	T
Pied-billed grebe	SR
Western grebe	T
FAMILY PHALACROCORACIDAE - Cormorants	
Doublecrested cormorant	T
Olivaceous cormorant	T
FAMILY ARDEIDAE - Herons, Egrets, Bitterns	
Great blue heron	R
Great heron	R
Great egret	SR
Snowy egret	T
Blackcrowned night heron	T
Yellowcrowned night heron	T
Least bittern	T
FAMILY THRESKIORNITHIDAE - Ibises	
Whitefaced ibis	T
FAMILY ANATIDAE - Ducks, Geese, Swans	
Whistling swan	T
Canada goose	T
Snow goose	T
Mallard	R
Mexican duck	SR
Gadwall	T
Pintail	T
Greenwinged teal	T
Bluewinged teal	T
Cinnamon teal	T
American wigeon	T
Northern shoveler	T
Wood duck	T
Redhead	T

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
Ringnecked duck	T
Canvasback	T
Lesser scaup	T
Common goldeneye	T
Bufflehead	T
Ruddy duck	T
Hooded merganser	T
Common merganser	R
Redbreasted merganser	T
FAMILY CATHARTIDAE - Vultures	
Turkey vulture	SR
FAMILY ACCIPITRIDAE - Hawks, Eagles, Harriers	
Goshawk	WR
Sharpskinned hawk	R
Cooper's hawk	R
Redtailed hawk	R
Swainson's hawk	WR
Zonetailed hawk	SR
Ferruginous hawk	T
Black hawk	SR
Marsh hawk	WR
Golden eagle	R
Bald eagle	WR*
FAMILY FALCONIDAE - Falcons	
Prairie falcon	R
Peregrine falcon	SR*
Merlin (pigeon hawk)	WR
American kestrel (sparrow hawk)	R
FAMILY PANDIONIDAE - Ospreys	
Osprey	T
FAMILY TETRAONIDAE - Grouse	
Blue grouse	R
FAMILY PHASIANIDAE - Quail, Pheasant	
Scaled quail	R
Gambel's quail	R
Montezuma (mearns) quail	R
Ring-necked pheasant	R
Chukar	R
FAMILY MELEAGRIDIDAE - Turkey	
Wild turkey	R

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
FAMILY GRUIDAE - Cranes	
Sandhill crane	WR
FAMILY RALLIDAE - Rails, Gallinules, Coots	
Virginia rail	T
Sora	T
Common gallinule	SR
American coot	R
FAMILY CHARADRIIDAE - Plovers	
Killdeer	R
Semipalmated plover	T
Blackbellied plover	T
FAMILY SCOLOPACIDAE - Sandpipers, Snipes	
Common snipe	WR
Spotted sandpiper	SR
Solitary sandpiper	T
Pectoral sandpiper	T
Least sandpiper	T
Willet	T
Greater yellowlegs	T
Lesser yellowlegs	T
Longbilled dowitcher	T
Marbled godwit	T
FAMILY RECIRVOROSTRIDAE - Avocets and Stilts	
American avocet	T
Blacknecked stilt	R
FAMILY PHALAROPODIDAE - Phalaropes	
Wilson's phalarope	T
Northern phalarope	T
FAMILY LARIDAE - Gulls, Terns	
Ringbilled gull	T
Franklin's gull	T
Black tern	T
Least tern	T*
FAMILY COLUMBIDAE - Pigeons, Doves	
Bandtailed pigeon	SR
Rock dove	R
Mourning dove	R
Whitewinged dove	SR

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
FAMILY <u>CUCULIDAE</u> - Cuckoos, Roadrunners	
Yellowbilled cuckoo	SR
Roadrunner	R
FAMILY <u>TYTONIDAE</u> - Barn Owls	
Barn owl	R
FAMILY <u>STRIGIDAE</u> - Owls	
Screech owl	R
Great horned owl	R
Pygmy owl	R
Elf owl	SR
Burrowing owl	R
Spotted owl	R
Flammulated owl	SR
Longeared owl	WR
Saw-whet owl	WR
FAMILY <u>CAPRIMULGIDAE</u> - Goatsuckers	
Whippoor-will	SR
Poor-will	SR
Common nighthawk	SR
Lesser nighthawk	SR
FAMILY <u>APODIDAE</u> - Swifts	
Black swift	T
Whitethroated swift	SR
FAMILY <u>TROCHILIDAE</u> - Hummingbirds	
Blackchinned hummingbird	SR
Broadtailed hummingbird	SR
Rufous hummingbird	SR
Calliope hummingbird	SR
Rivoli's hummingbird	SR (?)
FAMILY <u>ALCEDINIDAE</u> - Kingfishers	
Belted kingfisher	SR
FAMILY <u>PICIDAE</u> - Woodpeckers	
Common flicker (redshafted flicker)	R
Gila woodpecker	R*
Acorn woodpecker	R
Lewis' woodpecker	R, T
Yellowbellied sapsucker	R
Hairy woodpecker	R

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
Ladderbacked woodpecker	R
Williamson's sapsucker	R
Downy woodpecker	R
Northern Threetoed woodpecker	T
FAMILY TYRANNIDAE - Flycatchers	
Western kingbird	SR
Cassin's kingbird	SR
Scissortailed flycatcher	T
Wied's flycatcher	SR
Ash-throated flycatcher	SR
Eastern phoebe	T
Black phoebe	R
Say's phoebe	R
Gray flycatcher	SR
Traill's flycatcher	SR
Hammond's flycatcher	T
Dusky flycatcher	T
Coues' flycatcher	SR
Western flycatcher	SR
Western wood pewee	SR
Olivesided flycatcher	T
Vermilion flycatcher	SR
FAMILY ALAUDIDAE - Larks	
Horned lark	R
FAMILY HIRUNDINIDAE - Swallows	
Violet-green swallow	SR
Tree swallow	T
Bank swallow	T
Roughwinged swallow	SR
Barn swallow	SR
Cliff swallow	SR
Purple martin	SR
FAMILY CORVIDAE - Jays, Crows	
Steller's jay	R
Mexican (Arizona) jay	R
Scrub jay	R
Common raven	R
Whitenecked raven	R
Common crow	R
Clark's nutcracker	R
Pinyon jay	R

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
FAMILY PARIDAE - Chickadees, Titmice, Bushtits	
Mexican chickadee	SR
Mountain chickadee	R
Plain titmouse	R
Bridled titmouse	R
Verdin	R
Bushtit	R
Blackcapped chickadee	R
FAMILY SITTIDAE - Nuthatches	
Whitebreasted nuthatch	R
Redbreasted nuthatch	WR
Pygmy nuthatch	R
FAMILY CERTHIIDAE - Creepers	
Brown creeper	R
FAMILY CINCLIDAE - Dippers	
Dipper	R
FAMILY TROGLODYTIDAE - Wrens	
House wren	SR
Bewick's wren	R
Cactus wren	R
Longbilled marsh wren	WR
Canyon wren	R
Rock wren	R
FAMILY MIMIDAE - Mockingbirds, Thrashers	
Mockingbird	R
Catbird	SR
Brown thrasher	T
Bendire's thrasher	SR
Curvebilled thrasher	R
Crissal thrasher	R
Sage thrasher	WR
FAMILY TURDIDAE - Thrushes, Bluebirds	
American robin	R
Hermit thrush	SR
Swainson's thrush	SR
Eastern bluebird	WR
Western bluebird	R
Mountain bluebird	R
Townsend's solitaire	R

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
FAMILY SYLVIIDAE - Gnatcatchers, Kinglets	
Bluegray gnatcatcher	SR
Blacktailed gnatcatcher	WR
Goldencrowned kinglet	T-WR
Rubycrowned kinglet	WR
FAMILY MOTACILLIDAE - Pipits	
Water pipit	R
FAMILY BOMBYCILLIDAE - Waxwings	
Cedar waxwing	WR
FAMILY PTILOGONATIDAE - Silky Flycatchers	
Phainopepla	
FAMILY LANIIDAE -Shrikes	
Loggerhead shrike	R
FAMILY STURNIDAE - Starling	
Starling	R
FAMILY VIREONIDAE - Vireos	
Hutton's vireo	SR
Bell's vireo	SR*
Gray vireo	SR*
Solitary vireo	SR
Warbling vireo	SR
FAMILY PARULIDAE - Wood Warblers	
Black & white warbler	T
Tennessee warbler	T
Orangecrowned warbler	T-SR
Nashville warbler	T
Virginia's warbler	SR
Lucy's warbler	SR
Olive warbler	SR
Yellow warbler	SR
Yellowrumped warbler	
(Myrtle)	T
(Audubon's)	SR
Blackthroated gray warbler	SR
Townsend's warbler	T
Hermit warbler	T
Grace's warbler	SR
Blackpoll warbler	T
Palm warbler	T

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
Northern waterthrush	T
MacGillivray's warbler	SR
Common yellowthroat	SR
Yellowbreasted chat	SR
Redfaced warbler	SR
Wilson's warbler	T
American redstart	T
Painted redstart	SR
FAMILY PLOCEIDAE - Weaver Finch	
House (English) sparrow	R
FAMILY ICTERIDAE - Meadowlarks, Blackbirds, Orioles	
Eastern meadowlark	R
Western meadowlark	R
Yellowheaded blackbird	T
Redwinged blackbird	SR
Orchard oriole	T
Hooded oriole	SR
Northern oriole (Bullock's oriole)	SR
Scott's oriole	SR
Brewer's blackbird	SR
Greattailed grackle	SR
Brownheaded cowbird	SR
Bronzed cowbird	SR
FAMILY THRAUPIDAE - Tanagers	
Western tanager	SR
Hepatic tanager	SR
Summer tanager	SR
FAMILY FRINGILLIDAE - Grosbeaks, Finches, Sparrows, Buntings	
Cardinal	SR
Pyrrhuloxia	WR
Blackheaded grosbeak	SR
Rosebreasted grosbeak	T
Blue grosbeak	SR
Lazuli bunting	T
Indigo bunting	SR
Evening grosbeak	R - T
Purple finch	T
House finch	R
Cassin's finch	T - WR

TABLE III-6
(cont'd)

List of Birds That Maybe Encountered in Catron County, New Mexico

COMMON NAME	STATUS
Pine siskin	R
American goldfinch	WR
Lesser goldfinch	SR
Red crossbill	R
Greentailed towhee	WR
Rufoussided (spotted towhee)	R
Brown towhee	R
Abert's towhee	R
Lark bunting	T
Vesper sparrow	WR
Lark sparrow	SR
Rufouscrowned sparrow	R
Blackthroated sparrow	R
Cassin's sparrow	SR
Grayheaded junco	
Darkeyed junco (Oregon junco)	T - WR
Darkeyed junco (Slatecolored junco)	T - WR
Chipping sparrow	SR
Brewer's sparrow	WR
Harris' Sparrow	
Whitecrowned sparrow	WR
Goldencrowned sparrow	T
Whitethroated sparrow	T
Fox sparrow	WR - T
Lincoln's sparrow	WR - T
Swamp sparrow	WR - T
Song sparrow	WR
Savannah sparrow	WR - T
Blackchinned sparrow	SR
Chestnutcolored longspur	WR
Baird's sparrow	T*
McCown's longspur	T*
Varied bunting	T*

* On the New Mexico Threatened and Endangered Species List

Source: Robins et al. 1966; Clark 1987

TABLE III-7

List of Mammals Found or Known to Occur In Catron County, New Mexico

ORDER INSECTIVORA
Vagant shrew (Sorex vagrans)

ORDER CHIROYSTERA
Cave myotis (Myotis velifer)
Yuma myotis (Myotis yumanensis)
Little brown myotis (Myotis lucifugus)
Southwestern myotis (Myotis auriculus)
Longeared myotis (Myotis evotis)
Fringed myotis (Myotis thysanodes)
Long-legged myotis (Myotis volans)
California myotis (Myotis californicus)
Small-footed myotis (Myotis leibii)
Silver-haired bat (Lasionycteris noctivagans)
Western pysistrelle (Pipsistrellus hesperus)
Big brown bat (Eptesicus fuscus)
Red bat (Lasiurus borealis)
Hoary bat (Lasiurus cinereus)
Spotted bat (Euderma maculatum)
Allen's big-eared bat (Idionycteris phyllotis)
Townsend's big-eared bat (Plecotus townsendii)
Pallid bat (Antrozous pallidus)
Brazilian free-tailed bat (Tadarida brasiliensis)
Big free-tailed bat (Tadarida macrotis)

ORDER LAGOMORPHA
Cottontail (Sylvilagus floridanus)
Dessert cottontail (Sylvilagus auduboni)
Black-tailed jackrabbit (Lepus californicus)

ORDER RODENTIA
Cliff chipmunk (Eutamias dorsalis)
Gray-colored chipmunk (Eutamia cinereicollis)
Thirteentined ground squirrel (Spermophilus tridecemlineatus)
Spotted ground squirrel (Spermiophilus spilosoma)
Rock squirrel (Spermophilus variegates)
Golden-mantled ground squirrel (Spermophilus lateralis)
* Black-tailed prairie dog (Cynomys ludovicianus)
Gunnison's prairie dog (Cynomys gunnisoni)
Abert's squirrel (Sciurus aberti)
Arizona gray squirrel (Sciurus arizonensis)
Red squirrel (Tamiasciurus hudsonicus)
Botta's pocket gopher (Thomomys bottae)
Silky pocket mouse (Perognathus flavus)
Rock pocket mouse (Perognathus intermedius)
Ord's kangaroo rat (Dipodomys ordii)
Western harvest mouse (Reithrodntomys megalotis)
Cactus mouse (Peromyscus eremicus)
Deer mouse (Peromyscus maniculatus)

TABLE III-7
(cont')

List of Mammals Found or Known to Occur In Catron County, New Mexico

White-footed mouse (Peromyscus leucopus)
Brush mouse (Peromyscus boylii)
Pinon mouse (Peromyscus truei)
Rock mouse (Peromyscus difficilis)
Northern grasshopper mouse (Onychomys leucogaster)
Southern grasshopper mouse (Onychomys torridus)
Southern Plains woodrat (Neotoma micropus)
White-throated woodrat (Neotoma albigula)
Stephen's woodrat (Neotoma stephensi)
Mexican woodrat (Neotoma mexicana)
Gappers' red-backed mouse (Clethrionomys gapperi)
Meadow vole (Microtus pennsylvanicus)
Mexican vole (Microtus mexicanus)
Long-tailed vole (Microtus longicaudus)
Muskrat (Ondatra zibethicus)
House mouse (Mus musculus)
Porcupine (Erethizon dorsatum)
Montane vole (Microtus montanus)

ORDER CARNIVORA
Coyote (Canis latrans)
* Gray wolf (Canis lupus)
Gray fox (Urocyon cinereoargenteus)
Black bear (Ursus americanus)
* Grizzly bear (Ursus arctos)
Ringtail (Bassariscus astutus)
Racoon (Procyon lotor)
Long-tailed weasel (Mustela frenata)
* Black-footed ferret (Mustela nigripes)
Badger (Taxidea taxus)
Western spotted skunk (Spilogale gracilis)
Striped skunk (Mephitis mephitis)
Hooded skunk (Mephitis macroura)
Hog-nosed skunk (Concepatus mesoleucus)
Mountain lion (Felis concolor)
Bobcat (Lynx rufus)

ORDER ARTIODACTYLA
Colored peccarny (Tayassu pecari)
Elk (Cerrus elaplus)
Mule deer (Odocoileus hemionus)
White tailed deer (Odocoileus virginiamus)
Pronghorn (Antilocapra americana)
Bighorn sheep (Ovis canadensis)

* Eradicated

Source: Findley et al.

e. Threatened and Endangered Species

Several species of plants and animals have been identified for protection or special concern by the State of New Mexico (New Mexico Game and Fish Report 1987). In New Mexico, Endangered Group 1 species are defined as those whose prospects of survival or recruitment within the state are in jeopardy. In Catron County, these include the Peregine falcon, Gila chub, Gila trout, Bighorn sheep (Ovis canadensis mexinana), gray wolf (Canis lupus baileyi), black-footed ferret, and the Gila monster (Heloderma suspectum). Extirpated species are the grey wolf and the black-footed ferret. Other species known to currently or historically occur in Catron County are listed in Table III-8 (a). Table III-8 (b) is the Federally listed species which are threatened and/or endangered.

Several species of plants that are found in Catron County have been suggested as candidates for federal protection, and are listed in Table III-9. The source for this listing is the New Mexico Native Plant Protection Advisory Committee (1984). The most serious state category, (biologically endangered), includes the Zuni fleabane (Erigeron rhizomatus), Gila groundsel (Semecia quaerens), 2Mogollon dock (Rumex tomentellus), and the grama grass cactus (Pediocactus papyracanthus). Biologically threatened species include Hess's fleabane (Erigeron hessii), Wright's pincushion cactus (Mammillaria wrightii), Mogollon clover (Trifolium longipes), and Goodding's onion (Allium goodingii).

G. Cultural/Historical Resources

1. Status of Cultural/Historical Research

Professional interest in the Reserve MOA has been unsystematic and uneven in regard to areal coverage. Most of the research efforts have been focused on the Gila National Forest, especially within the Gila, San Francisco, Tularosa, and Mogollon River drainages. A bias toward sites with above ground architecture or surface features has also resulted in an unbalanced recovery of data from the several developmental periods of southwestern prehistory. The focus of the primary fieldwork in the area during three periods of intensive investigations,

TABLE III-8 (a)

New Mexico Threatened and Endangered Species, Catron County

1. Common black hawk (_Buteogallus anthracinus_) Endangered (Group 2), known or highly likely to occur. Summers primarily at lower elevations in the Gila, San Francisco, and Minbres drainages, which are key habitats for it

2. Bald eagle (_Haliaeetus leucocephalus_) Endangered (Group 2), known or highly likely to occur. Upper Gila basin is a key area, nests have been reported in Catron County

3. Mississippi kite (_Ictinia mississippiensis_) Endangered (Group 2), known to occur less than regularly and regular occurrence is unlikely in recent time (1960 or later). Migrants in the Gila-San Francisco valleys

4. Baird's sparrow (_Ammodramus bairdii_) Endangered (Group 2), known to occur less than regularly and regular occurrence is unlikely in recent time (1960 or later)

5. McCown's longspur (_Calcarius mccownii_) Endangered (Group 2), known to occur less than regularly and regular occurrence is unlikely in recent time (1960 or later)

6. Varied bunting (_Passerina versicolor_) Endangered (Group 2), known to occur less than regularly and regular occurrence is unlikely in recent time (1960 or later)

7.* Peregrine falcon (_Falco peregrinus_) Endangered (Group 1), known or is highly likely to occur in recent times

8. Least tern (_Sterna antillarum_) Endangered (Group 2), known to occur less than regularly, and where regular occurrence is unlikely in recent time (1960 or later). Migrant near Glenwood

9. Gila woodpecker (_Melanerpes uropygialis_) Endangered (Group 2), known to occur less than regularly, regular occurrence is unlikely in recent time (1960). Resident in the Gila Valley, Migrants near Glenwood

10. Bell's vireo (_Vireo bellii_) Endangered (Group 2), known to occur less than regularly, but where regular occurrence is likely in recent time. Summers in the lower Gila Valley and occasionally in the lower San Francisco Valley

11. Gray vireo (_Vireo vicinior_) Endangered (Group 2), known to occur or is highly likely to occur regularly in recent time. Glenwood area is key habitat

12.* Gila chub (_Gila intermedia_) Endangered (Group 1), known to occur less than regularly and where regular occurrence is unlikely in recent time (1960). Endemic to Gila basin, not collected in state since 1923.

TABLE III-8 (a)
(cont'd)

New Mexico Threatened and Endangered Species, Catron County

13. Roundtail chub (Gila robusta) Endangered (Group 2), known or highly likely to occur regularly in recent times. Gila river, from headwaters at the east fork and the vicinity of the confluence of the west and middle forks southward to Redrock. An isolated population in Twenty Creek, all are key habitat for G. n. grabani.

14. Spikedace (Meda fulgida) Endangered (Group 2), known or is highly likely to occur regularly in recent time. Limited to the Gila River system in the lowermost west and middle forks, the reach between Mogollon Creek and the head of the Middle Box (Cliff, Gila Valley) and the mouth of the Middle Box (key habitat)

15. Loach minnow (Tiaroga cobitis) Endangered (Group 2), known or is highly likely to occur regularly in recent time (see book for key habitats)

16.* Gila trout (Salmo gilae) Endangered (Group 1), known or is highly likely to occur regularly in recent time (see book for key habitats)

17.* Bighorn sheep (Ovis canadensis mexinana) Endangered (Group 1), known to occur less than regularly, regular occurrence is unlikely in recent time (1960)

18.* Gray wolf (Canis lupus baileyi) Endangered (Group 1), Extirpated from New Mexico, known to occur less than regularly, and where occurrence is unlikely in recent time (1960 or later)

19. Montane vole (Microtus montanus arizonensis) ("Arizona Race") Endangered (Group 2). Centerfire Bog is key habitat for this species, known or highly likely to occur regularly in recent time

20.* Blackfooted ferret (Mustela nigripes) Endangered (Group 1). Probably extirpated from the state, known to occur less than regularly and where regular occurrence is unlikely in recent time (1960)

21. Sonoran Mountain kingsnake (Lampropeltis pyromelana) Endangered (Group 2), known or is highly likely to occur regularly in recent time

22. Narrowhead garter snake (Thamnophis rufipunctatus) Endangered (Group 2). Key habitat areas are Gila and San Francisco rivers and their major tributaries, known or is highly likely to occur regularly in recent time

23.* Gila monster (Heloderma suspectum) Endangered (Group 1), known to occur less than regularly and where regular occurrence is unlikely in recent time (1960)

Source: New Mexico State Game Commission 1985

TABLE III-8(b)

Federally Listed Endangered Species

Listed Species

Bald Eagle (Haliaeetus leucocephalus) - Winters in the project area and is also a migrant. Roosts in large trees which may or may not be close to their feeding areas. These include rivers, reservoirs, and ponds.

Authority: John P. Hubbard, New Mexico Department of Game and Fish, State Capitol, Santa Fe, New Mexico 87503, (505) 827-7952.

American Peregrine Falcon (Falco peregrinus anatum) - The peregrine falcon prefers areas with steep rocky cliffs in close proximity to water. Dense bird populations provide the primary food source for the peregrine falcon and areas in which these bird concentrations are found are also important habitat.

Authority: John P. Hubbard, New Mexico Department of Game and Fish, State Capitol, Santa Fe, New Mexico 878503, (505) 827-7952.

Aplomado Falcon (Falco femoralis septentrionalis) - An endangered bird, is currently not found in New Mexico but may be introduced into historic range in the State. Historic range includes Catron, Chaves, Dona Ana, Eddy, Grant, Hidalgo, Lea, Lincoln, Luna, Otero, Sierra, and Socorro Counties. This species is found in open woodland, savanna or grassland habitats.

Authority: John P. Hubbard, New Mexico Department of Game and Fish, State Capitol, Santa Fe, New Mexico 87503, (5505) 827-7894.

Proposed Species

None

Critical Habitat

None

Candidate Species

Category 1 - None

Category 2

Swainson's hawk	(Buteo swainsoni)
Ferruginous hawk	(Buteo regalis)
Mexican spotted owl	(Strix occidentalis lucida)
Mountain plover	(Charadrius montanus)
Long-billed curlew	(Numenius americanus)
Western yellow-billed cuckoo	(Coccyzus americanus occidentalis)

TABLE III-9

Plants of Special Concern in Catron County, New Mexico

- Aletes filifolius, threadleaf false carrot, state priority 1, removed from consideration for federal protection

- Pteryxia davidsonii, Davidson's cliff carrot, state priority 1, no federal action

- Cirsium gilense, Gila thistle, state priority 1, no federal action

- Erigeron hessii, Hess's fleabane, biologically threatened, Federal Register, 15 December 1980, Candidate for federal protection

- Erigeron rhizomatus, Zuni fleabane, biologically endangered, Federal Register, 15 December 1980, candidate for federal protection

- Erigeron scapulinus, rock fleabane, state priority 1, no federal action

- Senecio cardamine, heartleaf senecio, state priority 1, Federal Register, 15 December 1980, removed from consideration for federal protection

- Senecio quaerens, Gila groundsel, biologically endangered, Federal Register, 15 December 1980, candidate for federal protection

- Senecio sacramentanus, Sacramento groundsel, state priority 1, no federal action

- Draba mogollonica, Mogollon whitlograss, state priority 1, Federal Register, 15 December 1980, removed from consideration for federal protection

- Lesquerella gooddingii, Goodding's bladderpod, state priority 1, Federal Register, 15 December 1980, candidate for federal protection

- Mammillaria wrightii, Wright's pincushion cactus, biologically threatened, no federal action

- Silene wrightii, Wright's catchfly, state priority 1, Federal Register, 15 December 1980, candidate for federal protection

- Trifolium longipes, Mogollon clover, biologically threatened, no federal action

- Allium gooddingii, Goodding's onion, biologically threatened, Federal Register, 15 December 1980, candidate for federal protection

- Rumex tomentellus, Mogollon dock, biologically endangered, no federal action

TABLE III-9
(cont'd)

Plants of Special Concern in Catron County, New Mexico

- Crataegus wootoniana, Wooton's hawthorn, state priority 1, no federal action
- Heuchera wootonii, Wooton's alum root, state priority 1, no federal action
- Pediocactus papyracanthus, gramma grass cactus, biologically endangered, candidate for federal protection

Source: New Mexico Native Plant Protection Advisory Committee 1984; Personal communications: Ms. Anne Cully 1987 the turn of the century, the 1940s and early 1950s, and the early 1970s, has always been the Formative or Puebloan periods of occupation. The completion of most of this work prior to the "scientific" revolution in archeology during the 1960s reflects the early preoccupation of archeologists with recognizing spatial and temporal patterns within the archeological record. Consequently, this work was oriented toward classification and chronology in order that culture histories might be constructed. As Berman (1979) repeatedly notes, recognition of the processes or developmental forces which contributed to the cultural/historical reconstruction as it is presently known still remains as a primary research goal

Within the Reserve MOA itself, a major shortcoming of the data base is the lack of systematic surveys over the majority of the area. Most of the archeological investigations have been conducted on major sites located on the larger drainages within the region. Survey efforts have been generally small in scale and frequently involve sampling strategies which are project specific. Prediction of site locations, distributions, and content is therefore extremely difficult for the Reserve MOA as a whole.

2. Known Archeological and Historic Properties

Within the Reserve MOA, there is a total of 1,210 cultural properties presently listed. Among these properties, 131 rock art localities (10.8 percent), four caves, six rockshelters, and five walls are registered within the State of New Mexico Laboratory of Anthropology files. Historic sites which may contain standing structures comprise less than one percent of the total site sample. This representation, however, is biased by the emphasis on recording prehistoric properties during earlier surveys. Survey coverage of the MOA has also been less than systematic, for survey efforts have either focused on narrow linear transects, spatially limited quadrants, or only partial coverage of a target area. Nevertheless, the types of sites that may be expected in the area are well known. Pithouse villages, pueblos, rockshelters, caves, wickiups, canals, walls, field houses, lithic scatters, quarries, rock art sites, other limited activity sites, log cabins, cemeteries, historic outbuildings, and military encampments are present. Within the proposed flight ellipse, survey coverage is minimal at best and highly biased. Of the 74 sites recorded within the U.S. Forest Service files, 58 are prehistoric and 16 are historic. The more sensitive site types, that of rock art (n=4), rockshelters (n=6), and modified caves (n=2) are poorly represented. Nine of the 16 historic sites potentially contain standing structures of log, milled lumber, or stone. The Laboratory of Anthropology files indicate the additional presence of one cave and 35 rock art localities among the sites recorded within the flight ellipse.

Eligibility for nomination to the National Register of Historic Places has not been determined for most of the known sites within the Reserve MOA. Only two, Tularosa Cave and the Forest Service's Negrito Mountain Lookout, have been determined to be eligible. An additional cave, O Block Cave, has been informally evaluated as eligible. Twenty-three petroglyph sites (four of which are located within the flight ellipse), three water control devices, and one wall are also regarded as eligible for nomination to the National Register of Historic Places.

Within the Reserve MOA, three sites are presently listed on the National Register of Historic Places. Bat Cave (LA-4935), Apache-Aragon HWS (LA-3251), and Starkweather Ruin (LA-38624) are within the MOA, but none are within the proposed flight ellipse. Bat Cave is just beyond the eastern periphery of the ellipse as presently proposed. Apache Creek Pueblo, listed on the New Mexico State Register is also within the MOA but outside the proposed flight ellipse.

H. Socioeconomic Considerations

1. Economic Considerations

This analysis concentrates on Catron County, which encompasses that portion of the Reserve MOA that is proposed for supersonic training operations. The primary source of supporting data was the Southwestern New Mexico Council of Governments, which contains the counties of Catron, Grant, Luna, and Hidalgo. In the spring of 1988, the Council of Governments updated its Statistical Handbook, which contains a rigorous documentation of the statistics available on its member counties. The Handbook was prepared by the Council of Governments with the assistance of the Department of Commerce, Economic Development Administration. This effort was an update of the original report prepared in July 1985. The following analysis will incorporate the findings of the Handbook as they pertain to Catron County and to the various impacts on the Reserve MOA.

2. Population

The population growth of Catron County is given in Table III-10 (Figure III-5). Catron County was first recorded in the census records in 1930 and saw its peak population in 1940. After that time, a general decline was experienced until the late 1980s. It is projected that the county will reestablish its population prior to the year 2020. These projections seem optimistic in the light of the growth limitations listed below in the area:

- Employment in the county is very cyclical and seasonal, established and supported by tourism activity, lumbering activity, and seasonal work by the U.S. Forest Service.
- Ownership of the land in the county is primarily federal, leaving little to support development by the private market. Eighty percent of the Reserve MOA is owned by federal and state government. Less than 10 percent of the MOA proposed for supersonic flight is privately owned.
- No additional water resource development projects are permitted in the area, reducing commitment to recreation, tourism, industrial/commercial growth, residential uses, and long range planning for economic growth and development.

Although the population projections may be encouraging, population growth in the coming years will have to support and be supported by, growth in other sectors of the economy. It does not appear that those supporting sectors are available to support the approximately 55 percent (by year 2020) growth picture presented above. The population has, however, recovered to approximately 3,000 persons to date, an approximate 35 percent increase since the low population level experienced in 1970.

Of greatest importance to the local population is its present and projected age composition. Figures III-6 through III-12 were prepared from the age

TABLE III-10

Catron County Population, 1930-2020

YEAR	CATRON COUNTY
1930	3282
1940	4881
1950	3533
1960	2773
1970	2198
1980	2720
1990	3204
2000	3749
2010	4223
2020	4633

Source: University of New Mexico, Bureau of Business and Economic Research 1988

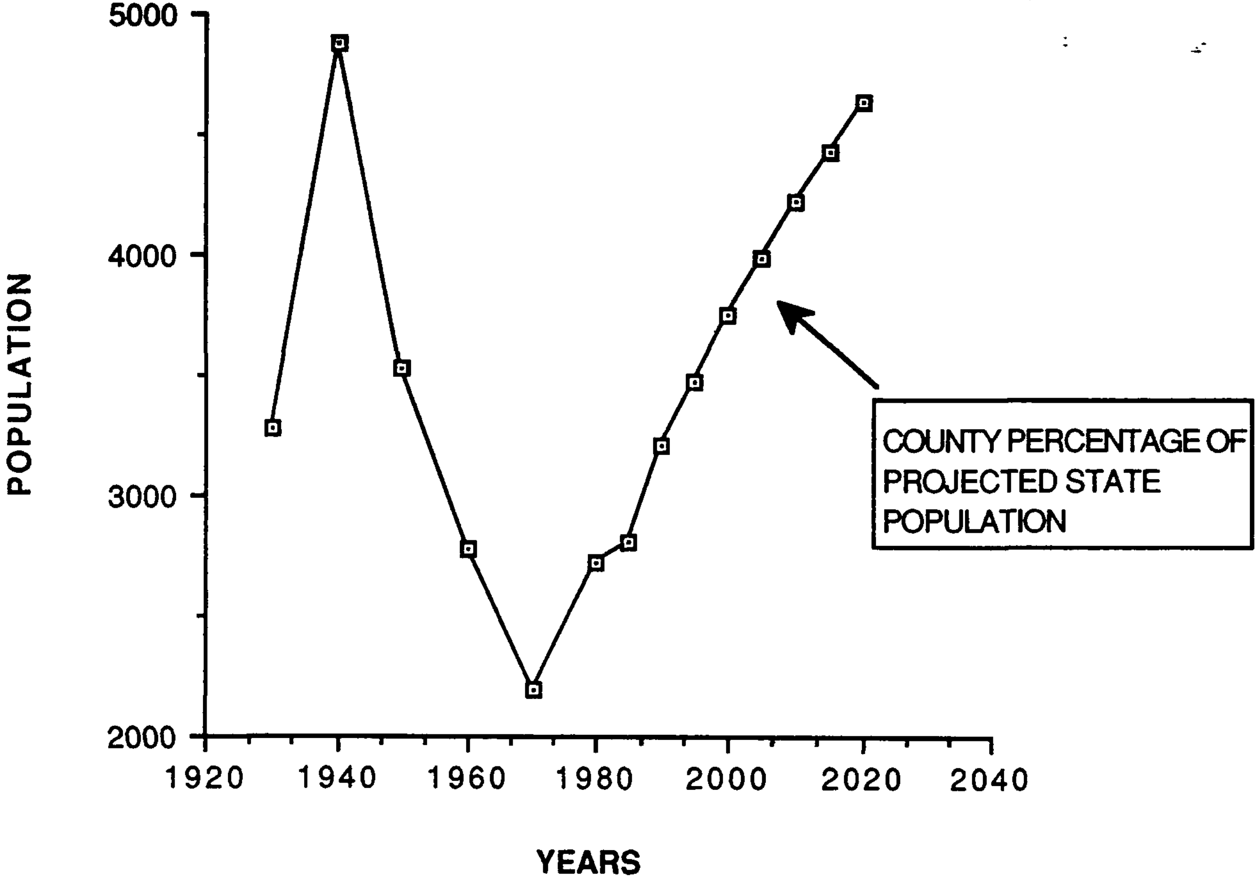
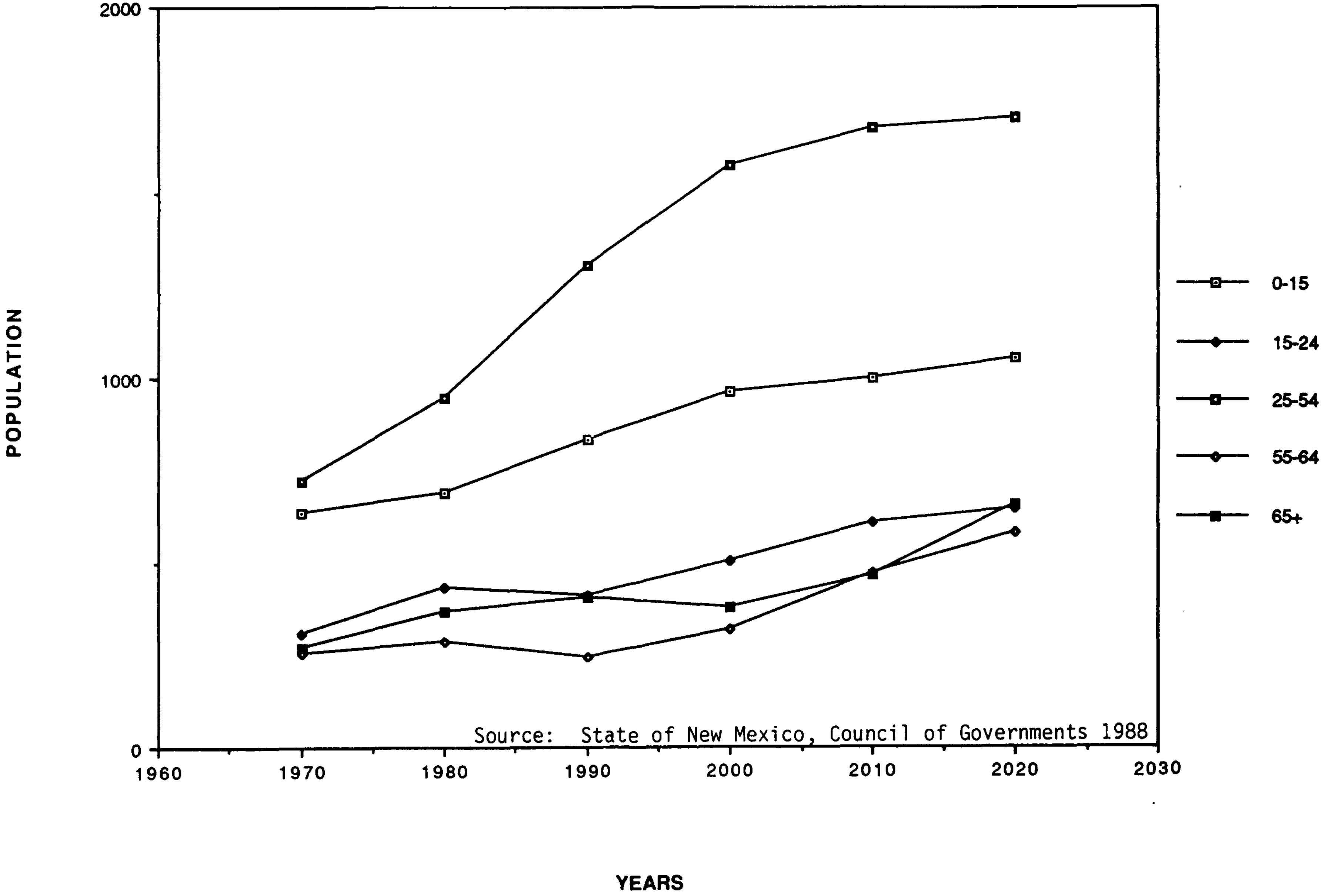
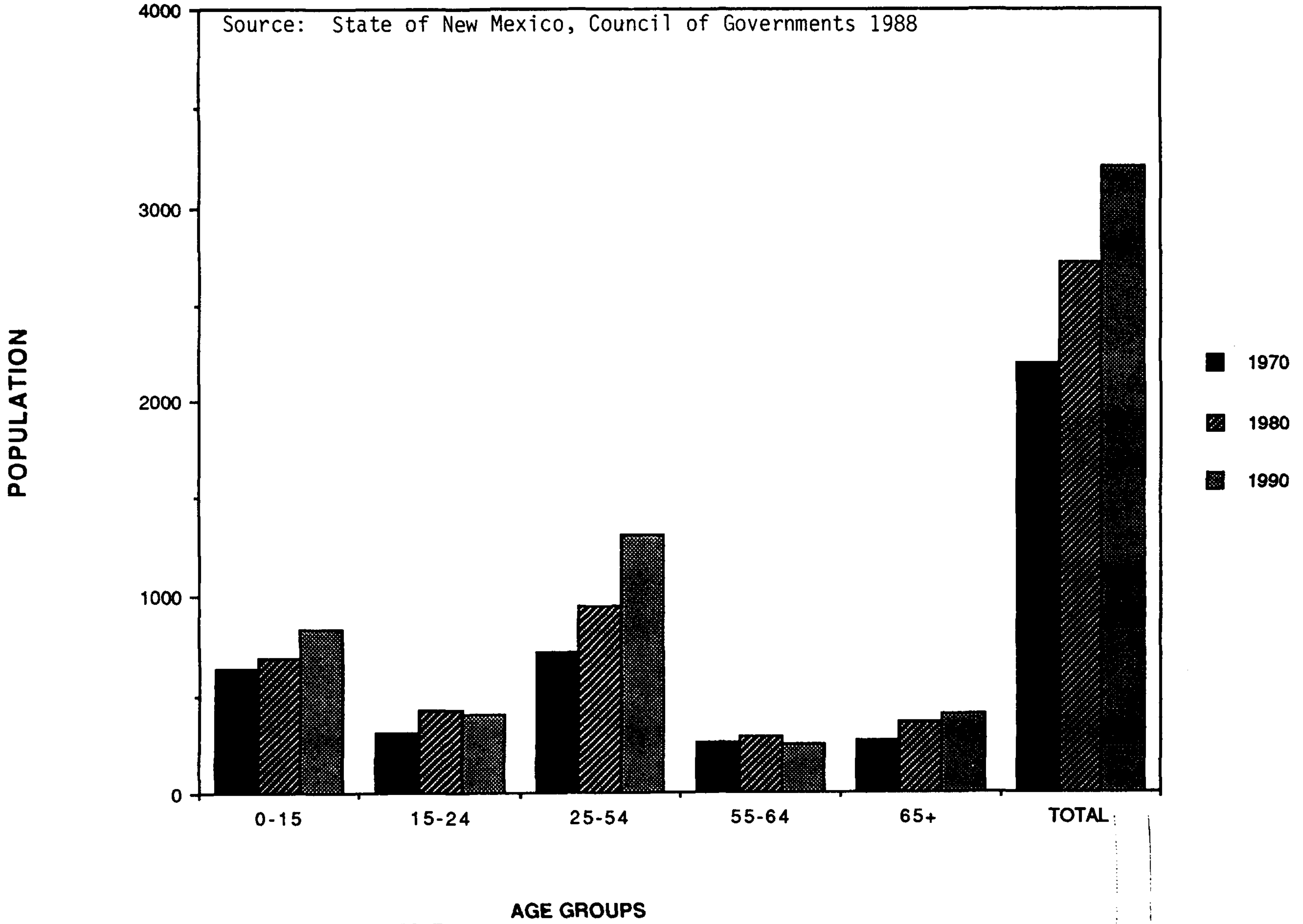


FIGURE III-5 Historical and Projected Population Growth, Catron County, New Mexico.



Source: State of New Mexico, Council of Governments 1988

FIGURE III-6 Population, By Age Group, Catron County, New Mexico.



Source: State of New Mexico, Council of Governments 1988

FIGURE III-7 Population Groups, Catron County, New Mexico 1970-1990.

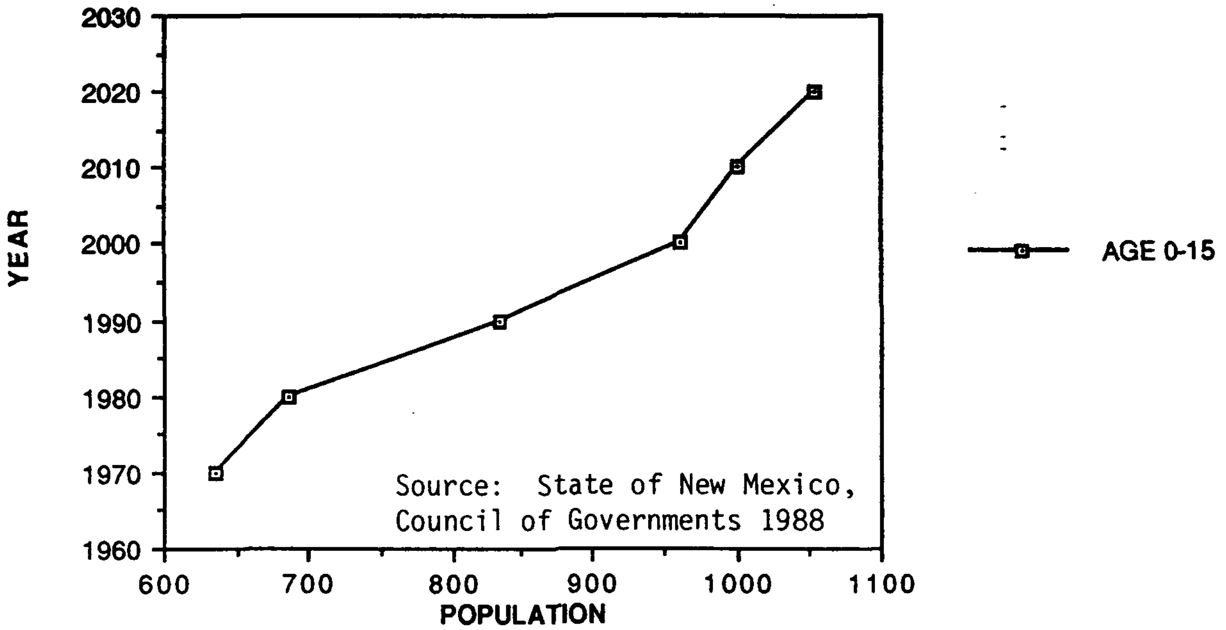


FIGURE III-8 Historic and Projected Population, Age Group 0-15, Catron County, New Mexico.

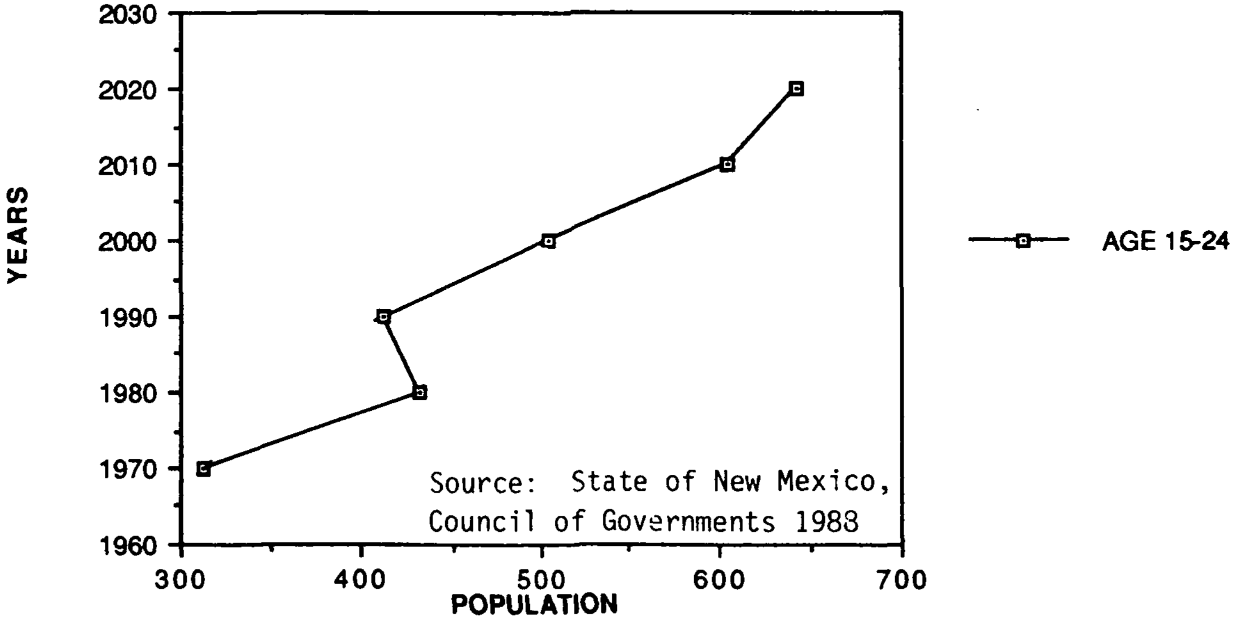


FIGURE III-9 Historic and Projected Population, Age Group 15-24, Catron County, New Mexico.

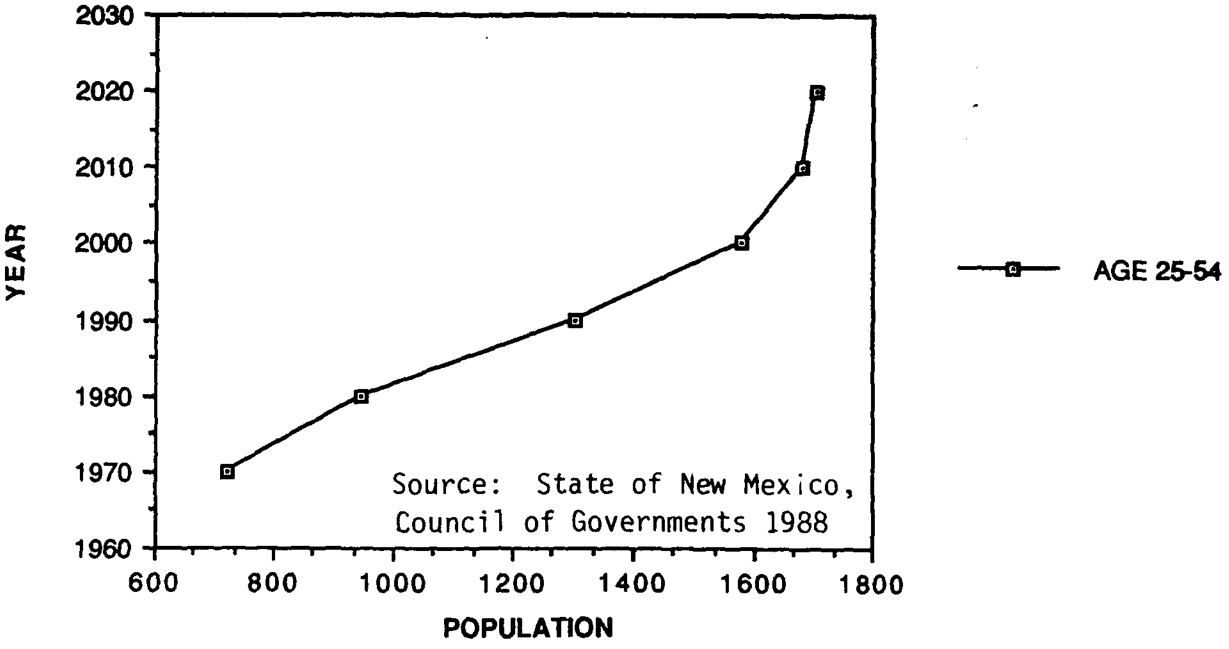


FIGURE III-10 Historic and Projected Population, Age Group 25-54, Catron County, New Mexico.

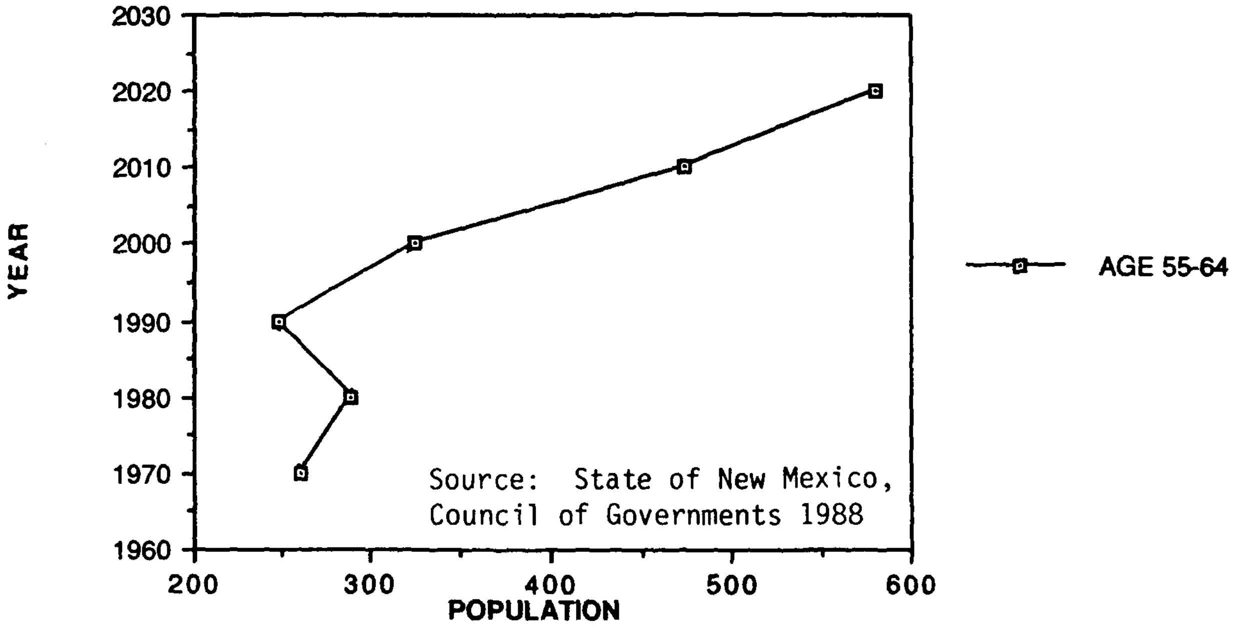
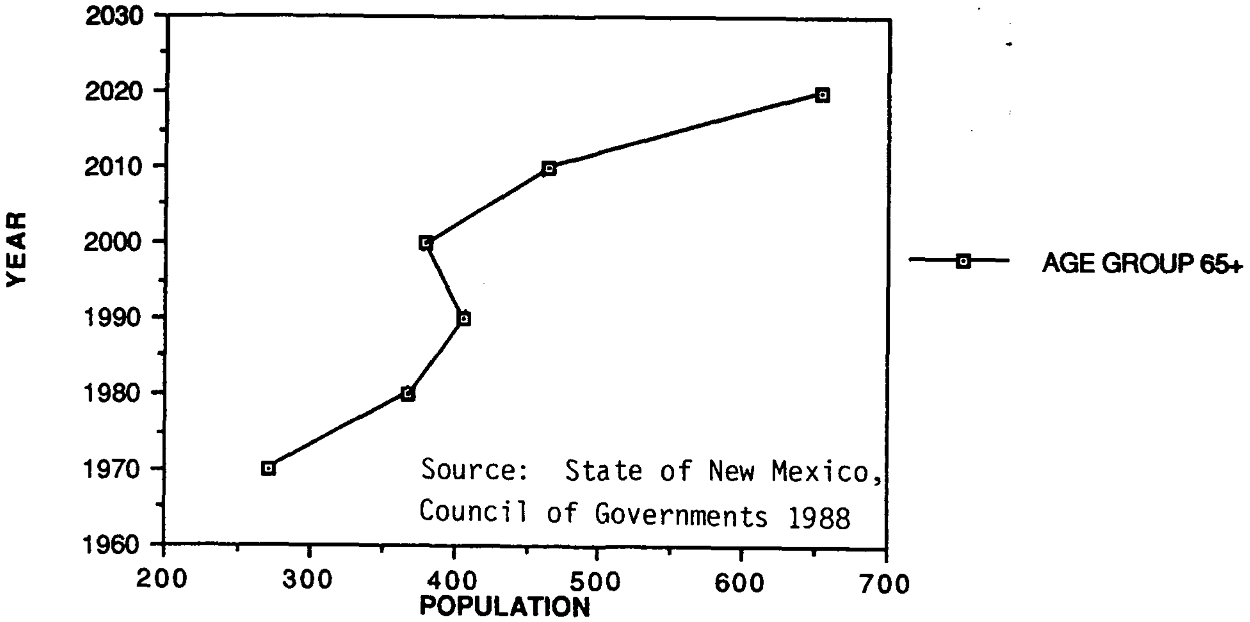


FIGURE III-11 Historic and Projected Population, Age Group 55-64, Catron County, New Mexico.



Source: State of New Mexico, Council of Governments 1988

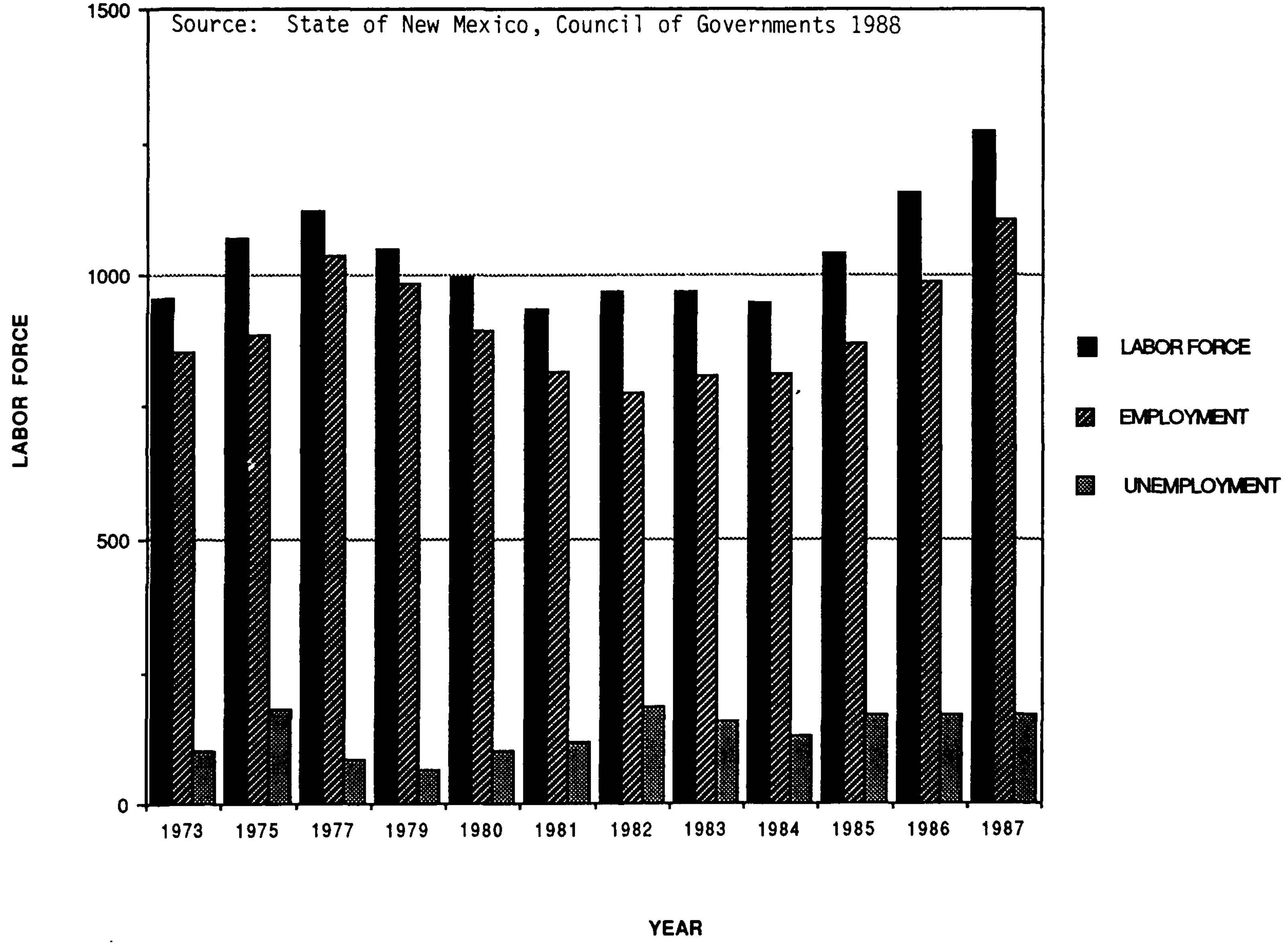
FIGURE III-12 Historic and Projected Population, Age Group 65+, Catron County, New Mexico.

distribution projections from the University of New Mexico as compiled by the Southwest New Mexico Council of governments. It is apparent that the highest population growth expected will occur in the age groups from 25 to 54, the ages that constitute the most stable labor force and the core of family life in a community. It also appears that there is little change predicted in the other age groups including a large number of children, a dominance of adults in the productive ages, and fewer elderly. This pattern is not supported in other area populations, but it appears to reflect the particular circumstances of Catron County. The population of Catron County is expected to regain most of its former losses, but dynamics in the age groups indicates stability of composition. Although the numbers of persons in the county will change over the foreseeable future, limited changes are expected to result in other areas of the local society or economy. The immediate difficulty will be the provision of school facilities and the continuing problem of keeping those persons in the productive ages from seeking employment in other areas.

3. Employment

The history of employment in Catron County is given in Figure III-13. The data indicates a rather stable labor force with a continuing unemployment problem. Although a small population growth has been experienced since 1980, the civilian labor force has not shown significant change. Unemployment in the county has remained practically constant at an average of 14.6 percent. The State of New Mexico, for the same period, experienced an average unemployment rate of 9.7 percent. The rate of seasonal employment in the county contributes both to the unemployment and the stability in the labor force. Although projections of the civilian labor force to the year 2020 have not been made, it is expected that the rate of employment will maintain itself, due in part to the limitations on growth and development in the county.

Projections have been made, however of the non-agricultural employment in Catron County and are shown in Table III-11. These figures indicate that employment will increase by approximately 10 percent by the year 2020. The annual increases are expect to be relatively low. The picture of population and employment



Source: State of New Mexico, Council of Governments 1988

FIGURE III-13 Employment, 1973-1987, Catron County, New Mexico.

TABLE III-11

Non-Agricultural Employment, 1985-2005

YEAR	EMPLOYED
1985	483
1990	492
1995	508
2000	523
2005	535

Source: State of New Mexico, Economic Development and Tourism Department 1988 stability continues to indicate that Catron County will not see extensive development within the foreseeable future and that short term or rapid fluctuations is not considered.

4. Personal Income

Per capita personal income, like the other socioeconomic indicators in Catron County, has shown a general tendency toward stability and maintenance. Table III-12 provides data concerning the historic growth in personal income in the county.

Per capita income showed a general decline in the early 1980s, but has slowly risen since that time. Research has shown that per capita incomes in the county average approximately 65 percent of the state averages. The limitation of growth, seasonal employment, and general lack of development will continue to keep county incomes below that of other areas of the state, particularly the more urban areas. So much of the county is under federal and state control that the encouragement of private development is extremely difficult.

Eight percent (926) of the county's population received $124,865 in food stamps in 1987. Ninety other persons were eligible for assistance under Title XIX, including aid to families with dependent children, supplemental security income, institutional assistance, and low income home energy assistance. In 1987, $93,647 in medical assistance was provided in the county, primarily in in-patient care, with approximately 25 percent of that figure going to physicians. These figures indicate a growing problem within the county. Community and county growth in industrial, commercial, and population base will be required if overall county improvement in personal income and quality of life are to be expected.

5. Trade

The history of retail, wholesale, and service trade is given in Table III-13. The number of establishments has remained primarily stable. The New Mexico Taxation and Revenue Department, Office of Tax Research and Statistics, reported

TABLE III-12

Per Capita Income, 1979-1984

YEAR	INCOME ($)
1979	6,989
1980	7,125
1981	5,626
1982	5,997
1983	6,338
1984	6,828

Source: State of New Mexico, Bureau of Economic Analysis 1988

TABLE III-13

Number of Establishments, 1981-1985

SEGMENT	1981	1982	1983	1984	1985
RETAIL	8	7	9	10	8
WHOLESALE	0	0	0	0	0
SERVICES	7	8	8	11	13

Source: State of New Mexico, Bureau of the Census 1988 an approximate nine percent increase in gross retail receipts between 1981 and 1987. County retail sales grew from $3,900,00 to $4,800,000 in that time period. The annual rate of growth in retail sales has averaged slightly over one percent, and the number of establishments shows no significant rate of increase. The picture of county stability and maintenance is established and likewise, the need for economic development in the county is identified.

6. Ranching

In 1987, 41,000 head of cattle were inventoried in Catron County by the New Mexico Agricultural Statistics Service, a three percent decrease over those reported in 1986. Of this number, 16,000 were beef cows, a three percent decline over 1986. However, cash receipts from all livestock has shown a 12 percent increase since 1984. In 1986, the cash receipts of all livestock in Catron County was approximately $14,000,000, up from $12,750,000 in 1984. The value of livestock has apparently covered the slight decrease in the numbers of livestock in the county.

In 1960, 44,000 head were contained in the county. By the year 1978, the count had risen to 53,000. By 1979, the count fell to 48,000. With periodic fluctuations, ranching in the county has and will remain overall fairly stable. This performance is a direct result of the use of federal property for ranching and/or grazing under a permit system.

The majority of cattle production is on federal lands whose use for such activity is subject to permit. The permits issued for ranching limits the number of cattle that can be grazed on the land. Substantial increases, in cattle production that would significantly contribute to the local economy, will be likewise limited. This system will act to stabilize the ranching industry in the county along present lines.

7. Farming

Only 12 percent of Catron County is suitable for farming activity. The performance of the farming sector of the local economy is given in Table III-14. Although there is a general tendency toward a smaller number of larger farms, the total cash receipts for all farm commodities increased by approximately 60 percent since 1981. Farm commodities produced in Catron County rose from approximately $10,000,000 to approximately $15,000,000 from 1981 to 1986. The increase is due to increased productivity, improved techniques, favorable markets, and technology. With only 12 percent of the county's land suitable for farm production, the future of farming in the county is primarily limited but stable, with increases coming from market fluctuations, pricing, and the abilities of the individual farmer.

8. Mining

Mining in Catron County is not a significant economic segment. The preponderance of mining in the area lies in Grant County, adjacent to the south, which produced approximately 300,000 tons of copper annually from a resource base estimated at 5,000,000 tons. Mining and mining employment in Catron County has been maintained at a low level, with a small number of operations and employers. Data available shows little mining activity in Catron County.

9. Recreation and Tourism

Eighty percent of Catron County is contained in the Gila and Apache National Forests and in Bureau of Land Management Property. Due to this fact, little private property is available for development placing, a limitation on economic development. This source of recreation and tourism play an important part in the economy of the county. The natural attractions of the area draw thousands of persons each year to the area and they contribute to seasonal income, employment, and total economic impact.

TABLE III-14

Cash Receipts From All Commodities, 1981-1986

YEAR	TOTAL CASH RECEIPTS (x $1,000)
1981	9,853
1982	11,570
1983	11,684
1984	13,442
1985	14,852
1986	15,422

Source: State of New Mexico 1986

Between 1980 and 1987, attendance at the Gila Cliff Dwellings National Park increased from 32,720 to 44,494 persons annually. Attendance at state parks in the area increased from 180,523 to 231,835 during the same period. The use of the Gila National Forest for hunting, fishing, camping, riding, and hiking has shown similar increases. The use of developed sites and dispersed recreation under the Reserve MOA is currently estimated to approach 40,000 visitor days annually. A visitor day is one person in attendance for a 12 hour period.

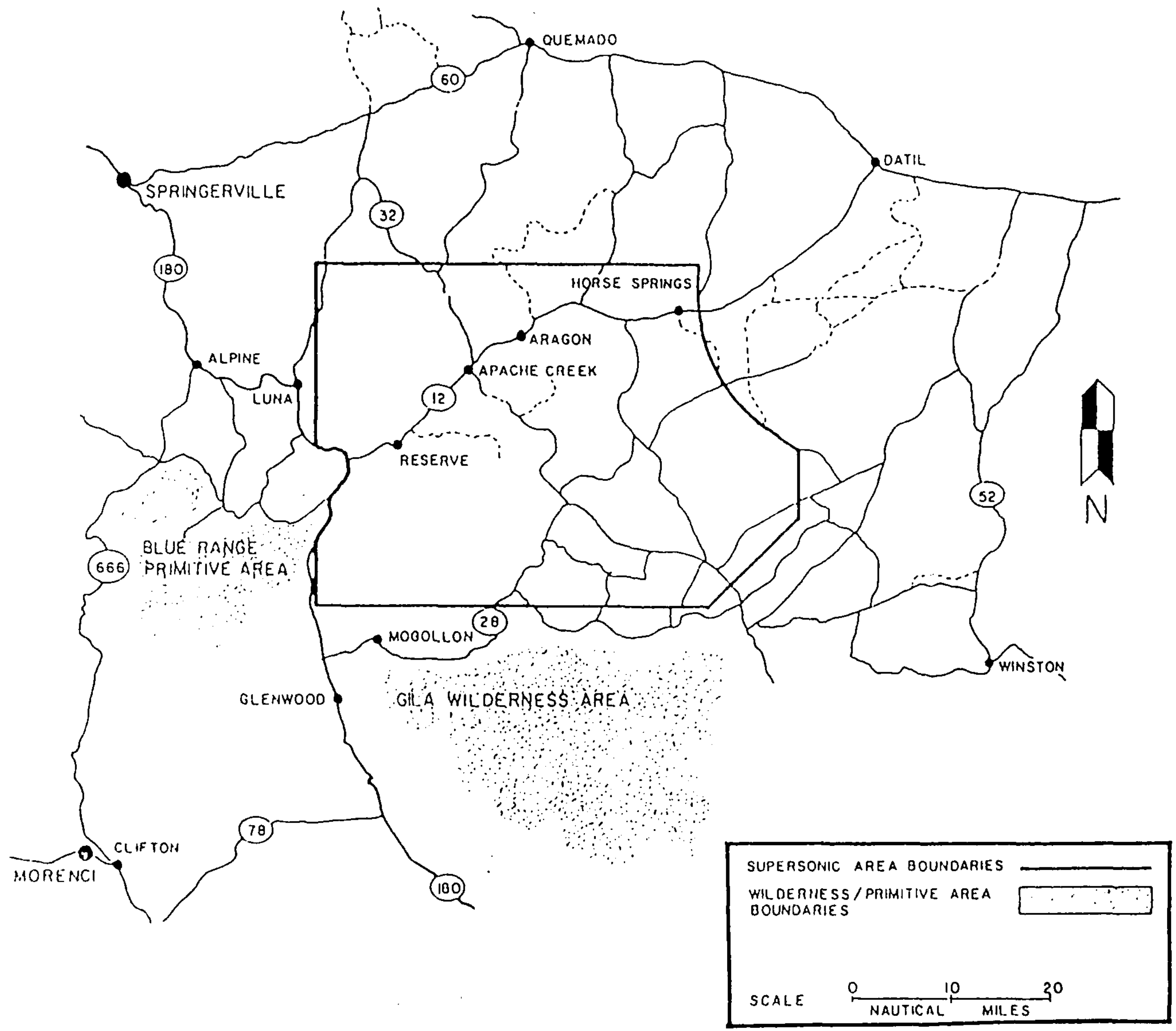
Catron County also contains Quemado Lake (130 acres), Snow Lake (100 acres), Wall Lake (19.5 acres), and Heart Bar Ranch (797 acres). Camping and fishing are the primary activities at these facilities. No additional water impoundments will be permitted in Catron County, severely limiting water oriented sports and activities. Snow Lake, Willow Lake, and Quemado Lake are outside the proposed flight areas. The three lakes will ultimately add an additional 100,000 visitor days to the area's resources.

10. Wilderness and Primitive Areas

Parts of the Blue Range Primitive Area and the Gila Wilderness lie in Catron County. No part of the proposed flight area covers any part of a wilderness or primitive area (Figure III-14).

I. Water Resources

Catron County is located within the Western Closed Basins, Rio Grande Basin, and the Little Colorado River Basin. Most of the county is within the Little Colorado River Basin. The northeast quarter of the county is located within the Western Closed Basin. The extreme northeast and southeast corners of the county are located within the Rio Grande Basin. These basins have been established by the New Mexico State Engineer (New Mexico State Engineers 1978). Water resources for the San Francisco River and Gila River sub-basins of the Little Colorado River Basin and the North Plains and San Augustine Plains sub-basins of the Western Closed Basin are described below.



Source: U.S. Air Force 1979

FIGURE III-14 Wilderness and Primitive Areas in the Vicinity of Reserve MOA.

1. Little Colorado River Basin

Factors controlling the hydrology of this basin are directly related to the climatology of the region. Precipitation is the source for all water within this drainage area. No groundwater is known to enter the basin from outside areas. Stream flow records are available for the Gila River near Gila, Red Rock, Virden, and at the Arizona Line. Streamflow records for the San Francisco River are available for Alma, near Glenwood, and on Whitewater Creek near Mogollon. Historic flow for the Gila and San Francisco Rivers is shown in Table III-15.

No large retention or regulatory dams have been constructed in the Lower Colorado River Basin in New Mexico. Wall Lake, on the headquarters of the East Fork of the Gila River, and Lake Roberts on Sapillo Creek, a tributary to the Gila, were constructed for recreational use. Wall Lake has a capacity of 126 acre-feet and Lake Roberts a design capacity of 1,008 acre-feet.

Groundwater is used for irrigation in the Virden Valley, along the San Francisco River and in the San Simon, Cliff-Gila, and Red Rock areas. Groundwater is used throughout the Lower Colorado River basin for domestic and stock purposes. The greater part of the Lower Colorado River Basin in New Mexico has not been hydrologically examined. The volume of ground water available for development is probably large, but so distributed as to make recovery in large quantities economically impractical. Data are lacking for quantitative determinations of overall supply in this basin.

Stream valley alluvium and the bolson fill are the only known extensive ground water reservoirs in the Lower Colorado River Basin. Alluvial reservoirs in the Gila and San Francisco River Valleys are stream connected. Recharge occurs simultaneously with groundwater withdrawal. Alluvial aquifers in channels and valleys of the Little Colorado River drainage system are also stream connected. These aquifers exist generally, but have only been developed in some areas for domestic and stock use. As most of the streams in the drainage are intermittent, recharge only occurs with infrequent periods of rainfall. Almost all rock formations in the basin will yield enough water locally to supply domestic and

TABLE III-15

Gila/San Francisco Rivers
Stream Flows

STATION	HISTORIC FLOW (ACRE-FEET YEAR)	DEPLETIONS (ACRE-FEET YEAR)
Gila River		
Above Blue Creek near Virden	89,400 (G)	16,200
Below Blue Creek near Virden	116,900 (G)	8,200
Inflow below Blue Creek	2,900 (E)	-
Other tributaries	5,900 (E)	-
San Francisco River		
Inflow New Mexico-Arizona Line	3,400 (E)	-
Near Glen Wood	45,400 (G)	-
Inflow below Glenwood	7,000 (E)	-

(E) Estimated
(G) Gaged

Source: New Mexico State Engineer 1978

stock needs. All rock formations contain some water; however, only a few can be considered good aquifers. Known and probable aquifers described in the stratigraphic unit columns for Catron County areas of the Little Colorado Basins are illustrated in Table III-16.

2. Western Closed Basins

The Western Closed Basins contains the North Plains and San Augustine Plains sub-basins. There are no records of streamflow within either sub-basin. During periods of intense precipitation, surface water flows in the poorly defined waterways for a short period of time. The New Mexico State Engineer (1978) has estimated surface flows in the North Plains sub-basin at approximately 6,350 acre-feet annually, and surface flow in the San Augustine Plain sub-basin at about 9,500 acre-feet annually.

The principal aquifer in the North Plains is the thick basalt of Quaternary age that underlies the North Plains and extends over half of the total area of the basin. The principal aquifer in the San Augustine Plains is formed by the basalt deposits of Quaternary age that underlie the middle of the basin. Large reserves of ground water should be present beneath the North Plains and San Augustine Plains sub-basin. All precipitation either sinks into the ground, or is used by vegetation and livestock. This figure is estimated at 800 acre-feet per square mile annually (New Mexico State Engineer 1978). The only known use of groundwater in the North Plains is for domestic and stock purposes. As the area is sparsely populated, the total amount of water used is not significant. Similar conditions apply in the San Augustine Plains sub-basin. Directional movement of ground water within the Western Closed Basins is thought to be south and southwestward into the lower Colorado River Basin. Known and probable aquifers within the Western Closed Basins are described in the stratigraphic-unit column illustrated in Table III-17.

TABLE III-16

Generalized Stratigraphic Section in Catron County Areas of the Little Colorado Basins, New Mexico

SYSTEM	STRATIGRAPHIC VISIT	WATER BEARING CHARACTERISTICS
Quaternary	Stream Channel Alluvium	Poor to excellent depending on the coarseness and degree of sorting; yields up to 2,000 gpm in the Gila River Valley. Generally yields fresh, locally slightly saline water.
	Terrace Gravel	Generally poor to no water because of locations above the general water table. Generally yields fresh water.
	Bolson Fill	Yields up to 1,000 gpm in the San Simon Valley. Generally yields fresh water.
Quaternary and Tertiary	Gila Conglomerate	Yields from less than 1 gpm up to 500 gpm depending upon the degree of consolidation and the locality. Generally yields fresh water.
	Basalt and Rhyolite	Locally water bearing, yields range from 1/2 to 10 gpm. Generally yields fresh water, but may have high concentrations of fluoride.
Tertiary	Detail Formation	Yields 1/2 to 10 gpm locally from the flow rocks, and up to 400 gpm where flows and interbedded sand and gravel occur below the regional water table. Generally yields fresh water.

TABLE III-16
(cont'd)

Generalized Stratigraphic Section in Catron County Areas of the Little Colorado Basins, New Mexico

SYSTEM	STRATIGRAPHIC UNIT	WATER BEARING CHARACTERISTICS
	Baca Formation	Generally unknown, but probably poor; reports from vicinity of Pietown indicate the formation is mostly red clay and siltstone, and non-water bearing to depths of 700 ft.
Cretaceous	Mesa Verde Group	Poor, yields generally less than 10 gpm. The Gallup Sandstone, where it occurs below the regional water table, is a relatively reliable aquifer for small amounts of water. Generally yields slightly to moderately saline water.
	Mancos Shale and Dakota Sandstone	Generally poor in the shale, sands, conglomerate, and limestone beds, somewhat better in the sandstone units, yield seldom more than 10 to 15 gpm. Generally yields fresh to slightly saline water.

Source: New Mexico State Engineer 1978

TABLE III-17

Generalized Stratigraphic Section in Catron County Areas of the Western Closed Basins, New Mexico

SYSTEM	STRATIGRAPHIC UNIT	WATER BEARING CHARACTERISTICS
Quaternary	Alluvium	Ground water possibilities not known may contain water where below regional water table. Quality of water uncertain.
	Bolson Deposits	Yields moderate to large quantities of water to wells. Yields fresh to moderately fresh water.
	Basalt (North Plains)	Yields small quantities of water to wells. Generally yields fresh to slightly saline water.
Quaternary and Tertiary	Basalt	Ground water possibilities not known.
	Gila Conglomerate	Yields small to moderate quantities of water to wells. Yields fresh to slightly saline water.
Tertiary	Basalt	Yields small to moderate quantities of water to wells. Yields fresh to slightly saline water.
	Datil Formation	Yields small quantities of water locally, and moderate quantities where below regional water table. Generally yields fresh to slightly saline water.
	Rubio Peak Formation	Yields small quantities of water to wells. Generally yields slightly saline water.

TABLE III-17
(cont'd)

Generalized Stratigraphic Section in Catron County Areas of the Western Closed Basins, New Mexico

SYSTEM	STRATIGRAPHIC UNIT	WATER BEARING CHARACTERISTICS
	Baca Formation	Ground water possibilities not known.
Cretaceous	Mesa Verde Group	Sandstone formations yield small quantities of water to wells in adjacent areas. Generally yields fresh to moderately saline water.
	Mancos Shale	Sandstone beds, where present within the formation, yields small quantities of water to wells in adjacent areas. Generally yields slightly to moderately saline water.
	Dakota Sandstone	Yields small quantities of water to wells in adjacent areas. Generally yields fresh water near outcrop.
Jurrassic	Zuni Sandstone	Yields small quantities of water to wells in adjacent areas.

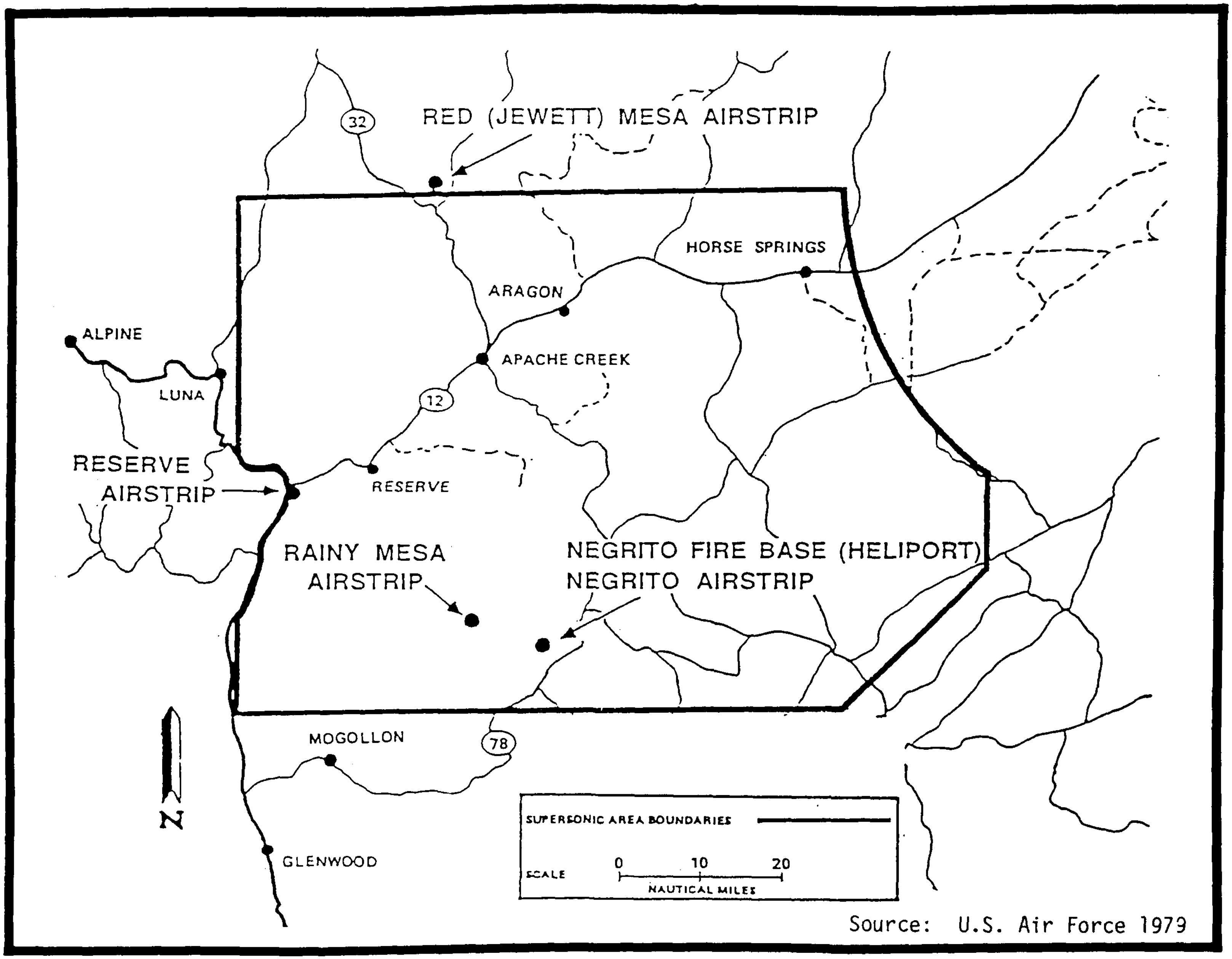
Source: New Mexico State Engineer 1978

J. Air Access

The Federal Aviation Administration (FAA) at Albuquerque, New Mexico controls the airspace over the Reserve MOA. Private aircraft are allowed to use this airspace. The supersonic training does not preclude the private use of airspace. There are four airstrips and one Base Heliport located within the supersonic boundary area. The following list identifies these airstrips and heliports and Figure III-15 shows general locations.

Reserve Airstrip	6,387' MSL	33° 41'N, 108° 51'W
Rainy Mesa	7,400' MSL	33° 33'N, 108° 38'W
Red (Jewett) Mesa Airstrip	7,622' MSL	34° 00'N, 108° 41'W
Negrito Airstrip	8,100' MSL	33° 33'N, 108° 32'W
Negrito Fire Base (Heliport)	8,100' MSL	33° 32'N, 108° 32'W

Since supersonic sorties are conducted at a 15,000 ft. minimum operating altitude, there is at least 7,000 ft. above any airstrip, where there should be no interference with private use of airspace.



Source: U.S. Air Force 1979

FIGURE III-15 Airstrips and Heliports in the Reserve MOA Supersonic Area.

IV. ENVIRONMENTAL CONSEQUENCES

A. Climate

Flying up to a maximum of 300 training sorties per month at the Reserve MOA should have no measurable impact on the area's climate. It should be noted that the 49 TFW will attempt to fly all souties that have a reasonable probability of supersonic flight occurrence at WSMR, and Reserve will be used as an over flow area for those that WSMR cannot accommadate. The most likely impact, if any, to the climate would be from pollutants emitted throughout the atmosphere. The number of sorties, amounts of pollutants generated and dispersion characteristics are such that meteorological conditions would not be affected.

B. Geology

Operation of the Reserve MOA is not expected to have any impact on the geology or physiography of the area. There is a remote possibility, however, that sonic booms could cause rockfall, avalanches, and earth slides. In such instances sonic booms are thought to be the ultimate triggering factor to a natural process which would have ultimately produced the same effect. Specific studies conducted for evaluating this phenomenon were inconclusive (Slutsky 1975).

C. Soil

It is expected that no impact will occur in the soils, since essentially they are undisturbed by flight activity of any type. The associations in the area are virtually undisturbed soils, and no positive or negative impacts would result on the soils in the Reserve MOA due to the proposed action.

D. Air Quality

The proposed Reserve Supersonic Area is located entirely within Catron County, New Mexico. Catron County is within the Southwestern Mountains-Augustine Plains Intrastate Air Quality Control Region (AQCR #156). Due to the sparse population and lack of ambient air quality monitoring data, EPA considers the area to be better than or cannot be classified in respect to attainment of the carbon monoxide, ozone, and nitrogen oxide standards. The proposed Reserve Supersonic Area is not located in an Air Quality Maintenance Area.

Military aircraft presently conducting flight training operations within the Reserve MOA emit air pollution contaminants of particulates, hydrocarbons, carbon monoxide, and oxides of sulfur and nitrogen. Table IV-1 provides an estimate of the projected annual pollutant emissions from the military operations in the Reserve MOA. The quantities of each pollutant were derived by using F-15 aircraft pollutant emission rates provided in the Air Quality Assessment Model and the current and projected annual hours of flying activity in the area.

These pollutants would be emitted over a large area and at an elevation ranging from about 6,000 ft. (over mountain peaks) to 44,000 ft. (over plains areas) AGL. EPA shows the area's mean annual morning and afternoon mixing heights to be about 1,200 ft. and 8,500 ft. AGL, respectively. The mean annual wind speed averaged through the morning and afternoon mixing heights are nine and 13 miles per hour, respectively.

As indicated above, a very small amount of the pollutants would be emitted below the mixing height. That which is emitted within the mixing height should not create a significant negative impact because the area has good dispersion characteristics. Some dispersion would also occur as a result of the turbulent wake behind the aircraft. Those pollutants emitted above the mixing height remain aloft until the mixing height exceeds the altitude in which the pollutants were emitted or are washed from the upper atmosphere by rain. By this time, the pollutants have traveled a great distance (sometimes hundreds of miles) and would be greatly diluted before being returned to ground level. Considering the relatively small change in pollutant emissions, dispersion characteristics and altitudes involved, operation of the Reserve MOA as previously defined should not result in a significant impact to local air quality.

TABLE IV-1

Estimated Annual Pollutant Emissions in Reserve MOA

POLLUTANT	F-15 EMISSION RATE (METRIC TONS/HR)	Estimated HOURS/YEAR	METRIC TONS/YR.
Carbon monoxide	8.4×10^{-3}	2,800	23.52
Hydrocarbon	9.4×10^{-4}	2,800	2.63
Nitrogen Oxides	2.5×10^{-1}	2,800	700.00
Particulates	3.2×10^{-3}	2,800	8.96
Sulfur Oxides	9.4×10^{-3}	2,800	26.32

Source: U.S. Air Force 1978a

It is possible that as a result of an emergency, fuel could be jettisoned into the atmosphere to reduce the gross weight of the distressed aircraft. Previous 49th TFW operational experience indicate that such occasions are extremely rare (less than five per year). Any fuel jettisoned would be above the 15,000 ft. MSL floor of the MOA and would be highly aspirated due to the fuel particle velocity and resistance of the atmosphere thus it would evaporate long before it reached ground level. No increased potential for fuel dumping results from supersonic training as compared to subsonic training.

E. Noise

1. General

Noise in the Reserve MOA will result from aircraft operations conducted at subsonic and supersonic speeds. Aircraft in the area will be subsonic during most of their flight, but will occasionally accelerate to supersonic speed.

2. Subsonic Noise Impact

The long term day-night average noise level (DNL) from subsonic flight operations in the Reserve MOA would be typical of a rural community. DNL is an equivalent sound level averaged over a twenty-four hour period with a ten decibel penalty added to any sound that occurs at night. As an example, if the expected daily average of 15 sorties were to pass directly over the same spot at 10,000 ft. above the ground, the DNL would be 31.6 decibels (dB). A DNL of 40 to 47 dB is the typical range of noise levels for a rural community (National Research Council 1977). DNL's below 55 dB are considered by the EPA to have no significant effect on public health and welfare (USEPA 1974). The U.S. Department of Housing and Urban Development considers DNL's below 65 dB acceptable for residential purposes without the need for noise attenuation.

3. Supersonic Noise Impacts

a. Summary

Before discussing sonic boom impacts, a summary of the sonic boom phenomenon and characteristics specific to the Reserve MOA is provided. The reader who desires a more indepth review of this is referred to Appendix D in the original Reserve MOA Draft Environmental Impact Statement (USAF 1979).

When aircraft exceed the speed of sound (Mach 1) a sonic boom is produced. The boom is an instantaneous sound similar to a thunder clap. Noise levels can vary considerably, depending on the aircraft size, speed, and distance to the observer. The maximum overpressure of a sonic boom is produced directly beneath the aircraft in flight and decreases with increased lateral distance from the flight track and with increasing altitude of the aircraft above the ground level.

An important consideration in the assessment of the effects of sonic booms is that not all booms created are heard at ground level. Sonic shock waves or rays are created when an object is traveling at a rate greater than the speed of sound. The speed of sound at any altitude is a function of the temperature; decrease in temperature results in a decrease of sound speed, and vice versa. Under standard atmospheric conditions, the air temperature decreases with increases in altitude (e.g., when the sea level temperature is 59°F, the temperature at an altitude of 30,000 ft. is about -49°). Thus, there is a corresponding decrease in speed, sound, and sonic shock waves will not penetrate below altitudes at which the local speed of sound is greater than the speed of the aircraft. Therefore, the shock waves are refracted back to higher altitudes if the plane moves subsonicly with respect to the speed of sound at ground level, although its speed at altitude is greater than the corresponding speed of sound. For example, at 30,000 ft. altitude, an aircraft may have to exceed a speed of Mach 1.13 before the boom would be heard on the ground. The heights and Mach number produced during F-15 combat maneuvering operations are such that less than one boom out of every three produced is likely to be heard at ground level. The other two of the three booms are refracted upward and are not heard at the ground. This same phenomenon, "cutoff", also acts to limit the width of sonic booms which reach ground level.

Elaborate procedures exist for calculating the pressure-time signature of sonic booms based on the specific shape and aerodynamics of the flight vehicle. An empirical procedure has been developed for situations where peak overpressure is the feature of interest (Carlson 1978). The method allows determination of on-track and off-track overpressures for aircraft in level flight or in climbing and descending flight paths. The method uses basic aircraft operating conditions such as Mach number, altitude, weight, and flight path angle. Comparison of sonic boom overpressures and duration as found from a wide range of measurements with those predicted by Carlson's (1978) procedure show the procedure is very accurate when atmospheric conditions are favorable for sound propagation. In nonstandard atmospheres (where there are winds and temperature deviations from the standard lapse rate which tend to distort the shock weave) the results are generally an overestimate and are thus considered to be the upper bound of the overpressure possible for the modeled conditions.

b. WSMR ACMI Model

An Air Combat Maneuvering Instrumentation (ACMI) system is not available in the Valentine or Reserve MOAs; however, one is available in the WSMR which is used for flight training in F-15s from Holloman AFB. Operations conducted in WSMR are representative of those proposed for the MOAs. Therefore, using the ACMI data at WSMR and Carlson's procedure it is possible to model potential impacts in the MOAs. The only significant adjustment required before applying the WSMR data is to make a pressure altitude correction (Galloway 1980).

An investigation of sonic booms produced in the WSMR airspace located over the north portion of WSMR and the North Extension Area was performed from July 1988 through January 1989, for the purpose of developing a sonic boom model.
The WSMR model determined by Wyle (1989) is represented by twin equations:

(1) $$CDNL = 25 + 10 \log_{10} N + 10 \log_{10} EXP \left(1/2\left[(X/11.1\ Mi)^2 + (Y/18.9\ Mi)^2\right]\right)$$

and,

$$(2) \quad n = 0.0012\ N\ EXP\ (-1/2[(X/13.0\ Mi)^2 + (Y/21.4\ Mi)^2])$$

where:

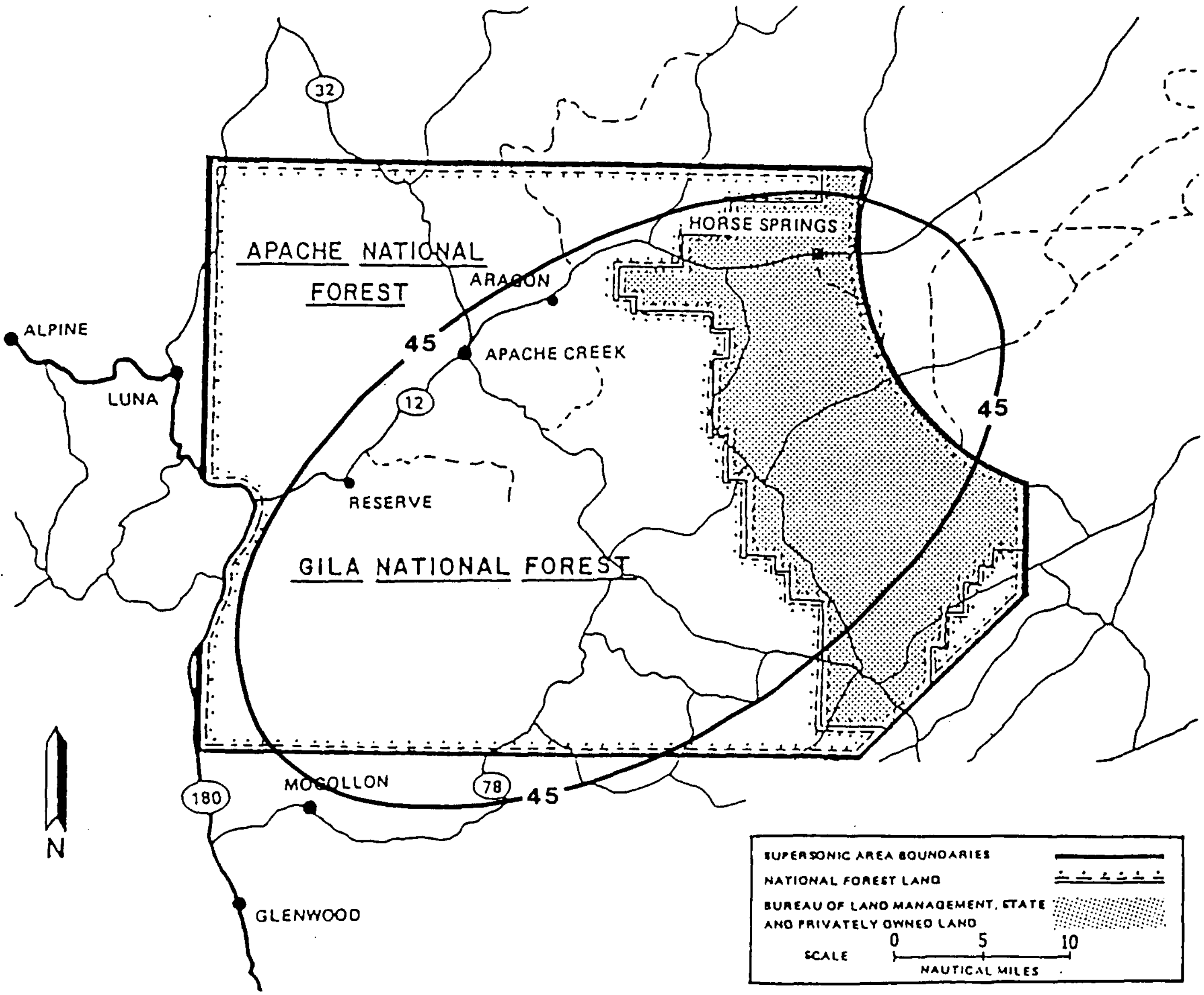
N = number of sorties per month
X = X-coordinate (ellipse) of a specific location
Y = Y-coordinate (ellipse) of a specific location
CDNL = C-weighted day-night noise level at the specific location
n = number of predicted booms per day at the specific location

CDNL and n contour plots can be generated from the above equations to show expected noise levels and expected sonic boom experiences. The CDNL and n contours are a function of the number of operation sorties with more sorties increasing the CDNL value and the predicted number of sonic booms per day at any given locations.

c. Reserve MOA Noise Prediction

The WSMR model described above was applied to the Reserve MOA to predict the effects of flying a maximum of 300 sorties per month each. Figures IV-1 and IV-2 show the predicted CDNL and n (sonic booms per day) values. The 45 dB contour, which is virtually contained within the Reserve MOA, defines the area outside of which the percent population that would be highly annoyed is less than 1.4 (National Reseach Council 1977). Figure IV-2 shows that virtually no more than one sonic boom will be heard in five days (0.2/day) outside the Reserve area.

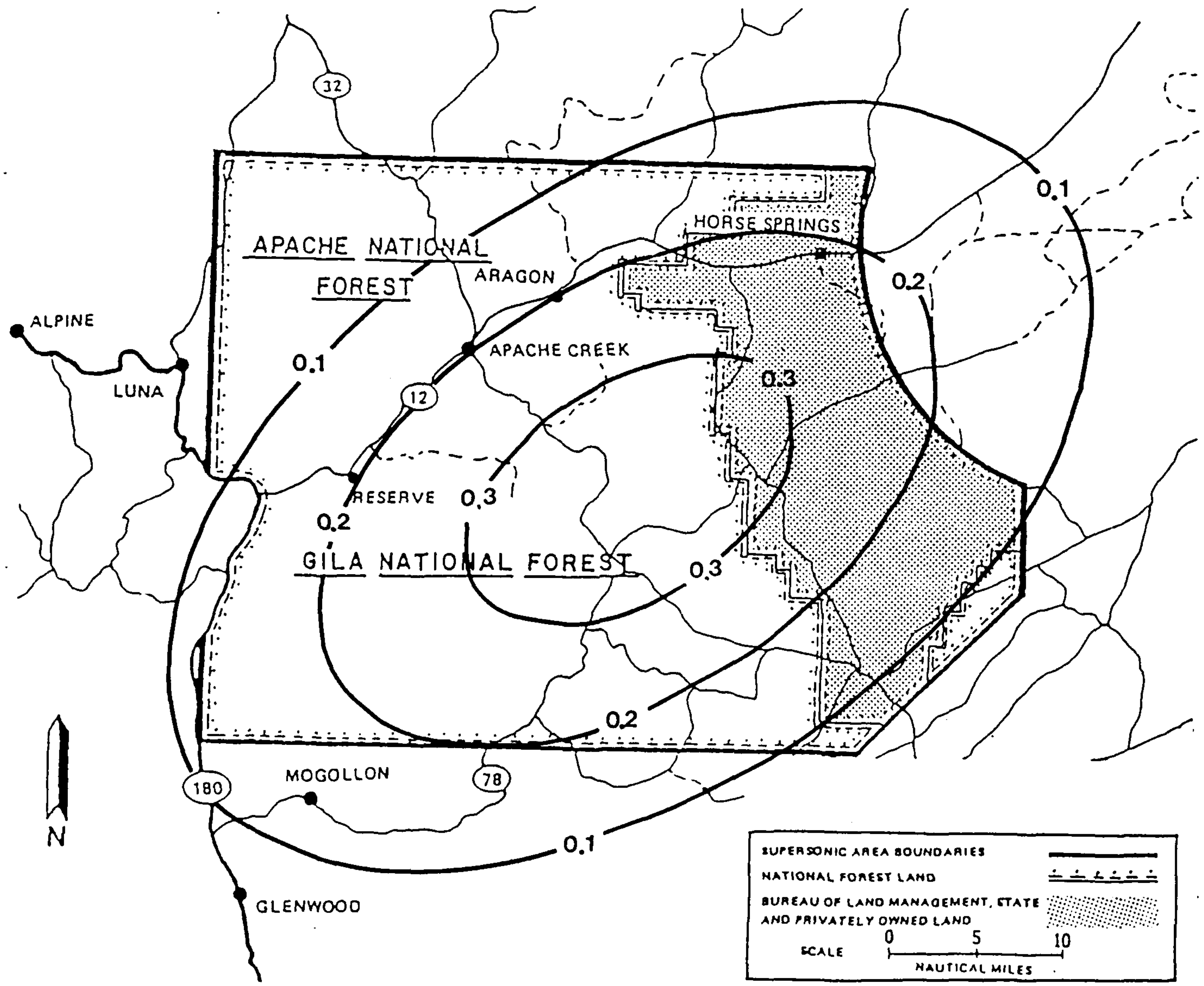
The EPA (USEPA 1974) indicates little or no public annoyance is expected to result from one sonic boom during the daytime below 0.75 pounds per square foot. The same low probability of annoyance is expected to occur within CDNL areas of less than 50 dB as described earlier in Figures IV-1 and IV-2. Maximum CDNL anywhere within Reserve MOA was modeled to be less than 50 dB. Considering



*Units in dB

Source: Wyle 1989

FIGURE IV-1 C-weighted Day Night Noise Level Distribution at Reserve MOA based on WSMR Model.



*Units are sonic booms per day

Source: Wyle 1989

FIGURE IV-2 Predicted Sonic Boom Activity at Reserve MOA based on WSMR Model.

these data, the National Research Council findings, and the EPA standards cited above, sonic boom generated noise from operating supersonic training within the Valentine and Reserve MOAs is not considered to have a significant impact on the local environments.

F. Biological Resources

1. Vegetation

Construction of runways, prop zones, etc. would not be required for the proposed operations and thus no direct losses to vegetation would be expected. No physical contact with the MOA terrain would be made unless for unexpected recovery of lost or downed equipment. Fires may occur in the event an aircraft crashes. Due to the sensitive ecosystem of the MOA, vegetation communities could require several years to recover from associated fires. The magnitude of the effect would depend upon several variables including fire fighting response time and efficiency, season in which the fire occurs, habitat type affected, and subsequent precipitation. There are currently no data available on the adequacy of fire fighting capability or response time due to the extreme variety of aircraft crashes within these areas.

2. Reptiles and Amphibians

Compared to studies of sonic boom effects on mammals, birds, and fish little has been accomplished with reptiles and amphibians. The impact of proposed operations within the Reserve MOA on these fauna is not well established. However, it is expected that the impact should not be significantly different from the other fauna and be of minimal extent.

3. Fish

Many studies have been conducted to determine the sensitivity of fish to sounds. Though these have indicated some sensitivity of fish to low frequency sounds, little information is available on the normal responses of fish to either naturally occurring or man-made sounds. There is a great reduction in sonic boom amplitude due to the acoustical mismatch between air and water, thus waterborne noise levels would be less than that in the atmosphere (Fletcher and Busnell 1978).

In one sonic boom study, a single fish did show a brief slowing of heart rate immediately after the arrival of the boom (Fletcher and Busnell 1978). A study conducted at the Ames Research Center (Runyon and Kane 1973) involved simulated boom overpressures of 550 pounds per square foot (psf) which impinged upon a clear tank containing guppies. The fish usually reacted to the passage of the shock wave by a flinching motion occasionally followed by a rapid movement, generally downward. There was a greater reaction by fish near the surface than by those near the bottom. The fish that did react did not appear to be alarmed and settled down immediately. "The exposed fish were kept isolated for observation for two months after the test and no adverse effects to the boom were noted" (Runyon and Kane 1973).

In a second investigation conducted at AMES Research Center trout and salmon eggs in their most critical phase of development were exposed to sonic booms generated by military aircraft where overpressures ranged from less than 1 to 4 psf. In each experiment a control group of eggs spawned at the same time as the experimental group which was raised in a separate location and not exposed to sonic booms. The number of egg and fish fry mortalities for each group was compared. Results indicated sonic booms caused no increase in mortality (Runyon and Kane 1973).

4. Birds

During a 1966 Edwards AFB study on animal behavior to sonic booms, poultry observed showed more response than the large animals (cattle, horses, etc.), especially in the early stages of the test. Occasional flying, running, crowding, and cowering were noted (Fletcher and Busnell 1978). Hinshaw et al. (1970) reported that hens exposed to four booms per day tended to run to shelter after the first boom, but later booms had less effect. Poultry showed mild reactions to the booms in 50 to 90 percent of the cases. In eight percent of the cases, the chickens reacted with crowding, cowering, or pandemonium but with no measurable effect on egg production.

Wild avian species will occasionally run, fly, or crowd when exposed to sonic booms. In a field and laboratory study (Teer and Truett 1973) mourning doves, mockingbirds, cardinals, lark sparrows, and quail were exposed to sonic booms or simulated boom overpressures to discover if booms adversely affected reproduction. Some differences in various phases of reproduction success were found between the control and test groups; however, none of the comparisons indicated the differences were caused by other than natural environmental factors. The laboratory test involved 7,425 incubated bird eggs which were observed to hatching. Chicks hatched from these eggs were observed to twelve weeks of age. Pressures of 2, 4, and 5.5 psf were delivered to the incubated eggs at three frequencies each day for 18 days. "Results of these tests showed that the pressures had no effects on hatching success, growth rates, or mortality" (Teer and Truett 1973).

A study conducted by Ellis (Ellis 1981) under cooperative agreement between the U.S. Fish and Wildlife Service (USFWS) and the USAF on the peregrine falcon involved gathering data at twenty-four breeding sites of ten raptorial birds in an effort to record responses to low level jets and sonic booms. The study concluded that, "while the birds were often noticeably alarmed by the subject stimuli, the negative responses were brief and never productivity limiting. In general, the birds were incredibly tolerant of stimulus loads which would likely be unacceptable to humans." The USFWS review of the Ellis study concluded that jet aircraft flights under 5,000 ft. AGL and mid to high altitude (higher than 5,000 ft. AGL) supersonic flight activity is not likely to jeopardize the continued existence of the peregrine falcon in the Reserve MOA Draft EIS (USAF 1979) (see Chapter 10 for FWS January 18, 1982 Letter).

5. Mammals

Domestic animals such as cattle, horses, sheep, and poultry show very little behavior effect from exposure to sonic booms (Cottereau 1972; Fletcher and Busnell 1978; Hinshaw et al. 1970; Nixon et al. 1968; International Civil Aviation Organization 1970). Effects on farm animals (horses, beef cattle, turkeys, broilers, sheep, dairy cattle, and pheasants) in 1966 at Edwards AFB show the behavioral reactions were considered minimal except for avian species. "Occasional jumping, galloping, bellowing, and random movement were among the effects noted. The responses of the large farm animal in these tests were judged to be in the range of normal activity in comparison with animals observed under controlled conditions. Pigs, both in the open and in buildings, showed a transient tendency to be quiet". Other scientists' review (International Civil Aviation Organization 1970) of the Edwards AFB study indicate the range of sonic boom overpressures was 1.7 to 3 psf. "Large farm animals reacted to the boom in some three to ten percent of the cases (e.g. occasional galloping of horses, bellowing of dairy cattle, increased activity of beef cattle); spontaneous behavior of this sort was, however, asserted to be equally prevalent in the absence of booms according to comparison observations in boom-free farm animals in a different state. There was, on the other hand, no measurable effect of these reactions on milk production, and food consumptions. It was observed that more severe reactions resulted from low level subsonic flights, motor cycles, paper blown by the wind and other startling effects" (International Civil Aviation Organization 1970). Nixon et al. (1968) and Fletcher and Busnell (1978) confirm the above observations for horses and cattle, and cattle and sheep, respectively. Hinshaw et al. (1970) also states horses, cattle, and sheep show brief periods of startle, but soon return to normal activity.

Fletcher and Busnell (1978) states cattle are generally described as briefly stopping their current activity or moving several steps and orientating toward the direction of the sound. Horses have been reported to show a more violent reaction than other grazing species. A few have been reported as showing muscular tremors, galloping, and jumping. There is a possibility that horses confined in buildings may show an exaggerated response as a result of being alarmed. Sheep have been described as temporarily stopping feeding, grazing, running, or ruminating in response to sonic booms. There appears to be no report of panic, injury, or impaired reproduction to any domestic animals evaluated (Fletcher and Busnell 1978).

Observations made by personnel (at the Luke Air Force Range, Arizona), regarding responses of bighorn sheep to sonic booms indicate minimal impacts of disturbance to the sheep (USFWS 1979). These observations are listed in Appendix D of the Reserve MOA Draft Environmental Impact Statement (USAF 1979). Desert big horn sheep on the Nellis AFB Range, Nevada, which have been exposed to sonic booms since 1955, show no significant change in the sheep population's age structure, longevity, or reproduction success. The population has been maintained around 1500 sheep since 1947 by harvesting (trophy hunts) and removing sheep to establish herds in other parts of Nevada. The Nellis AFB Range supports Nevada's largest population of sheep which accounts for about 40 percent of the state's total population (McQuivey 1978). Thus, it is not expected that the bighorn sheep in the Reserve MOA will be significantly impacted by supersonic operations.

6. Threatened and Endangered Species

Studies and experiments using a variety of mammals, birds, and fish have been performed including that by Ellis (1981) involving the endangered peregrine falcon. Results of these studies indicate no serious impact to test species from sonic booms. It is anticipated that the other threatened or endangered species (see Table III-7) such as the bald eagle and Roundtail Chub would likewise not be impacted.

7. Summary

Cottereau (1972) reports in all the studies he reviewed concerning sonic booms, whether real or simulated, that the authors came to the same general conclusions: sonic booms and subsonic flight noise has very little effect on animal behavior.

"Chronic direct effects on wild animals have not been investigated but no significant effects of this kind are presently foreseen".

The FAA (1973) arrived at the following conclusions:

- Animal damage claims are only a very small fraction of the total damage claims that have been submitted to the Air Force.
- The behavioral reactions of farm animals to sonic booms are, for the most part, minimal.
- All experimental evidence to date indicates that the exposure of chicken eggs to sonic booms does not affect their hatchability.
- Sonic booms do not appear to pose a threat to fish or fish eggs.
- Knowledge concerning the effects of sonic booms on wildlife is limited, but it appears that sonic booms do not pose a significant threat.

In summary, the available literature and special studies reviewed support the facts that domestic animals and wildlife can and do flourish in the presence of military aircraft operations, both subsonic and supersonic. Fletcher and Busnell (1978) recognizes this by pointing out that if aircraft noise was detrimental to wild animals, areas around large airports would be devoid of wildlife. This would also be true for military operating areas. Both the Nellis and Luke Air Force Ranges are approved for low level and supersonic flight and are colocated with wildlife refuges. Animals and wildlife on these ranges have been exposed to sonic booms for over 25 years with no apparent significant effect. It is thus concluded that while some individual animals may show an adverse response, the species as a whole should not be significantly impacted if the proposed supersonic operations are conducted over the Reserve MOA.

G. Cultural/Historical Resources

1. Synthesis of Available Data Concerning Impact of Sonic Booms

This synthesis of the available technological data related to sonic booms will summarize (1) damage effects to conventional structures, (2) damage effects to unconventional and natural structures, and (3) seismic responses.

a. Sonic Boom Damage to Conventional Structures

The response of modern conventional structures to sonic boom pressure waves is a complex phenomenon because of the many interacting variables which determine how a given structure will react. The many technical reports and papers which have been published over the past 25 years have attempted to predict damage levels through a combination of experimental programs and theoretical studies. Due to the complexity of the matter, however, the most consistent method of determining actual effects is through experimental programs. Consequently, three instrumental tests conducted in the 1960s provide the bulk of the data related to structural damage. The studies include flight tests performed in Oklahoma City at White Sands Missile Range, New Mexico (Blume et al. 1965), and at Edwards Air Force Base, California (Blume et al. 1967).

The Oklahoma City study was the first extensive flight test investigation of structural response. A series of flights was conducted over a six month period in which overpressures of 1 to 1.5 psf and instrumental responses of residential structures were recorded. The White Sands program was designed to study damage index levels associated with various types of structural materials such as plaster, glass and masonry. The test site which included 21 structures, ranging from newly constructed to uninhabited, old ranch houses, was subjected to 1,494 booms. The intensity of the booms varied from 1.6 to 23.4 psf. The Edwards Air Force Base investigations involved 102 flights and two instrumented structures. Overpressures of .97 to 5.5 psf were recorded. These three studies have contributed to the following conclusions:

(1) For nominal overpressures of up to 30 psf, damage will be minor in the form of plaster cracks, broken window panes, and masonry and tile cracks. Damage may be predicted only within several orders of magnitude (e.g., 10^{-5} to 10^{-2} broken windows per window boom exposure for 6 psf booms); however, it is known that damage rates will increase by 2 to 3 orders of magnitude for each doubling of the sonic boom overpressures (Hershey and Higgins 1973; Wiggins 1969).

(2) There is no evidence of damage or cumulative damage where the predicted overpressure is approximately 3.0 psf or less (Wiggins 1967; Runyan et al. 1973). Limited data are available which suggest that cumulative damage may result from recurring exposure to overpressures greater than 10 to 15 psf (Blume 1965).

(3) Building structures which have been maintained should not be damaged at boom overpressures less than 11 psf (Clarkson and Mayes 1972).

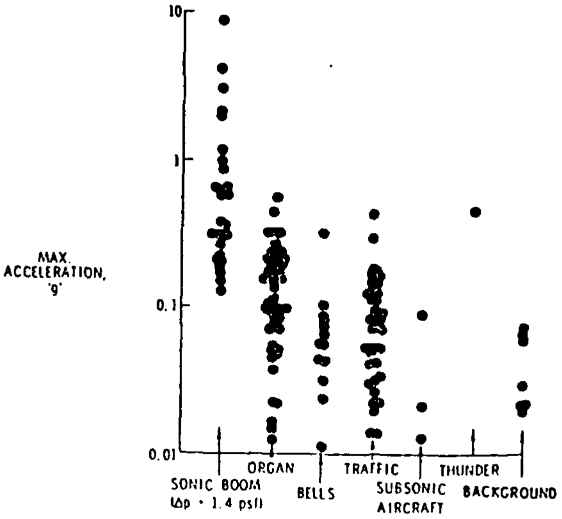
b. Sonic Boom Damage to Unconventional and Natural Structures

The potential damage of sonic booms to unconventional structures such as historic buildings, archeological structures (standing walls or pueblos, modified caves), or natural structures (rockshelters and rock art sites) is not as well documented as for conventional structures. The number of studies directly related to such irreplaceable sites is extremely limited. The unique nature of some of these resources (petroglyphs and pictographs) and their often fragile state in comparison to modern structures contribute to the concern regarding the applicability of the larger body of data related to conventional structures. Consequently, recent research efforts have been directed toward examining the impact of sonic booms on specific historic or archeological resources.

The initial studies related to historic structures were in response to the proposed Concord flights in Europe and North America. The Royal Aircraft Establishment, Farnborough, England, initiated a series of studies (Warren 1972) to determine the effect of sonic booms on cathedrals and public and domestic buildings which are centuries old. In order to assess the magnitude of the effect of the sonic booms, the effect of everyday sources of vibration (organ, bells, traffic, atmospheric turbulence, thunder) were monitored also. As can be seen in Figures IV-3 and IV-4, (from Clarkson and Mayes) the response of structural elements to the sonic booms was somewhat greater than the response to the normal environment. The response to the sonic booms, however, was not regarded as sufficient to cause damage to the historic structures (Warren 1972). An investigation of the response of an adobe structure to sonic boom activity has also been conducted. An adobe house on the Tohono O'Odham Reservation was instrumented and evaluated while supersonic flight training was conducted overhead. The conclusion of the study was that the adobe structure reacted similarly to a conventional structure (USAF 1979).

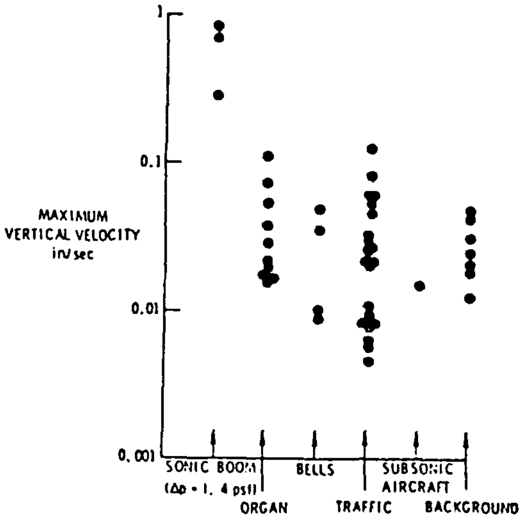
More recently, seismo-acoustic recordings of sonic booms were recorded at two sites within the Valentine MOA. A rockshelter site and a boulder field site, similar to that of a petroglyph site within the Valentine MOA, were instrumented so that overpressures and peak velocities could be measured. Of 10 overflights, only two sonic booms were actually detected on the ground. The generated peak overpressures were 0.103 psf and 0.123 psf for the rockshelter and boulder field, respectively. Battis (1981) noted that these values are significantly less than expected for an F-15 flying at Mach 1.1 between 15,000 and 20,000 ft. AGL, but offered no explanation for the apparent differences. Battis further notes that the expected motions are, at worst, eight percent of the limits set by strict blasting codes (Siskind et al. 1980a) and comparable to velocities which might be produced by local, low magnitude earthquakes.

Unfortunately, these studies do not provide levels of overpressures at which historic structures or archeological resources will be negatively affected by sonic boom activity. They merely support the general impression that such structures may be less sensitive than popularly thought; no "safe" limits have been defined. The only available guidelines are derived from tests associated with blast-related vibration (Siskind et al. 1980b). According to the Bureau of Mines studies, the current consensus concerning the level at which architectural damage may occur is 50.8 mm (2.0 in)/second peak particle velocity (Siskind et al. 1980a). A conservative, safe level of ground motion for dwellings is in the range of 2.0 to 3.8 mm/second (Siskind et al. 1980a). Sedovic (1984) suggests that a safe level for historic structures is between 5.08



Source: Clarkson and Mayes 1972: 752

FIGURE IV-3 Response of Cathedral Windows to Transient Pressure.



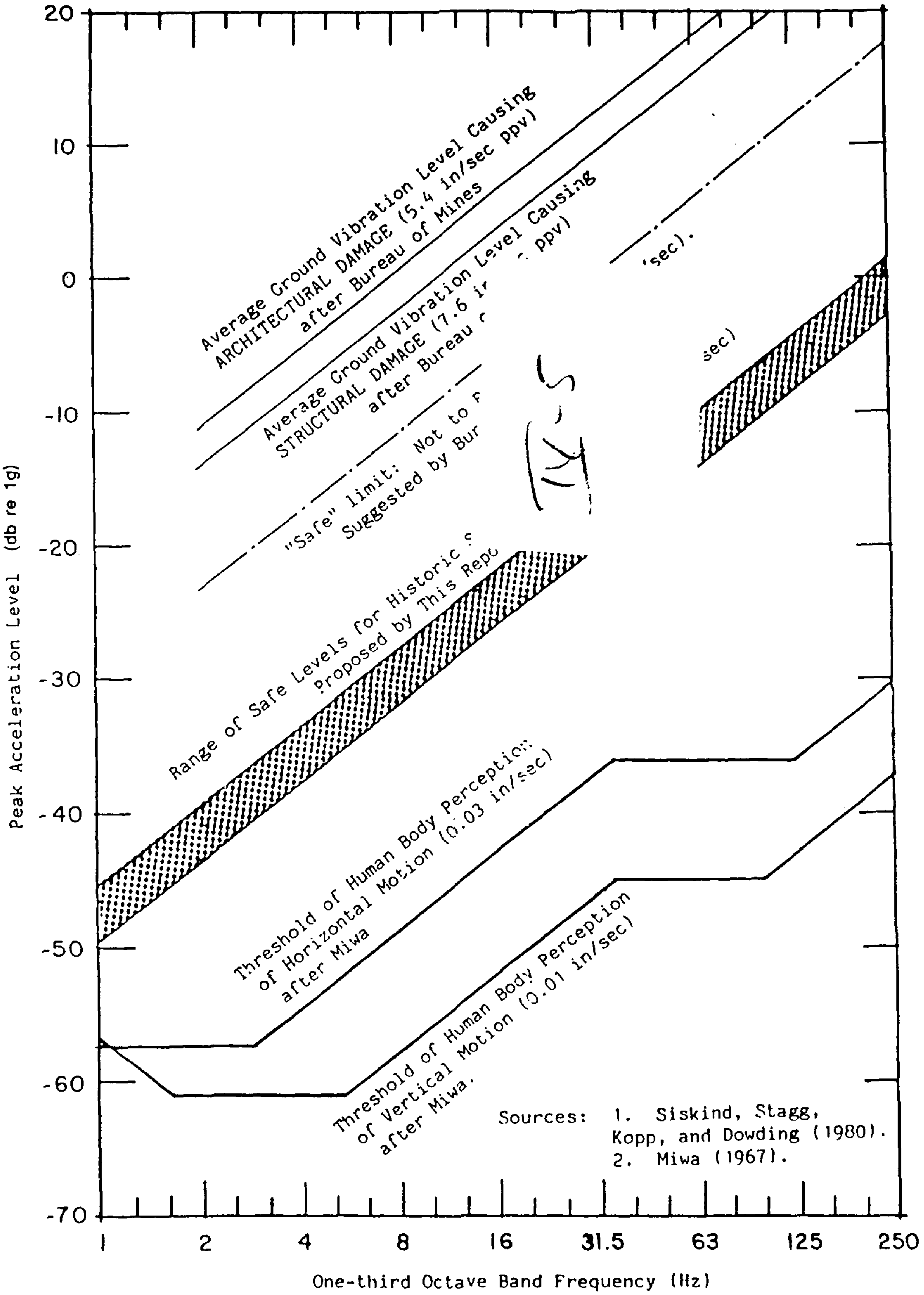
Source: Clarkson and Mayes 1972: 752

FIGURE IV-4 Response of Cathedral Vaulting to Transient Pressure.

mm (0.2 in) and 12.7 mm (0.5 in)/second peak particle velocity (Figure IV-5). These limits are based upon test blast results published by the Bureau of Mines (1980). Conversion of Wiggins' (1980) peak displacement data to peak particle velocities (Siskind et al. 1980b) indicates that the sonic boom induced velocities reported by Blume et al. (1965 and 1967) were within the safe range as defined by Sedovic (1984). The peak particle velocities noted by Battis (1981) during the limited Valentine MOA study and the Railroad Valley, Nevada study are all well within the safe range, also. Assuming a 5.19 psf overpressure and using the maximum admittance value found in the Railroad Valley study, Battis notes that the projected velocity will be 2.1 mm (0.083 in)/second which is well within the arbitrarily defined safe range.

Views concerning a safe level of ground motion associated with historic structures differ, however. Ashley (1976), examining blast effects in urban areas, proposed peak particle velocities of 7.5 mm (0.3 in) and 12 mm (0.47 in)/sec for ancient and historic monuments and housing in poor repair, respectively. Technical data to derive or support these values are not presented. King et al. (1985) note that the generally accepted view in Germany, Great Britain, and Sweden is that historic structures and archeological sites should not be subjected to even minor, artificially induced ground motions. Government set levels of maximum ground motion for historic structures in these three countries are therefore 2 mm/sec, 2.5 mm/sec, and 2 mm/sec, respectively. King et al. (1985) in their vibration hazard investigations of Canyon Culture National Historical Park, concur with this perspective and recommend a 2.0 mm/sec particle velocity to be the upper limit for induced motions in structures.

The media which is subjected to vibration is also a determining factor of the potential damage level. Langefors and Kihlstrom (1963) and Esteves (1978) present thresholds for a variety of soil types, construction, and blast frequencies (Tables IV-2 and IV-3). The relationship of the propagation velocity (c) to particle velocity (V) and ground strain (e) ($e=V/c$) indicates that low velocity materials will have higher ground strains and potential for failure for a given particle velocity. Consequently, a rock formation will exhibit a



Sources: 1. Siskind, Stagg, Kopp, and Dowding (1980).
2. Miwa (1967).

FIGURE IV-5 Comparison of Standards for Building Damage and Human Perception

TABLE IV - 2 Damage Levels from Blasting
(Langefors and Kihlstrom 1963)

DAMAGE EFFECTS	PEAK PARTICLE VELOCITY SAND, GRAVEL, CLAY BELOW WATER LEVEL: c= 1,000 - 1,500 m/sec (1)		MORAINE, SLATE OR SOFT LIMESTONE: c = 2,000 - 3,000 m/sec		GRANITE HARD LIMESTONE OR DIABASE: c = 4,500 - 6,000 m/sec	
	mm/sec	in/sec	mm/sec	in/sec	mm/sec	in/sec
No noticeable crack formation	18	0.71	35	1.4	70	2.8
Fine cracks and falling plaster threshold	30	1.2	55	2.2	110	4.3
Crack formation	40	1.6	80	3.2	160	6.3
Severe cracks	60	2.4	115	4.5	230	9.1

(1) Propagation velocity in media is given by c.

TABLE IV-3 Limiting Safe Vibration Values of Pseudo
Vector Sum Peak Particle Velocities (Esteves 1978)

TYPE OF CONSTRUCTION	PEAK PARTICLE VELOCITY INCOHERENT LOOSE SOILS, SOFT COHERENT SOILS, RUBBLE MIXTURES: c < 1,000 m/sec (1) c < 3,300 ft/sec (1)		VERY HARD TO MEDIUM CONSISTENCE COHERENT SOILS, UNIFORM OR WELL-GRADED SAND: c = 1,000 - 2,000 m/sec c = 3,300 - 6,600 ft/sec		COHERENT HARD SOILS AND ROCK: c > 2,000 m/sec c > 6,600 ft/sec	
	mm/sec	in/sec	mm/sec	in/sec	mm/sec	in/sec
Special care, historical monuments, hospitals, and very tall buildings	2.5	0.10	5	0.20	10	0.40
Current Construction	5	.20	10	.40	20	.80
Reinforced construction, e.g., earthquake resistant	15	.60	30	1.20	60	2.40

(1) Propagation velocity in media given by c.

higher threshold for damage than an alluvial soil; unfortunately, neither study presents experimental data to support its proposed thresholds.

c. Seismic Effects of Sonic Booms

Goforth and McDonald (1968) have conducted the most extensive experimental and theoretical investigation of seismic effects of sonic booms. Earth particle velocities recorded at three seismological observatories in California, Arizona, and Utah were correlated with overpressure, flight parameters, and meteorological data in order to evaluate the seismic impact of the sonic booms. Their study resulted in the following conclusions:

(1) Ground particle velocity produced by a sonic boom is linearly related to the maximum overpressure of the boom for overpressures less than 5 psf. Experimental data suggests that each pound per square foot of overpressure produces a peak particle velocity of 0.1 mm/sec on low density rock and 0.075 mm/sec on high density rock.

(2) Peak particle velocities on the exterior of the boom footprint are attenuated by a factor of 6 relative to the center of the footprint.

(3) Peak particle velocities recorded at a depth of 44 ft. are attenuated by a factor of 75 relative to those at the surface.

(4) One recording station provided evidence in support of the existence of velocity-coupled Rayleigh waves (Baron et al. 1966; Espinosa et al. 1968). However, these waves did not produce the maximum particle velocities associated with the boom. The necessary conditions of lateral uniformity of the near surface geological units and velocity distribution for the amplification of such waves to a damaging level is considered unlikely.

(5) The largest peak particle velocity recorded in association with a sonic boom of 2.5 psf was a velocity of 0.34 mm/sec. This amounts to less than 1 percent of the seismic damage threshold for residences established by the U.S. Bureau of Mines (Goforth and McDonald 1968).

Results obtained in ground motion studies in Great Britain confirm the above conclusions. The British experiments yielded peak particle velocities up to 0.3

mm/sec -- a value on the same order as that of passing vehicles (automobiles and trucks).

An additional concern is the possibility of avalanches or earth slides being triggered by sonic booms. The only cited test series (Lillard et al. 1965) in which the triggering of avalanches was attempted by producing sonic booms with nominal peak pressures of up to 10.4 psf failed to disturb the snow fields. The U.S. Forest Service, however, rated the avalanche hazard as "low" during the test period. Nevertheless, undocumented evidence exists which suggests that sonic booms can and do trigger avalanches (Rathe 1986). Credible observations of earth slides or rock fall being associated with sonic boom events exist, also. In 1967, the National Park Service reported the fall of overhanging cliffs immediately after a sonic boom. Cliff dwellings in Canyon de Chelly National Monument, Arizona were damaged. Within Bryce Canyon National Park, Utah three sonic booms were followed by the fall of 10 to 15 tons of earth and rock (U.S. EPA 1971). Unfortunately, such observations do not permit a scientific evaluation of the causal role of the sonic booms. The sonic booms may have been the primary factor in the triggering of the avalanches or earth slides. They may have been a minor contributing factor to a natural process which was about to produce the same effects. They may also have had no influence whatsoever on the avalanches but were merely coincidental.

d. Potential Impact of Focal Booms

It has been demonstrated theoretically (Onyeonwu 1975) and experimentally (Vallee 1967, 1972; Wanner et al. 1972; Haglund and Zane 1974) that focused or superbooms are quite rare, especially in regard to focus factors several times greater than that of level flight booms. The effect of the focused booms is also more localized than that of a carpet boom. As Plotkin (1985) notes, for a given maneuver, focus occurs only once on a fixed ground footprint. The intersection of the focus boom with the ground is a line rather than an area. A superfocus is even more limited in its effect, for its intersection with the ground is at one instant at a single point. Because of the different nature of focus booms, the chance of intersection with the ground is less than that of the carpet boom.

When a focal zone does intersect with the ground, it is a single event rather than the continuous nature of the carpet boom (Plotkin 1985).

The most recent data concerning the impact of focal booms associated with tactical fighter maneuvers is derived from the comparison of flight test data and focus boom prediction models (Plotkin 1985). The following conclusions were reached through this study:

1. Areas where carpet boom overpressures are exceeded are on the order of 0.5 square mile.
2. Focal zones with focus factors of two or more occur over areas of about 0.1 square mile.
3. The highest predicted focus factors are about three times that of a normal carpet boom.

Although Plotkin (1985) and others (Fengler and Bishop 1986) downplay the probability of focus booms occurring, the fact that they do occur during tactical maneuvers and that they may exhibit overpressures two to three times greater than those of carpet booms increases the probability of damage to either historic or prehistoric cultural properties. After all, the cultural properties of concern wi6thin the Reserve MOA could easily be impacted by overpressures which affect only 0.1 square mile or 64 acres. Admittedly, the chance of a focus boom impacting a cultural property is less than that of a more widespread carpet boom; however, the greater overpressures associated with focus booms (Tables IV-4 and IV-5) are sufficiently large to induce instantaneous damage to the cultural properties.

e. Cumulative Effects

Although the predicted overpressures of 1 to 5 psf associated with Aerial Combat Maneuvering appear to be within the "safe" range as defined by the U.S. Bureau of Mines standards (Sedovic 1984; King et al. 1985), there remains the problem of attempting to assess the long term effect of repeated booms. The British studies (Warren 1972) on historic structures indicate that the level of vibration induced by sonic booms would be well below the level that would cause

TABLE IV-4

Focal Zone Areas for Fighter Turns

	10,000 Ft		15,000 Ft		30,000 Ft		45,000 Ft	
	0°		0°		0°		45°	
	P	A	P	A	P	A	P	A
F-4	5	0.36	Not Calculated		2.4	0.78	2.4	0.65
	11	0.0003			6	0.001	4.8	0.006
F-15	5	0.21	4.1	0.2	2.4	0.75	Not Calculated	
	11	0.013	8.2	0.043	3.0	0.13		
	13	0.00014						
F-16	4	0.241	3.3	0.15	1.9	0.346	Not Calculated	
	8	0.016	6.6	0.003	3.0	0.025		

P = Pressure (psf)
A = Area (square miles)
Source: Plotkin 1985

TABLE IV-5

Focal Zone Areas for Fighter Acceleration

	10,000 Ft		15,000 Ft		30,000 Ft		45,000 Ft	
	Level		10° dive		30° dive		Level	
	P	A	P	A	P	A	P	A
F-4	7	1.8	7	0.70	5	0.45	No Focus At Ground	
	11	0.26	11	0.12	11	0.005		
	16	0.16	16	0.003				
F-15	6	1.1	5	1.46	No Focus At Ground		2	1.26
	11	0.08	8	0.23			5	0.33
	16	0.002	11	0.055				
F-16	5	1.0	5	0.43	4	0.36	2	1.28
	11	0.023	11	0.0045	8	0.005	4	0.218

P = Pressure (psf)
A = Area (square miles)
Source: Plotkin 1985

instantaneous damage; however, Warren (1972) recognized that the sonic booms would contribute to the processes that promote damage in the long term. Consequently, sonic boom effects must be evaluated along with other vibration-inducing environmental forces as well as other physical and chemical forces. Such conclusions are in accord with the statement of the Sonic Boom Panel of the International Civil Aviation Organization (1971):

> The notion of a 'lifetime' of a given structure may throw further light on the problem of sonic boom-induced damage. This is a new concept that is not yet commonly used by building engineers. Every structure accumulates damage (much of it not visible) from a variety of environmental conditions: wind loads, mechanically induced vibrations, temperature and humidity changes, weathering, general aging, etc. This may eventually terminate its life. Cumulative damage may therefore be referred to in a context approximating structural fatigue. The likelihood of visible damage owing to a sonic boom thus depends upon how far the structure is along its lifetime.
>
> A structure or structural element near the end of its lifetime would have a lowered threshold for damage and conversely. That is to say, the stress that will break a structural element is not invariable with time, but varies during its lifetime.

Unfortunately, the present data base provides very little information concerning the contribution of repeated sonic booms to the deterioration of unconventional or natural structures. Limited studies (Peschke et al. 1971; Kao 1970; Blume 1965) concerning the effect of repeated exposure of conventional structures to sonic booms of less than 3 psf have yielded conflicting results. The White Sands Missile Range study which involved 680 successive flights at a scheduled overpressure of 5.0 psf resulted in the conclusion that no cumulative effect was identifiable (Blume et al. 1965). An experimental simulator study by Kao (1970) which subjected window glass to repeated overpressures ranging from 4 psf to 20 psf confirmed the Blume et al. (1965) study findings that a cumulative effect was not identifiable at overpressures less than 5.0 psf. Another simulated experiment (Peschke et al. 1971), however, resulted in contradictory findings. The results of tests involving repetitive (500 times) exposure of the wood frame, plaster wall panels to 1 to 5 psf overpressures indicate that cracking can occur at overpressures of 1 psf. The failure of the plaster was progressive and crack propagation was observed at overpressures below 2 psf. It is noteworthy that most of this cracking was evident only under examination with the aid of ultraviolet light; nevertheless, this study provides experimental evidence of structural weakening when materials are exposed to repeated sonic boom occurrences. A more recent experimental study by the Institute for Aerospace Studies (Leigh 1975) in Toronto, however, demonstrated that prestressed plaster panels would have a virtually infinite life under repeated exposure to overpressures of 10 psf. Such conflicting results related to modern or conventional materials raise serious questions concerning the technological expertise available to evaluate the damage threshold of aged, nonconventional structures submitted to repeated sonic boom exposures.

2. Assessment of Potential Effects

The cultural resources within the Reserve MOA exhibit differing physical characteristics which will affect their response to sonic boom induced airblasts and ground vibrations. For example, the presence or absence of extant structures and the context of the site (whether a buried alluvial site, rockshelter, or rock art site) are directly related to the potential impact of sonic booms. Five classes of cultural resources with different potential for sonic boom damage have been defined. These classes are: (1) buried sites; (2) surface or low profile sites, (3) extant structures, (4) rockshelters, and (5) rock art sites.

a. Class 1 - Buried Sites

Since the impact of sonic booms is attenuated rapidly with increasing depth, subsurface archeological deposits such as buried alluvial sites and caches, and mines are least likely to be affected by sonic boom impacts. No direct impact is anticipated.

b. Class 2 - Surface or Low Profile Sites

This class of cultural resources includes surface artifact scatters, quarries, mounds from the collapse of fieldhouses and pueblos, water control walls and canals, historic cemeteries, corrals, and wickiups. Although these resources are more exposed to sonic boom impact, their low profile in relation to airblasts renders the potential for direct impact almost negligible.

c. Class 3 - Extant Structures

Within the Reserve MOA extant structures are represented for both the prehistoric and historic periods. Homesteads, lookout towers, outbuildings, military installations and modified caves are represented. Standing structures of log, milled lumber, or stone are present on the historic sites while rubble rock or dressed rock walls are present within the modified caves. Given these building materials, two categories of susceptibility to vibration damage may be established. The first category includes those structures most likely to be affected by sonic booms. Buildings constructed of stiff or brittle materials such as stone, brick, adobe bricks, or concrete blocks are included in this category. The potential for damage of these structures is further increased by their generally poor condition due to abandonment and a lack of maintenance. The stone structures within the modified caves have the greatest potential for damage for the reflection of the airblasts would greatly accentuate the magnitude of the overpressure. The Negrito Mountain Lookout of the Forest Service is also included in this category, even though its susceptibility is presently unknown. Its height contributes to direct exposure to airblasts, but its low surface area may lessen the impact. Unfortunately, the response of such structures to sonic booms is presently unknown. The second category consists of buildings with more resilient facades (e.g., wood) and a stronger structure (intersecting walls, solid rather than block construction). The potential for damage is reduced further if the structure has been well maintained.

d. Class 4 - Rockshelters

Topographically, rockshelters and caves within the Reserve MOA are situated at high altitudes within geological settings which may be sensitive to potential damage from rock falls or landslides which could be induced by sonic boom vibrations. Rockshelters and caves which are potentially eligible for nomination to the National Register of Historic Places exist within the Reserve MOA.

e. Class 5 - Rock Art Sites

Petroglyphs and pictographs occur on the surfaces of boulders, rock outcrops, and rockshelter walls within the Reserve MOA. Theoretically, airblasts or vibrations from sonic booms may induce more rapid deterioration of such surfaces. More fragile formations, such as volcanic tuff, or rock surfaces which are already exfoliating are likely most vulnerable to sonic boom impact.

Of the cultural resources within the Reserve MOA, the potential impact of the sonic booms is of greatest concern for extant stone structures, modified caves, rockshelters and rock art sites. Although survey of the MOA, and the flight ellipse area in particular, has not been systematic or extensive, it is apparent that extant structures are poorly represented. This is especially true for the immediate impact zone of the flight ellipse. From the present evidence, instantaneous damage to the more sensitive Class 4 and 5 sites, and even to the Class 3 (extant structures), is not likely given overpressures of 1 to 3 psf. The cumulative effect of repeated exposure of the Class 4 and 5 sites to sonic booms, however, is unknown. There remains a serious technological gap in our ability to predict the contribution of such impacts to the deterioration of the Class 4 and 5 sites.

3. Recommendations

The following recommendations are based upon the information presently available. It should be noted that the recent monitoring study of the sonic booms produced by Air Combat Maneuvering activity over White Sands Missile Range has provided data critical to the assessment of the potential impact of sonic booms on cultural resources.

Twenty-five years of research concerning the structural damage caused by sonic booms has been largely limited to studies for nominal overpressures up to 30 psf. These studies have indicated: (1) "building structures in good repair should not be damaged at boom overpressures less than about 11 lb/ft^2..." (Clarkson and Mayes 1972), (2) damage from 6 psf nominal booms is considered to be a rare occurrence (10^{-5} to 10^{-2} broken windows per window-boom exposure) and quite minor in scope, (3) the damage rate will increase by 2 to 3 orders of magnitude for each doubling of sonic boom pressures up to 30 psf, and (4) cumulative minor damage effects from repeated exposure to low amplitude (ca. 2 psf) booms has not been evident in extended sonic boom tests. Unfortunately, 2these conclusions have been largely derived from studies of modern structures and sonic booms produced by straight-line overflights; consequently, questions concerning the overpressures produced (both carpet and focus booms) by air combat maneuvering activity and the potential damage to a wide range of special or unconventional structures such as archeological sites or older historic buildings remain.

Limited monitoring projects within the Reserve (Fengler and Bishop 1986) and Valentine (Battis 1983) MOAs and the recent extended monitoring of ACM activity over WSMR provide the data most relevant to these concerns. Monitoring of Air Combat Maneuvering (ACM) activity over the Reserve MOA resulted in the recording of only 11 sonic booms for 72 supersonic sorties. The average overpressure for these booms was 0.8 psf. The limited number of booms recorded provided data with uncertain statistical significance; however, it did show the Oceana sonic boom model overpredicted the frequency and magnitude of sonic booms. Special studies conducted in the Reserve MOA to observe effects on rockshelters and rock art also provided limited data to discern thresholds of potential impacts because overpressure levels of induced sonic booms were barely above the detection capability of the instrumentation used to monitor the overpressures. Both studies however, provides historical data for indicating that atmospheric condition tend to lessen the impacts from that which is predicted by theoretical models.

The recent monitoring of ACM activity at WSMR between July 1988 and January 1989 has provided data essential for more definitive analysis of such questions. The WSMR monitoring study verifies that the overpressure values derived from these limited studies are more representative then those derived through previous modeling efforts. During the six month monitoring period, there were 4600 ACM sorties. A total of 591 sonic boom events were recorded. Each boom was typically recorded at three or four locations. The average peak overpressure was 0.673 psf (Table IV-6). The average maximum peak overpressure was 3.523 psf. These low values indicate that the potential impact on the archeological and historical resources would be significantly less than that previously anticipated. Even though the archeological and historical resources are more fragile than most of the structures subjected to sonic boom studies, it is apparent that overpressures of one to three psf are significantly lower than the levels generally accepted as capable of damaging modern structures.

The potential damage of sonic booms to unconventional structures or natural structures is not as well documented as for conventional structures. The limited number of studies (Clarkson and Mayes 1972; Warren 1972; USAF 1979; Battis 1981; King et al. 1985) available, however, support the conclusion that such structures may be less sensitive than popularly thought. Unfortunately, these studies do not provide specific levels at which historic structures or archeological resources will be negatively affected by sonic boom activity. A consensus concerning a safe level of ground motion associated with historic structures remains to be reached. Bureau of Mines studies (Siskind et al. 1980a) indicate that a safe level of ground motion for dwellings is in the range of 2.0 to 3.8 mm/second. Ashley (1976), on the other hand, proposed peak particle velocities of 7.5 mm and 12 mm for ancient and historic monuments and housing in poor repair, respectively. King et al. (1985) in their vibration hazard investigations of Chaco Canyon National Historical Park note European standards of 2.0 to 2.5 mm/second as a safe level for historic structures. King et al. (1985) concur with this perspective and recommend a 2.0 mm/sec particle

TABLE IV-6

White Sands Boom Monitoring Project (July 1988 to January 1989)

Site No.	Time Up (Days)	No. of Records	Records Per Day	CDNL (dB)	Avg Lpk (psf)	Max Lpk (psf)	Min Lpk (psf)	Std Dev (psf)	Variance (psf)
2	122.5	48	.39	51.8	.611	7.195	.096	1.106	1.223
3	177.9	55	.31	47.0	.580	4.416	.279	.597	.356
4	154.2	85	.55	52.5	.649	2.619	.099	.646	.417
5	103.5	34	.33	46.4	.668	3.686	.110	.712	.507
7	146.1	12	.08	40.4	.641	1.588	.195	.462	.213
8	166.2	41	.25	53.2	.590	4.416	.248	.743	.552
9	177.1	123	.69	51.7	.687	4.216	.094	.720	.519
10	169.9	74	.44	51.4	.820	3.936	.248	.743	.552
11	143.8	50	.35	46.7	.585	2.598	.099	.592	.351
12	191.3	63	.33	52.3	.540	1.396	.248	.297	.088
13	155.4	84	.54	53.0	.916	5.148	.263	.873	.761
14	189.9	108	.57	55.7	1.151	6.669	.099	1.251	1.565
15	171.2	90	.53	53.6	.991	4.414	.108	1.003	1.005
17	174.2	102	.59	56.9	.742	5.248	.248	.779	.606
18	148.1	43	.29	49.1	.785	3.758	.096	.781	.610
19	186.0	101	.54	52.4	.884	6.607	.234	.945	.893
20	188.4	112	.59	51.3	.737	2.786	.248	.598	.358
21	176.1	122	.69	54.3	.988	5.208	.108	.856	.732
22	145.5	92	.63	50.1	.639	2.725	.042	.654	.427
23	171.0	120	.70	54.1	.933	4.423	.101	.998	.997
24	182.0	79	.43	58.0	.672	1.862	.234	.438	.192
25	181.4	42	.23	43.3	.647	3.126	.248	.558	.311
26	160.2	65	.41	45.0	.545	2.786	.248	.488	.238
27	177.5	99	.56	54.7	.582	5.888	.248	.740	.548
28	117.3	13	.11	38.4	.525	2.213	.263	.519	.270
29	167.6	67	.40	46.7	.636	3.406	.101	.613	.376
30	179.0	59	.33	42.9	.415	2.239	.099	.420	.176
31	108.8	10	.09	38.7	.513	1.299	.214	.380	.144
32	149.4	68	.46	51.1	.720	5.118	.103	.937	.878
33	55.1	9	.16	43.6	.642	1.972	.279	.523	.273
34	148.4	36	.24	42.2	.479	1.764	.101	.381	.146
35	184.7	80	.43	46.4	.523	2.877	.087	.488	.239
36	172.9	25	.14	40.8	.543	2.213	.263	.420	.178
37	156.5	35	.22	37.1	.432	.989	.248	.192	.037
38	137.5	13	.09	37.5	.543	2.387	.132	.618	.382
Total Records		2259							
Ave. Recs/Day			.39						
Ave. Lpk					.673				
Ave. Max Lpk						3.523			
Ave. Min Lpk							.175		

Source: Wyle 1989

velocity to be the upper limit for induced motions in structures. Studies by Goforth and McDonald (1968) and Battis (1981) indicate that sonic boom overpressures of less than 5 psf will result in particle velocities within this safe range. Consequently, if the overpressures resulting from Air Tactical Maneuvering are within the 1-3 psf range as indicated by the Fengler and Bishop (1986) study and the 1988 WSMR study, there will be no instantaneous impact to any of the classes of historic and archeological resources with the Reserve MOA.

The cumulative impact of repeated sonic booms to the deterioration of unconventional or natural structures, however, is not easily assessed. The recent data collected at WSMR indicate that the average maximum peak overpressure (3.523 psf) is well within the safe range and therefore the cumulative impact should be negligible over even an extended period of time. The low probability of a boom overpressure being greater than 5 psf (Figure IV-6) together with the extremely low probability of boom reoccurrence at a given point in space renders the potential for cumulative damage to be extremely low.

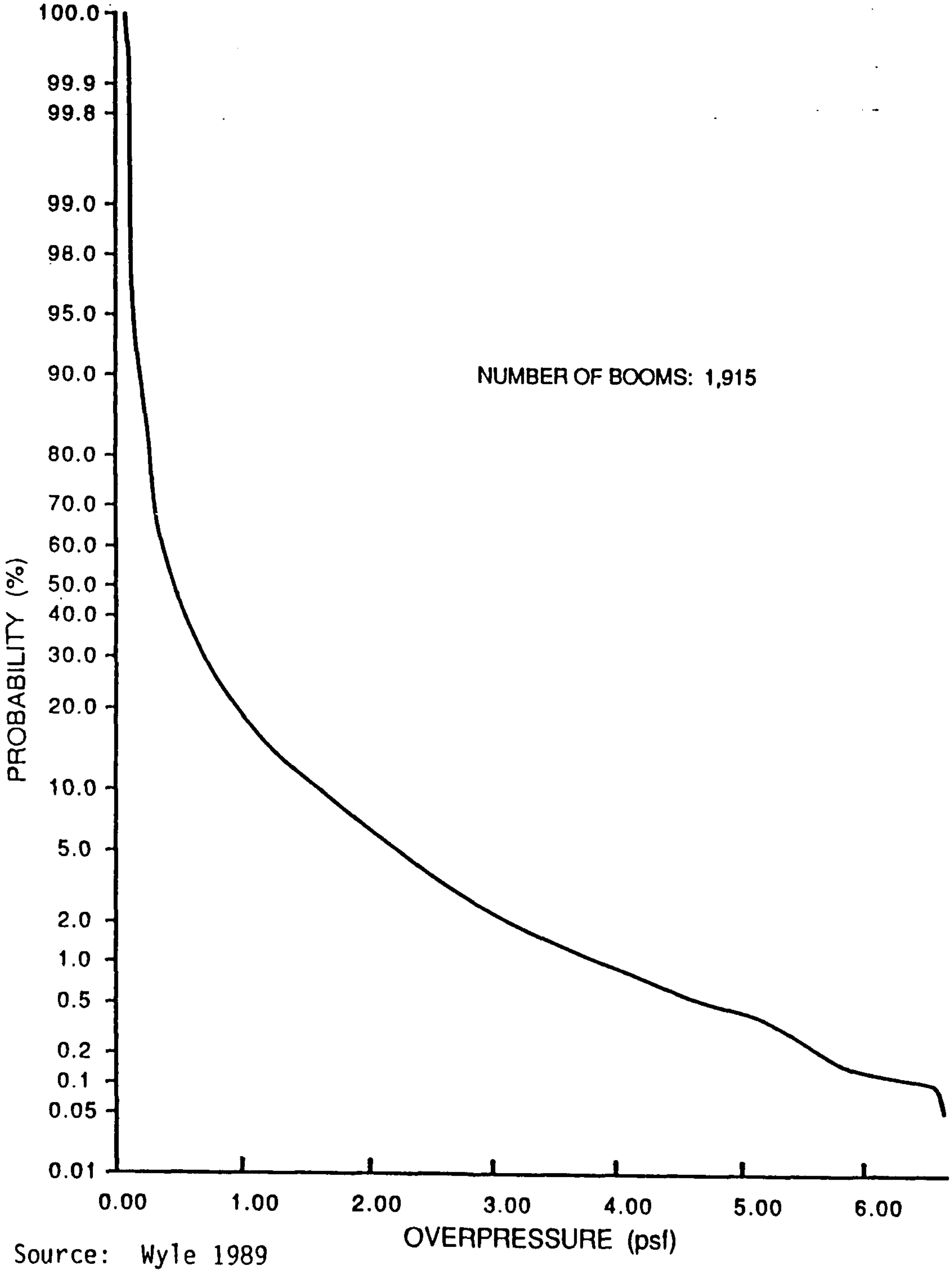
H. Socioeconomic Considerations

1. Population

Analysis of the population indicates that activity within the Reserve MOA has had and will have little effect on the growth of population in Catron County. Population decline to as low in 1970 has been reversed, and a general recovery is predicted. There is no evidence that these changes have been affected or will be affected by any activity within the Reserve MOA. No impact from the proposed action on the population in the county is expected. Impacts on the local population will result from the manner in which the county resolves the development problems that result from other sources.

2. Employment

It is not expected that growth in employment, unemployment, or the total number of available jobs will be negatively impacted by the proposed action. No impact



Source: Wyle 1989

FIGURE IV-6 Cumulative Distribution for Overpressures of All Recorded ACM Sonic Booms.

on federal employment, primarily land management and road maintenance, is expected to result. Local employment is directed by the available civilian labor force, the economy, the availability of jobs, and the season. No impact on these areas is expected to result. Agricultural employment has shown some decline and recovery in recent years, and no impacts on agricultural activity is expected from the proposed action.

3. Personal Income

It is not expected that activity at the Reserve MOA will have any impact on the level of per capita income of the county or the general financial well being of the area. Operations at the MOA do not require based personnel, local expenditures, support, or assistance from the county. Therefore, the MOA can have little impact on the level of personal income in the county. No significant impact from the proposed action on personal income is foreseen.

4. Trade

Operations at the Reserve MOA will have no significant impact, positive or negative, on the trades in the county. The rate of growth of trades will be forever linked to those factors limiting growth in the county. It is not seen that the proposed action will produce any improvement or decline in business in the county.

5. Ranching

It is not expected that activity proposed for the Reserve MOA will have any significant impact on ranching in Catron County. The ranching industry is severely limited by the availability of grazing land, by the permitting system for grazing rights on federal lands, and by the vagaries of the livestock markets themselves. No impact on this situation is expected to result if the proposed action is implemented.

6. Farming

The proposed activity at the Reserve MOA is not expected to create significant impact on farming in the county. Farming is sensitive to a broad range of natural and man-made factors, and farming responds to the annual combination of those factors. However, the proposed actions will not have any positive or negative impact on farming or those factors which directly impact farming.

7. Mining

Activity in the Reserve MOA will have no significant impact on mining activity in the area. The amount of federal and state lands under development control will also insure that no impacts from the proposed action will occur. Mining activities are few in the county, and they would be unaffected by any proposed activity or action.

8. Recreation and Tourism

It is not expected that the recreation and tourism segment of the local economy will feel significant impact from proposed activity at the Reserve MOA. The natural resource base will be unaffected, and the draw of the area for recreation and tourism should remain unaffected. No activity proposed would alter significantly the ability of the local area to benefit annually from recreation and tourism.

9. Wilderness and Primitive Areas

No part of the proposed flight area covers any part of a wilderness or primitive area. No significant impacts are expected to result.

I. Water Resources

The proposed action of supersonic training in the Reserve MOA will not impact water resources at or around the MOA. The nature of the operation does not require any water consumption. Although rare, during an emergency it could be necessary to jettison fuel over the MOA. The expelled fuel is not a threat to local surface or ground water since it would be jettisoned at or above 15,000 ft. MSL and would thus evaporate long before reaching ground level. Local water supply is more than adequate to meet the demands for fire fighting support.

J. Solid Waste/Hazardous Waste Materials

There is no solid waste associated with training in the Reserve MOA and therefore no adverse impact is anticipated. Particulate and gaseous emission from aircraft operations have been estimated for the Reserve training mission (see Table IV-1). Mixing and dispersion under the existing conditions would provide further assurance that sufficient emission dilution occurs before emissions reach ground level.

K. Energy Conservation Potential

The 49th TFW would prefer to fly all supersonic sorties at WSMR but the Army's ongoing missions at WSMR prevent this. The selection of the Valentine and Reserve MOAs as alternate supersonic training sites as opposed to more distant locations is at least partially in the interest of fuel economy. The fuel level used in military aircraft is a resource that is both irreversible and irretrievable but the use is consistent with national policy.

L. Airspace Impact

Private aircraft are not and would not be prohibited from use of the Reserve MOA airspace. The airspace is under the control of the FAA at Albuquerque, New Mexico. Over and above subsonic area operations, supersonic training will not result in special procedures or operating limitations being placed on private aircraft. The proposed supersonic training sorties within the Reserve MOA should have minimal impact on general aviation in the area.

V. ALTERNATIVES TO THE PROPOSED ACTION

A. Background

1. General

For optimum combat capability, the 49th TFW needs sufficient airspace to fly 1,200 sorties per month during which supersonic flights may occur. Existing areas in the vicinity of Holloman AFB cannot accommodate all the monthly 49th TFW requirements for airspace approved for supersonic operations. It is anticipated that WSMR will continue to support about 600 supersonic sorties per month on a long term basis. As the WSMR testing schedule allows, the 49th TFW may be able to fly more than 600 supersonic sorties per month in the WSMR airspace; however, the additional sortie capability (above 600 per month) will be variable and cannot be counted on in terms of national defense. To accomplish the air superiority mission, the 49th TFW needs additional supersonic airspace capable of handling 600 sorties per month. Depending upon the airspace size, availability, location, and environmental consequences, all 600 sorties could be flown in one area or divided between several areas. A maximum of 300 sorties per month are proposed at both Valentine and Reserve MOAs.

2. Alternative Consideration

These alternatives are the same as those presented in the EIS which was completed in 1984. These alternatives have been reevaluated based on present information and latest data available. Alternatives selected in order to meet the 600 sortie shortfall consider the following basic categories: (1) utilize existing MOAs within 150 NM of Holloman AFB, (2) utilize other existing supersonic airspace outside 150 NM of Holloman AFB by air refueling or temporarily deploying aircraft to another base, (3) create a new MOA capable of handling supersonic operations within 150 NM of Holloman AFB, and (4) the "no action" alternative.

3. MOA Selection Criterion

Requirements and guidelines for MOA selection are as follows:

a. As required by Air Force and FAA regulations, the area should be located in airspace transitted by few commercial airways and servicing limited established airports and general aviation traffic, thus, avoiding/minimizing the impact which military flight operations may have on other airspace users.

b. The area should be very sparsely populated so that the fewest number of people are affected by the potential noise impacts resulting from supersonic flight activity.

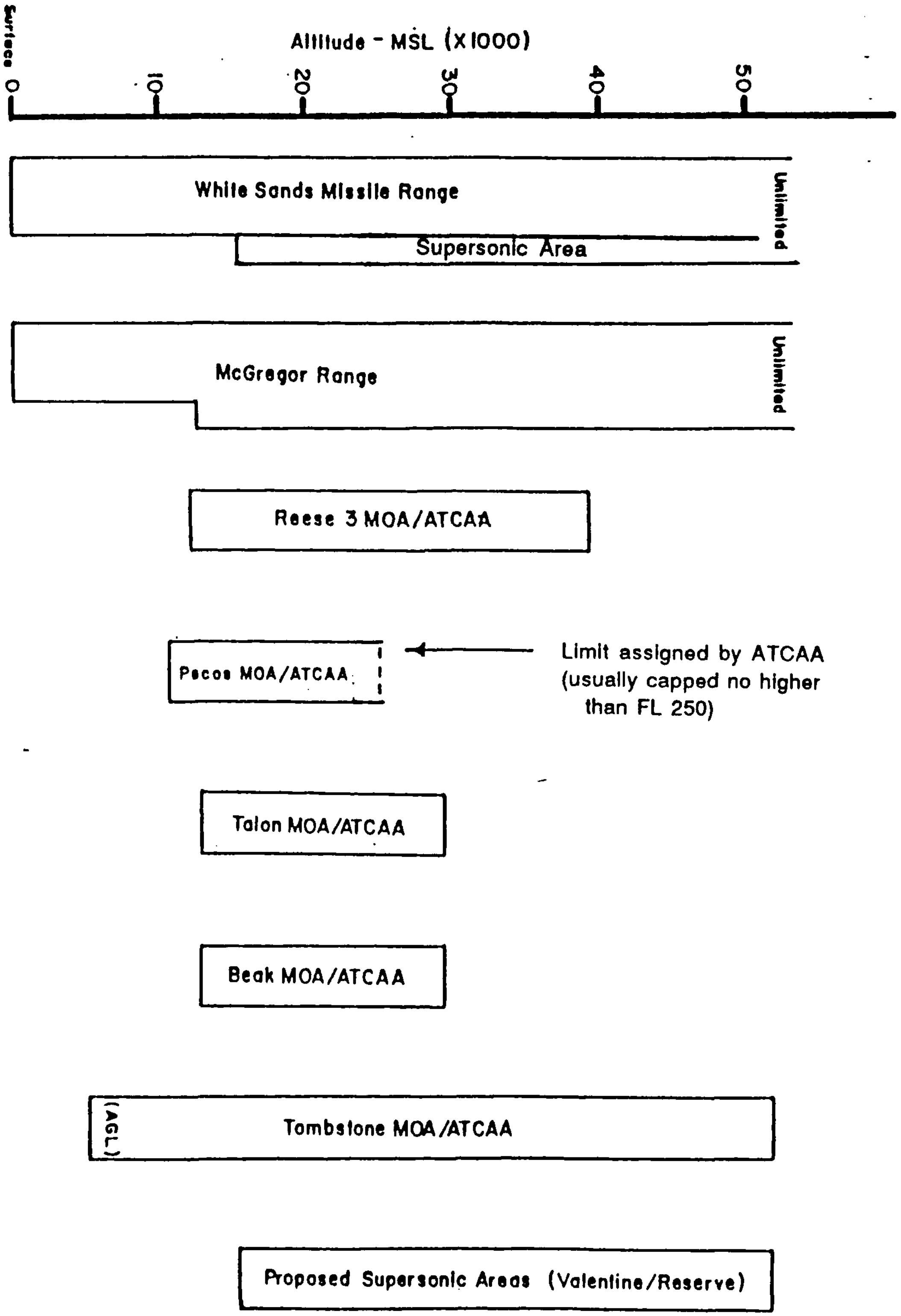
c. The size of the area must be large enough to allow effective use of the F-15 long-range radar and associated weapons systems. The F-15 radar can acquire targets which are in excess of 80 NM away. When flights are conducted in small operating areas, where the maximum separation available between aircraft is less than 30 NM, the pilot is unable to exploit the full capability of the F-15 weapons systems. Large areas also enhance realistic tactical missions by providing additional airspace for adversary aircraft to evasively maneuver to avoid F-15 radar detection. Based on previous operational experience, the minimum area size to accomplish effective F-15 missions is 40 x 50 NM.

d. The proposed supersonic sorties should not replace any existing operations. Operational altitudes available for the area must be low enough to accommodate realistic missions but not so low as to conflict with effective air route traffic control and general aviation traffic. In addition, since ground sonic boom effects are inversely proportional to the altitude of the aircraft above the ground, the minimum operational altitudes must be a compromise to allow realistic scenarios while minimizing the sonic boom effects on the public beneath the airspace. Altitudes of the areas discussed are illustrated in Figure V-1.

B. Alternative Evaluation

1. Utilize Existing Airspace Within 150 NM of Holloman AFB

The reason for locating the area within 150 NM of Holloman is to minimize time and fuel required in transit to and from the area. Based on an area located 150 NM from Holloman, F-15s expend approximately 850 gallons of fuel (round trip), leaving approximately 1,200 gallons of fuel or about 30 minutes of flying



Source: U.S. Air Force 1979

FIGURE V-1 MOA Operating Altitudes

time available for tactical flying in the area. Any area located in excess of 150 NM would increase transit time and fuel required, resulting in less tactical flying time. This waste of time and fuel should be minimized from a cost effective/operational standpoint. All military flying areas, except WSMR areas, located within 150 NM of Holloman AFB were evaluated for potential supersonic flight using the above selection criteria. Additionally, the airspace was examined to determine if any location would be suitable for establishing a new supersonic military operations area. Figure V-2 depicts the commercial airways, and existing military areas within 150 NM of Holloman AFB. Analysis for each of the alternate areas located within this airspace follows.

a. Beak Military Operations Areas

The Beak areas are located 30-80 NM east/northeast of Holloman Air Force Base. Although the size of the area is adequate, the population beneath the Beak MOA area is: Cloudcroft -- 570; Mescalero -- 900; and Ruidoso -- 4,260 (Rand McNally 1988).

Numerous other smaller communities such as Lincoln, Capitan, and Fort Stanton are also located beneath the Beak MOAs. The Beak MOAs are used for 479th TTW T-38 flight operations. Loss of these areas for T-38 training would seriously degrade the mission of the 479th TTW.

b. Talon Military Operations Area

The Talon MOA is located approximately 60-100 NM east of Holloman AFB. The population density beneath most of the airspace is low. Because of the commercial air traffic route over the area, the maximum altitude available is 29,000 ft. MSL which would be unsuitable for F-15 training. Even if the upper altitude could be raised to 51,000 ft. MSL and commercial air traffic could be rerouted around the area, F-15 supersonic flight requirements could not be accommodated. In May 1980, the 479th TTW in coordination with the FAA changed the Talon MOA boundaries in order to divide the MOA into three separate working areas. This action caused the MOA to shift to the northeast since the area's

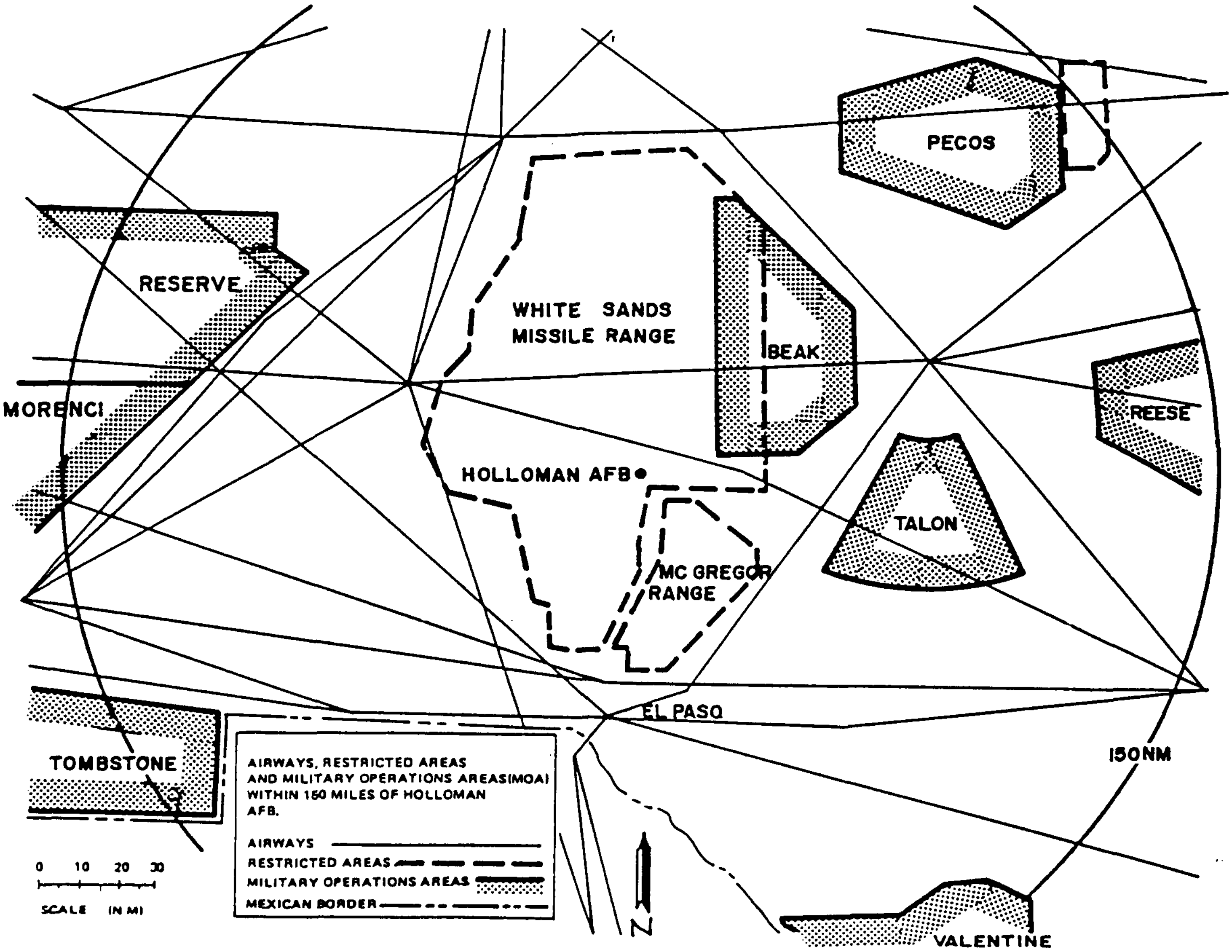


FIGURE V-2. Airways, Restricted Areas and Military Operations Areas (MOA) within 150 NM of Holloman AFB.

Source: U.S. Air Force 1979

boundaries are now defined by the Roswell navigation aid. The cities of Artesia (population 10,385) and Carlsbad (population 25,496) are now within the borders of the MOA (Rand McNally 1988). If the boundaries were expanded to the previous borders and a five NM buffer were placed around each of these cities and Carlsbad Cavern National Park, the resulting area available for supersonic operations in the Talon MOA would be 20 x 30 NM. This is too small for suitable F-15 supersonic flights. Another major disadvantage associated with using the Talon MOA for F-15 missions is the fact that it is used extensively for T-38 flight operations. Due to the large number of T-38 sorties, Talon MOA and Beak MOA are vital areas for accomplishment of the 479th TTW flying mission.

c. R-5103 McGregor

The McGregor Area (Restricted Area 5103) is located 15 NM southeast of Holloman and 16 NM northeast of El Paso, Texas, metropolitan area (population 350,000). The airspace managed by the U.S. Army at Ft. Bliss, Texas, is divided into three areas. All three areas are used extensively for Army surface-to-surface/surface-to-air missile and gunnery training. To provide increased local airspace for T-38 flying, Holloman AFB has a letter of agreement with the Army which allows T-38 usage of R-5103C airspace for approximately 18-20 hours per week. R-5103C, the airspace north of N32°15'00", is the only portion of R-5103 that Air Force aircraft are allowed to fly. This northern area is approximately 15 x 30 NM and is consequently too small for useful F-15 supersonic activity. In addition, the limited scheduling basis also makes the airspace unsuitable for consideration as a F-15 supersonic flight area. Even if more time were available to Holloman in the McGregor area, as with the Beak and Talon MOAs, all subsonic airspace within 80 NM of Holloman must be dedicated to T-38 flight operations due to the aircraft's short operating range and high daily sortie rate.

d. Pecos Military Operations Area

The subsonic Pecos MOA is approximately 100 NM northeast of Holloman AFB. The airspace is managed by Cannon AFB, located at Clovis, New Mexico. Although Pecos is Cannon's only MOA, approximately 3-4 hours per day would be available for F-15 shared usage.

The area is large enough to accomodate F-15 supersonic flights; however, the present vertical dimension is limited, extending from 10,500 ft. MSL to as assigned by ATC (usually capped no higher than FL 250). It is possible that the maximum altitude of the areas could be increased. This action would require several changes to the existing high altitude structure above the MOA. First, extensive commercial air carrier traffic operating on the high altitude jet route (J-74) which presently transits the MOA would have to be re-routed around the area when flying is in progress. J-74 is the preferred east-west route between Los Angeles/San Diego and Dallas-Ft. Worth/Atlanta by the FAA and commercial carriers (airlines). The re-routing could be accomplished by Air Route Traffic control vectors or by physically moving the airway clear of the Pecos airspace. This re-routing would result in increased flight time and increased fuel costs for the commercial carriers.

Secondly; increasing the maximum available altitude in the Pecos MOA would require restricted use or a complete relocation of the refueling track which presently overlies the Pecos area. Besides the existing airway and refueling track conflicts mentioned above, the major difference between the Pecos and Valentine MOAs is population. Because the population of the Pecos MOA (2,000) is greater than twice that of the Valentine MOA (700), more area residents would be affected by sonic boom activity in the Pecos area, for a given number of F-15 supersonic sorties as compared to the Valentine area.

e. Reese 3 Military Operations Area

The Reese 3 MOA is located approximately 130 NM east of Holloman AFB. Extensive T-38 training from Reese AFB is conducted in the MOA and little scheduling flexibility would be available for F-15 sorties. Less than four hours per day would be available for shared usage of the area. Sonic booms would affect a large number of people residing near the MOA in the cities of Tatum (population

896), Lovington (population 9,727), Hobbs (population 28,794), Denver City (population 4,904), and Seminole (population 6,080) (Rand McNally 1988).

f. Reserve Military Operations Area

The Reserve MOA is located approximately 120 NM west northwest of Holloman AFB. Although three airways transit the area, it is geographically large with vertical altitudes ranging from 5,000 ft. above ground level to 51,000 ft. mean sea level. Approximately six to eight hours daily are available for F-15 shared use. The area has no established airports with hard surfaced runways and minimum general aviation traffic. Although the supersonic portion of the area is relatively small (33-47 NM) the large overall size of the adjoining subsonic portions of the area allows effective utilization of the long range F-15 radar system. Mission scenarios can be planned so that participating aircraft use the radar system to converge from the subsonic portions of the area to the supersonic section for visual air combat maneuvering. Only the northeastern corner of the area is proposed for supersonic flight to avoid to the maximum extent possible populated areas and designated wilderness areas beneath the remaining portion of the Reserve MOA. The area presently accommodates a maximum of 300 supersonic sorties per month or about half of the required F-15 supersonic flying sorties that must be flown outside the WSMR airspace.

g. Tombstone Military Operations Area

The Tombstone MOA is located about 135 NM southwest of Holloman. It is managed by the 355 TFW located at Davis-Monthan AFB in Tucson, Arizona. The subsonic MOA is used extensively by A-7, A-10 and various other military aircraft which operate from the Tucson area and would be available for less than two hours per day for F-15 use. Even if scheduling priority for the airspace could be given to F-15 sorties, the area is not large enough to effectively employ the F-15 weapons system. Due to numerous major airways along the northern border and the Mexican border on the south, the possibility for expansion of the geographic area boundaries appears unlikely. The area has sparse population, which is desirable for supersonic flights; however, the existing utilization by Davis-Monthan aircraft and the small size make it an undesirable alternative for F-15 sorties.

h. Valentine Military Operations Area

The Valentine MOA is located 140 NM southeast of Holloman. At present, the 49th TFW (with the exception of limited use by the 67 TRW and the U.S Navy aircraft from Chase Field) is the sole user of this airspace. Consequently, no military shared use problems are encountered. F-15 area time would only be limited by the amount of daylight time available. There are no established airports with hard surfaced runways within the area and only limited general aviation traffic transits the area. The Valentine MOA is large with suitable vertical altitudes ranging from 15,000 ft. MSL to 51,000 ft. MSL. The population density is very low with only one small community (Valentine, population 213) located directly beneath the proposed airspace.

i. Summary of Comparisons

Table V-1 provides a review of the existing airspace in comparison to the criteria. The Valentine and Reserve MOAs clearly satisfy the necessary physical requirements and criteria, pending only environmental review and approval from pertinent agencies and the general public.

2. Special Combined MOA Usage

Since Valentine and Reserve MOAs are the only MOAs which satisfy the physical Air Force and FAA requirements within 150 NM of Holloman, joint useage with WSMR is a logical alternative to satisfy the 49th TFW mission.

a. Utilize Only the White Sands Missile Range and the Reserve MOA for Supersonic Operations

If the magnitude of existing military and civilian flight activity in the Reserve MOA would not support significantly increased F-15 flight operations above the

TABLE V-1

Comparative Review of Existing Airspace Within 150 NM of Holloman AFB, New Mexico

EXISTING AIRSPACE	COMMERCIAL AIRWAY IMPACT	SPARSELY POPULATED	SIZE GREATER THAN 40 X 50 NM	NO EXISTING MISSION IMPACT
Beak MOA	-	-	*	-
Talon MOA	-	-	-	-
R-5103 McGregor	*	*	_	-
Pecos MOA	-	-	*	-
Reese 3 MOA	-	-	*	-
Reserve MOA	-	*	*	*
Tombstone MOA	*	*	-	-
Valentine MOA	*	*	*	*

*No impact

Source: U.S. Air Force 1979; Geo-Marine, Inc.

maximum projected 300 sorties, then only when WSMR could accommodate 900 sorties a month would the 49th TFW meet proficiency objectives of 1200 sorties per month.

(1) Reserve MOA Contingencies

The 162nd Tactical Fighter Group, Air National Guard at Tucson, Arizona, is the scheduling authority for the Reserve MOA. The area is used extensively on a shared use basis by numerous military units stationed throughout the southwest United States. Any increase in F-15 sorties to the area above the maximum projected 300 sorties per month would result in decreased availability of the airspace for other military/civilian organizations. Three high altitude jet airways (Figure V-2) which define major commercial air carrier routes from the West Coast to the south central portion of the United States, presently transit the Reserve MOA. When F-15 aircraft, use the higher portions of the airspace where commercial air carrier routes are normally flown, commercial air traffic must be routed from the restricted airway to avoid the MOA. The rerouting results in increased flight time and increased fuel costs for the commercial carrier..

Assuming the Reserve area is used for supersonic flights and the problems associated with increasing the number of F-15 sorties to the area could be resolved, the environmental impact of the aircraft noise and sonic booms would be as shown in Figure IV-1 (maximum of 300 sorties per month). Figure V-3 shows the relative long-term average "c-weighted" day night noise level for the CDNL 45 ellipse. If operations were raised to 600 sorties per month, the noise levels shown in Figure IV-1 would be about three decibels higher. At this volume of activity, the 50 dB level would be approached along with the threshold of public annoyance. Splitting the operations equally between WSMR and Reserve would help reduce the number of people under the WSMR airspace that are highly annoyed. Currently there are about 150 people living under the WSMR supersonic airspace. About 2.9 percent of these are expected to be highly annoyed by noise impacts. Considering the availability of time in the Reserve MOA, it is unrealistic to project more than a maximum of 300 sorties per month, and consequently the activity at WSMR would need to maintain up to 900 sorties per month or the 49th TFW would have to accept the resultant sortie shortfall.

(2) WSMR Contingencies

There are two options that must be considered in the attempt to find more time in the WSMR airspace: (a) mission priority change and (b) weekend flying; however, neither of these would reduce the impact to the people under the WSMR airspace.

(a) Priority Change

Except for live ordnance air-to-air gunnery which has limited priority, 49th TFW usage of the WSMR must be scheduled on a daily non-interference basis. Because of their critical importance to national security and extremely high operating costs, defense research/development and operational test/evaluation projects must take priority over all other WSMR activities. Due to the potentially hazardous, rigidly controlled, and classified nature of development test projects, the only airspace where the projects can be safely/effectively flown in is within restricted areas where public access is closely guarded. The WSMR satisfies all of the above testing requirements and is the only national test range located over land within the United States.

Nothing is foreseen which would change the present non-interference scheduling policy for Holloman missions in WSMR airspace (USAF 1978). Projects are scheduled as far in advance as possible, then rescheduled on a daily basis as required for timely and economical accomplishment. The 49th TFW and 479th TTW then adjust their weekly and daily flying schedules so as to utilize the remaining range time.

(b) Weekend Flying at WSMR

The other alternative to the WSMR/Reserve option would be to consider weekend flying at WSMR. The 49th TFW could fly 50 supersonic sorties per day on weekends; however, higher priority programs (WSMR) are anticipated to cut this figure to 45 sorties (long-term basis). Thus using weekend days for two weekends could push the long-term projected WSMR sortie rate from 600 to 780 sorties per month. This option does not completely resolve the sortie shortfall and if implemented would result in a seven day workweek for base support personnel since they would have to continue providing support to the 479th TTW on Mondays through Fridays. Although the mission objective is to be combat ready seven days per week, all Air Force bases work on a regular Monday through Friday workweek during peacetime. The minor gain in sorties would have to be weighed against the reduced morale. Military families are already tasked with excessive family separations due to temporary duty and remote overseas duty. The resultant impacts are difficult to quantify; but from informal surveys of personnel currently assigned to Holloman, the impacts would be significant.

b. Use Only the White Sands Missile Range and the Valentine MOA for Supersonic Flying

If the Reserve area is not used for supersonic flights, operationally, the Valentine MOA use could be increased from the maximum projected 300 to 600 supersonic sorties per month. The 49 TFW is the primary military user of the Valentine airspace and no major conflict with other military/commercial users of the airspace exists.

Up to 50 percent (600) of the 1,200 monthly F-15 supersonic required sorties could be flown in the Valentine airspace. Approximately 30 F-15 sorties would use the area per day. Utilizing the data produced from the WSMR sonic boom study (a maximum 300 sorties per month), less than one sonic boom per day would be expected to be heard on the ground at any specific location. The 45 CDNL contour (Figure V-3) would be contained entirely within the Valentine MOA, which is well below equivalent EPA criteria (49.7db, EPA 1974) for human annoyance. Doubling the sortie rate to 600 would add 3 dB to the CDNL contours shown in Figure V-3. The number of sonic booms heard at the Valentine MOA due to 300 sorties per month (Figure V-4) would double if the sortie rate were doubled to 600 per month.

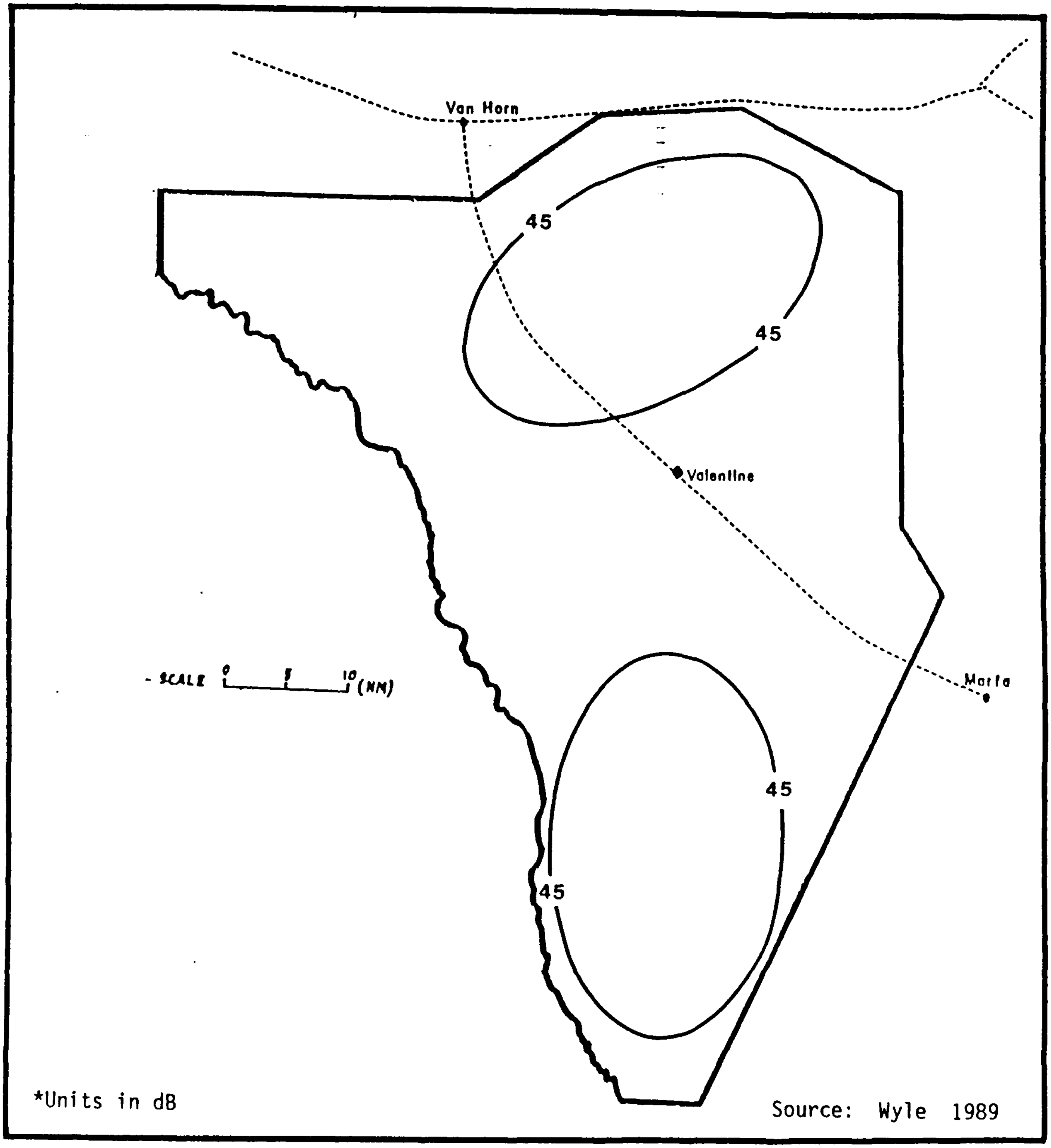


FIGURE V-3 C-Weighted Day Night Noise Level Distribution at Valentine MOA Based on WSMR Model.

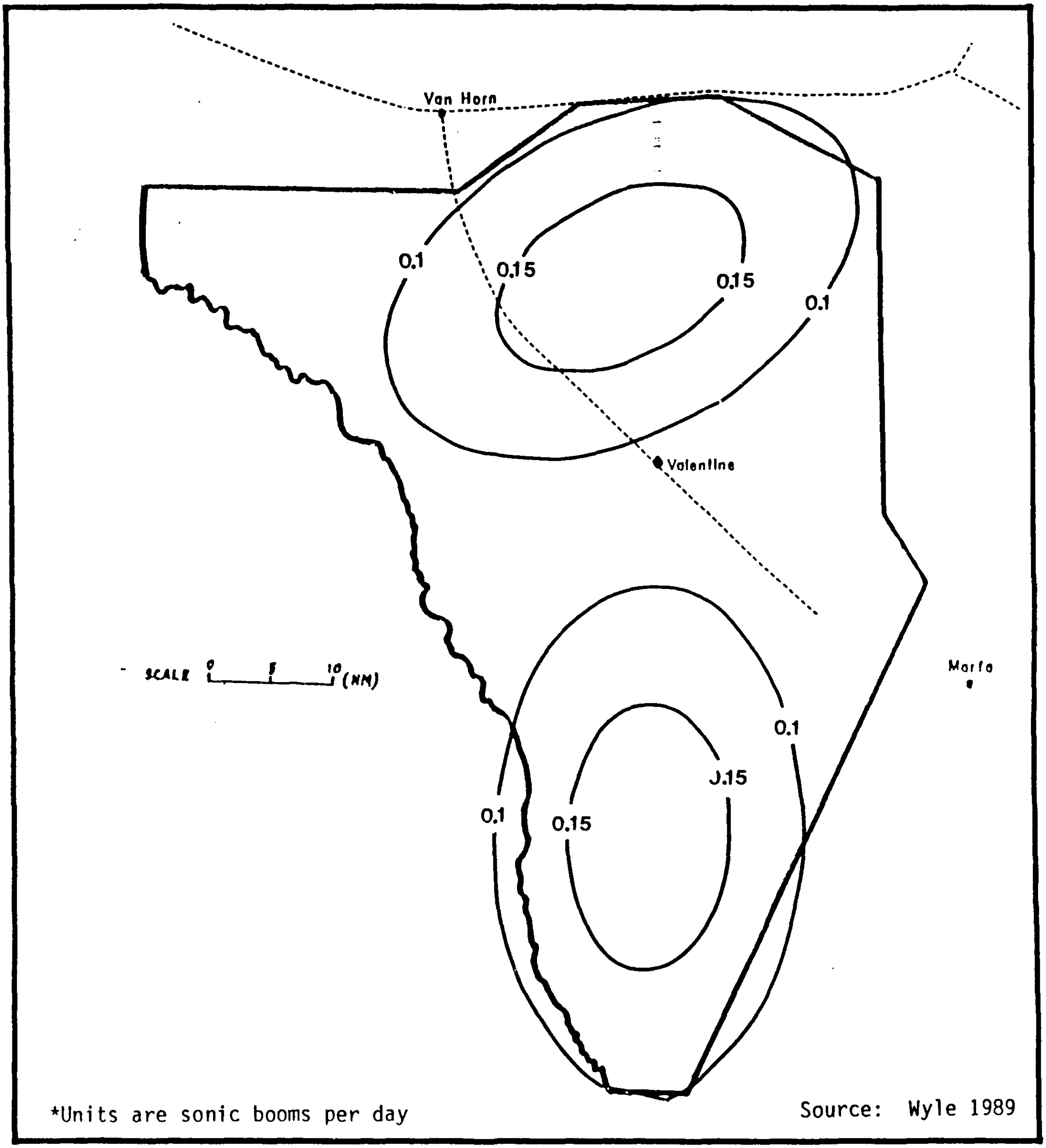


FIGURE V-4 Predicted Sonic Boom Activity at Valentine MOA Based on WSMR Model.

There are three options to the WSMR/Valentine Alternative that must be considered as possible ways to reduce the impact on the local public: enlarge or reduce size of Valentine MOA and change vertical altitude. (Weekend flying at WSMR has previously been analyzed and the factors discussed also applies to this option.)

(1) Enlarge Size of the Valentine MOA

The area boundaries of the Valentine MOA have been designed to accommodate present and future supersonic operations. While enlarging the MOA would allow for establishing more operational maneuvering areas with better spacing, there are constraints that limit the size of the MOA.

No area expansion is possible to the north due to major vector (V-198) and J (2) series airway as well as the town of Van Horn and the numerous communities located along Interstate 10. Expansion to the east or southeast is limited by the McDonald Observatory, Harvard Radio Telescope, Davis-Mountain resort area, and the City of Marfa. However, the distance from Holloman (over 150 NM) increases beyond the maximum operationally desired distance. Moving either the true easter boundary, or the southeastern boundary both have the same effect, and 150 NM is the desired limit. Any expansion of the western or southwestern area boundary is not possible due to the Mexican government's prohibition of encroachment into their airspace.

(2) Reduce Size of the Valentine MOA

A reduction in the Valentine MOA size would likely force a shift from the existing designated operational maneuvering areas. This would result in a restriction to select various areas with optimal terrain and minimal population density. Thus, the potential for an adverse affect would be greater.

(3) Increase Minimum Altitude Boundary

The effects of sonic booms are directly related to the altitude of the supersonic aircraft. As the aircraft's altitude above the ground increases, the resulting sonic boom noise and overpressure effects decrease. The higher the minimum altitude, the less impact supersonic flight will have on the public beneath the airspace. This relationship was a predominant factor in the selection of minimum operation altitude of 15,000 ft. MSL. Although a much lower minimum altitude would significantly enhance operational combat sorties, use of altitudes below 15,000 ft. MSL were rejected as a compromise with other flight activities and in order to minimize the potential noise effects. Any upward revision of the present minimum altitude would reduce the quantity of vertical airspace available and seriously degrade the capability to support realistic air combat missions. For example, during one supersonic test, 50 percent of the pilots reported that supersonic events occurred at an altitude below 22,000 ft. MSL. Pilots would be forced to employ the aircraft in the high altitude regime where low air density causes reduced engine/airframe efficiency and decreases the maximum performance of the aircraft.

Although operation at altitudes above 30,000 ft. MSL is tactically sound during the initial intercept phase, as the engagement progresses into a three dimensional "dog fight" all participants must decrease altitude to utilize the maximum acceleration and turning performance of their aircraft.

3. Utilize Existing Airspace Outside 150 NM by Air Refueling or Temporarily Relocating the Holloman Aircraft

Since there are a number of locations within the United States where supersonic training is conducted by other units, one option considered was joint use of that airspace by the 49th TFW and the respective managing unit. This alternative would be economically and operationally costly, but WSMR supersonic activity could be augmented in this fashion.

a. Operate From Holloman with Refueling

Holloman F-15s could operate on a very limited basis to and from the supersonic Sells MOA. The Sells airspace is the primary flying area for F-16, F-4 and F-15 aircraft operating out of Luke AFB, Arizona, and A-7/A-10 aircraft from Davis-

Monthan AFB, Arizona. Due to the scarcity of supersonic airspace in the southwestern United States, the Sells MOA is scheduled 90 percent of the time from sunrise to sunset for local military flying requirements. Based upon an average daylight period of 12 hours, the Sells MOA would be available approximately one to one and one-half hours per day for Holloman F-15 usage. This would equate to two or three 30 minute flying periods which would accommodate a maximum of 8 to 12 supersonic sorties per day. It is possible that some of the sorties presently using the Sells MOA do not require supersonic flight for optimum mission accomplishment.

By scheduling the non-supersonic required sorties out of the Sells MOA to other subsonic areas, increased Holloman utilization of the supersonic airspace could be attained. Assuming that sufficient shared use time was available to support the same number of sorties to the Sells MOA as projected for the Valentine and/or Reserve MOAs (15 sorties per day), the Sells airspace would receive less than one additional sonic boom per day. Increasing the quantity of supersonic activity in the Sells MOA, which currently experiences an estimated 45 sonic booms per day, should not represent a significant environmental impact.

Because of the greater distance involved, the operational cost per F-15 sortie to the Sells MOA will be significantly greater than the cost per sortie to the Valentine or Reserve areas. The additional costs are attributable to the increased F-15 flight time and the inflight refueling support necessary to accomplish sorties in the Sells MOA. An F-15 sortie to the Reserve or Valentine area requires a total flight time of 1.4 hours for the 280 NM round trip from Holloman. The 1.4 hours of flying time includes 30 minutes of area flight time. To accomplish 30 minutes of flight activity on a sortie to the Sells MOA, a total flight time of 2.5 hours would be required for the 800 NM round trip. Reserve/Valentine missions can be flown without inflight refueling, while each sortie to the Sells airspace would require one KC-135 refueling aircraft per day for aerial refueling to and from the area to accomplish 30 minutes of area training time. The total flight time for each KC-135 mission would average approximately 5 hours. Using fiscal year 79 costs per flying hour (figures obtained from Headquarters Tactical Air Command Management Analysis personnel for the F-15 and KC-135) the cost per F-15 sortie for 30 minutes of supersonic flight in either the Reserve or Valentine MOA was $3,535, whereas the Sells MOA cost per sortie would be approximately $10,064.

The additional cost resulting from F-15 operations to the Sells MOA is feasible on a limited scale since each pilot must maintain refueling proficiency and aerial refueling can be accomplished in conjunction with realistic supersonic missions. This alternative, which requires refueling support on a daily basis appears to be impractical due to excessive cost, nonavailability of adequate airspace, airspace time, and KG 135 tanker support. Inflight refueling was also considered as means of utilizing the Nellis Range supersonic airspace located 500 NM west of Holloman. Compared to the Sells MOA, the Nellis Range airspace is located a greater distance from Holloman and has less range time available. Because of the costs, the Nellis airspace is not considered to be a feasible alternative.

b. Deploy Holloman Units to Satellite Locations

Another alternative for obtaining supersonic sorties is by temporarily stationing Holloman units at operating locations where there is access to supersonic airspace. However, there are important factors for not relocating either the 49th TFW or the 479th TTW.

In the environmental evaluation for the beddown of aircraft at Holloman AFB, over 84 alternate bases were evaluated for the F-15 beddown and 89 bases for the T-38 operations. Holloman is considered to be the optimum location for the F-15 and T-38 aircraft beddown based on the following criteria:

- The location is well suited for overseas deployments from the continental United States. Additionally, F-15s positioned at Holloman enhance air defense capabilities in the south central portion of the United States.
- Airspace in the vicinity of Holloman is capable of supporting supersonic flight activity over sparsely populated areas.

- Holloman is characterized by good year-round flying weather with no extended periods of weather below 2,000 ft. MSL (cloud ceilings) and three miles visibility.
- Live ordnance air-to-air (F-15) and air-to-ground (T-38) gunnery ranges are located near Holloman so that transit time enroute to and from the ranges is minimized.
- Existing base support facilities required only limited new construction to accommodate F-15 and T-38 operational requirements.
- The placement of both wings at Holloman resulted in a net increase of 70 personnel as opposed to the 770 decrease in base personnel that would have occurred if the T-38 wing had been located elsewhere. The desirable operational attributes of the Holloman location and the high costs normally involved in moving to and setting up operations at another base make relocation of either the 479th TTW or the 49th TFW very costly, and operationally impractical.

One Valentine area resident at a local project scoping meeting suggested that the 49th TFW be relocated to a Texas Gulf Coast military base to conduct supersonic flights over water. Proposed locations near overwater supersonic areas were evaluated and eliminated from consideration based on one or more of the following reasons.

- Location within the United States with respect to employment/deployment considerations.
- Availability of air combat maneuvering supersonic airspace/ranges.
- Presence of an existing mission programmed for long-term activity on the base.
- Marginal weather conditions for tactical operations.
- Local community encroachment problems.
- Gross facility deficiencies.

(1) Nellis AFB Range Complex

The Nellis range complex is located north of Las Vegas, Nevada, approximately 500 NM northwest of Holloman AFB. Due to the distance from Holloman, the only practical alternative for utilization of this airspace would involve deploying a unit to Nellis AFB. Before examining the advantages and the disadvantages of a satellite operating location, the availability of area time for Holloman to use the Nellis Range complex must first be considered. The Nellis Air Force Base complex has and is being used extensively to support mission requirements of combat ready flying units permanently stationed at Nellis AFB.

Additionally, because the areas are large, supersonic certified, and have minimum operation restrictions, the range area provide invaluable tactical training for aircrews participating in Tactical Air Command Exercises allowing combat ready pilots from units located throughout the United States to periodically deploy to Nellis AFB and practice, evaluate, and refine combat tactics in a simulated, but very realistic, wartime environment. The continual scheduling demand for Nellis range airspace by the training exercises and the flying units stationed at Nellis results is nearly 100 percent utilization of the areas during the daylight hours. Although 49th TFW pilots use the airspace on a short-term basis while participating in the periodic exercises, any long-term shared use of the areas is not considered feasible due to existing airspace utilization, travel cost, and expense to support a satellite operation. If adequate shared use time was available on the Nellis Range Complex, the costs associated with temporarily deploying squadrons there for supersonic sorties would be approximately the same as for the Tyndall AFB, Florida operation discussed later.

(2) Florida AFBs with Overwater Supersonic Training Areas

To examine specific problems associated with satellite operating locations, there are a number of Air Force bases located in Florida where supersonic overwater areas are available and existing area utilization would support significant 49th TFW shared usage. By continuously maintaining one of the three Holloman F-15 squadrons at a satellite base having access to supersonic airspace, approximately 33 percent more F-15 sorties would have supersonic capability. If this option was employed to augment existing F-15 supersonic capability (50 percent WSMR) a total of 83 percent of the 49th TFW F-15 sorties could be flown in supersonic approved airspace. Although the 33 percent represents a significant increase above present supersonic capability, the operational practicality and cost effectiveness of such an alternative are questionable for the following reasons.

To avoid the prohibitive expense of maintaining a complete on-site parts inventory, replacement of aircraft parts would be maintained at Holloman and transported to the operating location when required. In addition to increased transportation costs, the time delay in getting parts from Holloman would reduce aircraft incommission rates at the operating location. With a third of the wing deployed away from Holloman on a long-term basis, the wing's quick reaction deployment posture would be seriously degraded. In the event the wing was tasked to mobilize for rapid worldwide deployment, critical time would be lost by not having a significant portion of the wing resources at home and immediately available.

The adverse impact on the morale of Air Force personnel required to support this alternative is another factor which must be considered. While deployed to the operating base, families of operations and maintenance personnel would have to remain at Holloman. The necessity for family separation is accepted in the military; however, the validity of forced family separation to accomplish supersonic training at a satellite location when that flying could be reasonably accomplished in areas near Holloman would be seriously questioned. If the alternative was implemented, to lessen the resulting family separation impact, each squadron at Holloman would rotate personnel to serve a maximum of 60 days at the temporary operating base.

An additional factor relating to satellite base operations must be considered. Although supersonic training over water would expose very few people to sonic booms, deployed operations would increase the number of takeoffs and landings at the satellite operating base, resulting in an increased noise impact on populated areas near the base.

The following data summarizes the major costs required to deploy and maintain an F-15 squadron (24 aircraft) at Tyndall Air Force Base, Florida. Tyndall was selected as an example because of its access to supersonic areas over the Gulf of Mexico where minimum environmental impact would be anticipated. Cost estimates are based upon deploying/maintaining a squadron size detachment at Tyndall AFB for one year with a rotation of personnel back to Holloman every 50 days. A squadron size operation requires 291 enlisted and 37 officers for a total personnel package of 328. The total cost per year to accomplish this alternative, using fiscal year 1979 costs, is estimated to be $29,646,024. The total includes deployment costs, temporary duty personnel costs, personnel rotation costs, and F-15 flying time/sortie operational costs. Computations used to derive both individual and total operating costs are provided in Appendix F of the Reserve MOA Draft Environmental Impact Statement (USAF 1979). Based on the lack of supersonic airspace where 49th TFW F-15 sorties could operate on a shared basis without the need for costly inflight refueling and/or satellite operating bases, the potential of this alternative to provide required proficiency is limited. Although such short-term operations would be practical to some degree, on a long-term basis, shared use of distant supersonic areas in lieu of establishing local supersonic areas does not appear feasible.

4. Utilize Mexican Airspace

This alternative was not considered feasible even though the area met the selection criteria. Mexican constitutional restrictions do not allow foreign military aircraft training over Mexico.

5. Create New Airspace

The potential for establishing a new MOA for T-38 and/or F-15 operations is very limited due to the present number of MOAs, restricted areas, and high/low altitude airways (see Figure V-2). All airspace within operating range of the T-38 (90 NM) is completely saturated with existing areas and airways. Therefore, the feasibility of developing another area for T-38 operations and allow F-15 use of the Talon area appears unlikely. When the 150 NM operating range is considered, possibilities for establishing a new area are limited due to the concentrated network of high and low altitude airways. In no case would it be possible to propose even a 40 x 40 NM flying area without deleting or rerouting at least two or more high/low altitude airways. Due to the amount of civilian traffic utilizing routes in the vicinity of El Paso, Albuquerque, Tucson and Roswell, the ramifications associated with implementing this action are significant. If existing airways could be relocated, it is very likely that the resulting area would not be as sparsely populated.

6. No Action

Acceptance of this option would result in continuation of aircraft emissions stated in Table IV-1. Noise levels would also remain in the low 40 DNL range which is typical of a rural community. From an operational standpoint, the 49th TFW would continue to squeeze as many supersonic sorties as possible into the WSMR airspace, resulting in degraded missions. If no additional supersonic airspace was found, approximately 300 to 600 sorties per month could not be performed; those flown would be limited in time and are resulting in less effective training. If the Valentine MOA could be used for supersonic training of 300 sorties per month, the 49th TFW could meet the sortie requirement during the months WSMR could accommodate 900 sorties; however, again the WSMR sorties would continue to be degraded and the 49th TFW mission would be in jeopardy.

C. Summary

No action to increase the quantity of supersonic airspace would restrict realistic flight operations and significantly degrade the wartime effectiveness and survivability of F-15 aircrews. Except for the Valentine area and a portion of the Reserve area, existing or new areas located within 150 NM of Holloman are not considered feasible alternatives for supersonic flights. Compared to the Valentine and Reserve areas, alternative supersonic areas would result in a negative impact on existing military utilization, commercial general aviation traffic, and would expose significantly more people to sonic boom activity.

The capability of sharing supersonic airspace managed by other units is limited by the transit distance required to conduct the operation. Except for WSMR, The capability of sharing supersonic airspace managed by other units is limited by the transit distance required to conduct the operation. Except for WSMR, Reserve, and Valentine MOAs, the nearest supersonic airspace is 400 NM from Holloman AFB. To obtain the same area-time per sortie, costly inflight refueling and long F-15 transit times would be necessary to support this alternative.

The costs, degraded deployment posture and operation limitations resulting from deploying a squadron to a satellite location for shared use supersonic activity area are unattractive when compared to local flights to the Valentine/Reserve area(s).

From a cost effective and operationally practical view, supersonic activity utilizing airspace within 150 NM of Holloman AFB appears to be a desirable alternative.

Because of the operational and environmental suitability of the Reserve area, it appears that supersonic operations would impact that area the least of any area considered except the Valentine MOA. Relocation of the 49th TFW or 479th TTW is considered impractical because of the desirable attributes of the Holloman location and the excessive costs required to move and set up operations at another base, aside from the economic impact on the local community.

Although the sonic boom impact of 600 sorties per month in either Valentine or Reserve compare favorably with EPA noise annoyance criteria, the Air Force proposes to divide the sorties equally between the two MOAs. This would help reduce noise impacts and provide for greatest mission enhancement. While the Reserve MOA can accommodate only one-half the long term sortie shortfall, it does provide for intercept training against dissimilar type aircraft that do not carry enough fuel to fly to the Valentine MOA. The 49th TFW may require supersonic flight on the intercept missions in order to effectively perform during operations. The combination of Reserve/WSMR would result in the 49th TFW continuing to train in a manner that does not provide for maximum efficiency on each mission conducted in WSMR. Considering fiscal constraints and the cost of flying aircraft, the Air Force must assure that each pilot is able to achieve the mission objectives on each sortie. Splitting the 600 sortie shortfall between Reserve and Valentine would provide for mission objectives while at the same time minimizing the impact of sonic booms on any one area.

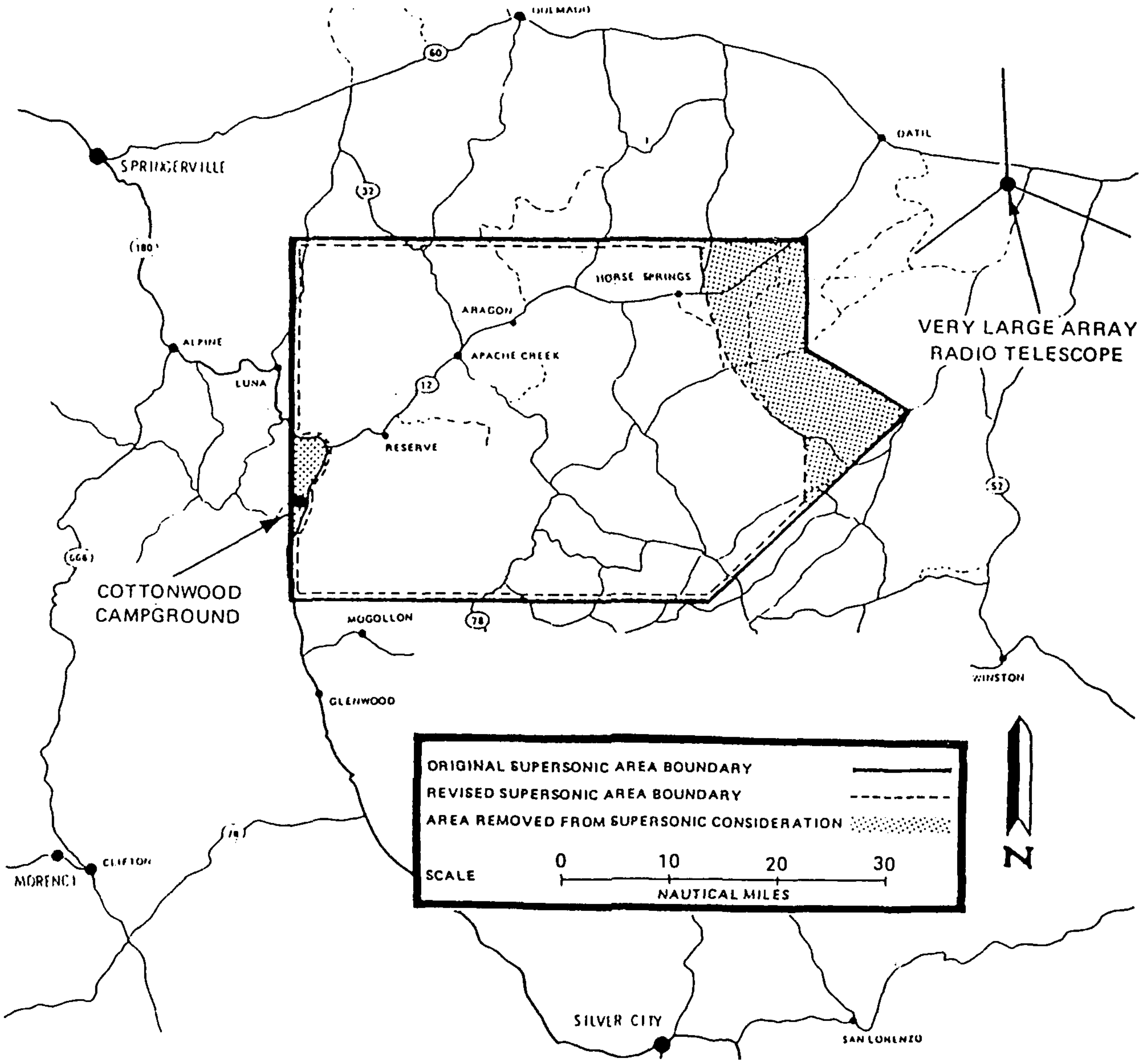
VI. MITIGATING MEASURES

In order to reduce the potential effect of supersonic aircraft training, several actions have been and will be undertaken by TAC. Most of these actions are directed toward reducing the opportunity for noise or restricting the time and location where noise may cause annoyance.

A. Land Use and Annoyance

The 49th TFW has already taken a number of actions to minimize the impact of the proposed supersonic training on the present and future land uses of the area. First, a large area of the eastern portion of the Reserve MOA was taken out of the proposed supersonic boundary area due to a very large array radio telescope. The Air Force modifies the northeastern boundary to provide a 20 mile separation between the MOA supersonic boundary and the closest antenna (Figure VI-1). Second, the Reserve supersonic boundary area was modified again to eliminate Cottonwood Campground. Third, the minimum operational altitude proposed for the area was established as 15,000 ft. MSL. The relatively high altitude (8,000-10,000 ft. above ground) was selected as a compromise to allow realistic F-15 training while minimizing the noise and overpressure effects experienced at ground locations.

Also, an important step in minimizing the number of people who will hear sonic booms is the location of primary maneuvering areas in the least populated portion of the MOA. The Air Force has documented that essentially all actual combat maneuvering in which supersonic flight would take place occurs while the aircraft are within an approximately elliptical area about 12 miles wide and 18 miles long. Sonic booms produced during this maneuvering would largely lie within a larger ellipse approximately 22 miles wide and 28 miles long. However, in the WSMR sonic boom study for model development, tracking data showed the operational ellipse was 35 x 60 statute miles. The locations of the ellipses are defined by the geographical points on the ground used for navigation reference. By careful selection of these reference points the 49 TFW can confine the bulk of



Source: U.S. Air Force 1979

FIGURE VI-1. Originally Proposed Supersonic Boundary Area of Reserve MOA.

supersonic operations within areas having the least number of people (commensurate with the terrain and mission requirements).

An additional factor which will mitigate the impact of supersonic training is minimum weekend/holiday flying activities and restriction of daily sorties to daylight hours only.

B. Claims Policies and Procedures

Claims for property damage and personal injury as a result of Air Force sonic boom activities are processed in accordance with the procedures set out in Air Force Manual 112-1. Claims for sonic boom damage are most often handled under Chapter 7 of the manual which implements the Military Claims Act (Title 10, United States Code, Section 2733). This Act authorizes the Air Force to pay for damages or injuries caused by "noncombat activities". A "noncombat activity" includes supersonic flights and sonic booms that are created by such flights. A claimant need not allege or prove a negligent or wrongful act by military or Air Force civilian personnel in order to recover under this theory. The claimant need only prove a "casual connection" between the authorized noncombat activity and the injury or damage claimed.

Sonic boom claims for damage may be denied for one of two reasons: (1) there was no Air Force aerial activity being conducted at the time the damage occurred, or (2) the damage resulted from other causes, such as structural deficiencies or water damage. In some cases, partial payment is made on a claim because, although the sonic boom was not the only cause of the damage, it may have been a contributing factor. An apportionment is made equal to the damages caused by the sonic boom versus the other cause(s).

C. Related Sonic Boom Study

A sonic boom study was conducted at the WSMR MOA as part of this environmental document. The purpose of the study was to record sonic boom events on a network of sound recorders designed for noise analysis. A computer model was employed to extrapolate these noise data from the WSMR MOA to the Reserve MOA based upon anticipated flight patterns. The results of the extrapolation indicate the overpressures and noise levels that might actually be expected at ground levels at the Reserve MOA. These results are used to minimize the noise effects at the Reserve MOA by adjusting flight patterns to avoid populated and sensitive areas.

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VIII. ACRONYMS AND ABBREVIATIONS

ACMI - Air Combat Maneuvering Instrumentation

AFB - Air Force Base

AFR - Air Force Regulation

AGL - Above Ground Level

ALL - Airborne Laser Laboratory

AQCR - Air Quality Control Region

ATC - Air Training Command

ATCAAA - Air Traffic Control Assigned Airspace Area

CFR - Code of Federal Regulations

dB - Decibels

DIVAD - Division Air Defense

DNL - Day-Night Level

EID - Environmental Improvement Division

FAA - Federal Aviation Administration

FACC - Ford Aerospace and Communications Corporation

FL - Flight Level

FONSI - Finding of No Significant Impact

ft. - feet

GBFEL-TIE - Ground Based Free Electron Laser-Technology Integration Experiment

gpm - gallons per minute

HUD - Housing and Urban Development

km - Kilometer

LRF - Laser Range Finder

mm - millimeters

MOA - Military Operations Area

mph - Miles Per Hour

MSL - Mean Sea Level

MTR - Military Training Route

NAAQS - National Ambient Air Quality Standards

NM - Nautical Mile

OSHA - Occupational and Safety Health Administration

ppm - parts per million

PSD - Prevention of Significant Deterioration

SM - Statute Mile

TAC - Tactical Air Command

TDS - Total Dissolved Solids

TFW - Tactical Fighter Wing

TSP - Total Suspended Particulates

TTW - Tactical Training Wing

USAF - United States Air Force

USEPA - United States Environmental Protection Agency

USFWS - United States Fish and Wildlife Service

WSMR - White Sands Missile Range