An Evaluation of Research by New Mexico State University on the Fort Stanton Experimental Ranch: A Report (1982)

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AN EVALUATION OF RESEARCH BY NEW MEXICO STATE UNIVERSITY ON THE FORT STANTON EXPERIMENTAL RANCH

A Report Prepared by the

Committee for Review of Ongoing Research at Fort Stanton Ranch, New Mexico
Board on Agriculture and Renewable Resources
National Research Council

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NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Task Force responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

This study was supported by the Bureau of Land Management of the Department of the Interior.

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PREFACE

In 1963 New Mexico State University signed an agreement with the Bureau of Land Management, U.S. Department of the Interior, for the use of 26,000 acres of a military reservation, called Fort Stanton, for livestock, wildlife, and range research. The Fort Stanton Experimental Ranch lies 125 miles northeast of Las Cruces, where New Mexico State University is located. The topography is characterized by fairly level mesas dissected by steep canyons. Open grassland vegetation is found on the mesas and on gentler slopes at the base of mesas. Mule deer and pronghorn antelope are the two most important game species found at Fort Stanton.

The city of Ruidoso, 15 miles from Fort Stanton Ranch, has requested permission from the Bureau of Land Management to build a Sierra Blanca Regional Airport on a portion of the Fort Stanton Ranch. The airport would service the recreational, industrial, and home development needs of the area.

The Bureau of Land Management requested an independent and objective review of the research at the Fort Stanton Experimental Ranch by the Board on Agriculture and Renewable Resources, National Research Council, National Academy of Sciences.

The objective of the review is to help the department understand the relative importance of the ongoing research and the relative loss to users of this research should the request for the airport site be approved. Subobjectives are:

1. Document the overall goals and design of the scientific and educational use of the experimental range and document past results.

2. Determine the impact of the airport proposal (known as Site B) on the ongoing scientific and educational work and its goals (see subobjective no. 1 above). Define, as precisely as possible, those portions of the scientific and educational work (hereafter called research) that would be eliminated and those portions that would be adversely affected but that could still be successfully completed (including any major mitigation measures needed).

3. For the ongoing research that would be terminated and the projects that would be eliminated:

INTRODUCTION

STATEMENT OF PROBLEM

New Mexico State University has been conducting research on 26,000 acres (10,526 hectares) of lands administered by the Bureau of Land Management known as the Fort Stanton Experimental Ranch. The Sierra Blanca Airport Commission, New Mexico, has requested approval from the Department of the Interior to construct a jet-capable regional airport on a portion of these lands. A committee of the Board on Agriculture and Renewable Resources of the National Research Council has been asked to review the research conducted by New Mexico State University at the Fort Stanton Experimental Ranch to help the Department of the Interior understand the relative importance of the research and the relative loss to users should the airport request be approved.

The committee report will be divided into seven sections: (1) an introduction, (2) a description of the broad elements of the Fort Stanton research program, (3) a description of the airport site (termed Site B in supporting documents) and potential impacts of the Airport on the Fort Stanton Experimental Ranch, (4) an analysis of broad and long-term impacts on the research conducted by New Mexico State University, (5) a detailed discussion of impacts on specific research projects, (6) unique features of the research, and (7) conclusions.

DESCRIPTION OF THE EXPERIMENTAL RANCH

Fort Stanton Experimental Ranch is located in eastern New Mexico in the vicinity of the towns of Carrizozo, Hondo, and Tularosa. It consists of 26,000 acres of rolling landscape divided by fences into five major pastures (Figure 1). The ranch is bisected by public paved and gravel roads. In the center of the ranch is a state of New Mexico facility for care of mentally retarded persons and a correctional facility. New Mexico State University has constructed a superintendent's residence and a combination bunkhouse-office building near the paved highway. The state university uses the ranch for research on range management, livestock nutrition, wildlife management, watershed studies, soil studies, and related research. Approximately three employees are permanently located at the ranch. Faculty and students drive from Las Cruces (approximately 125 miles)

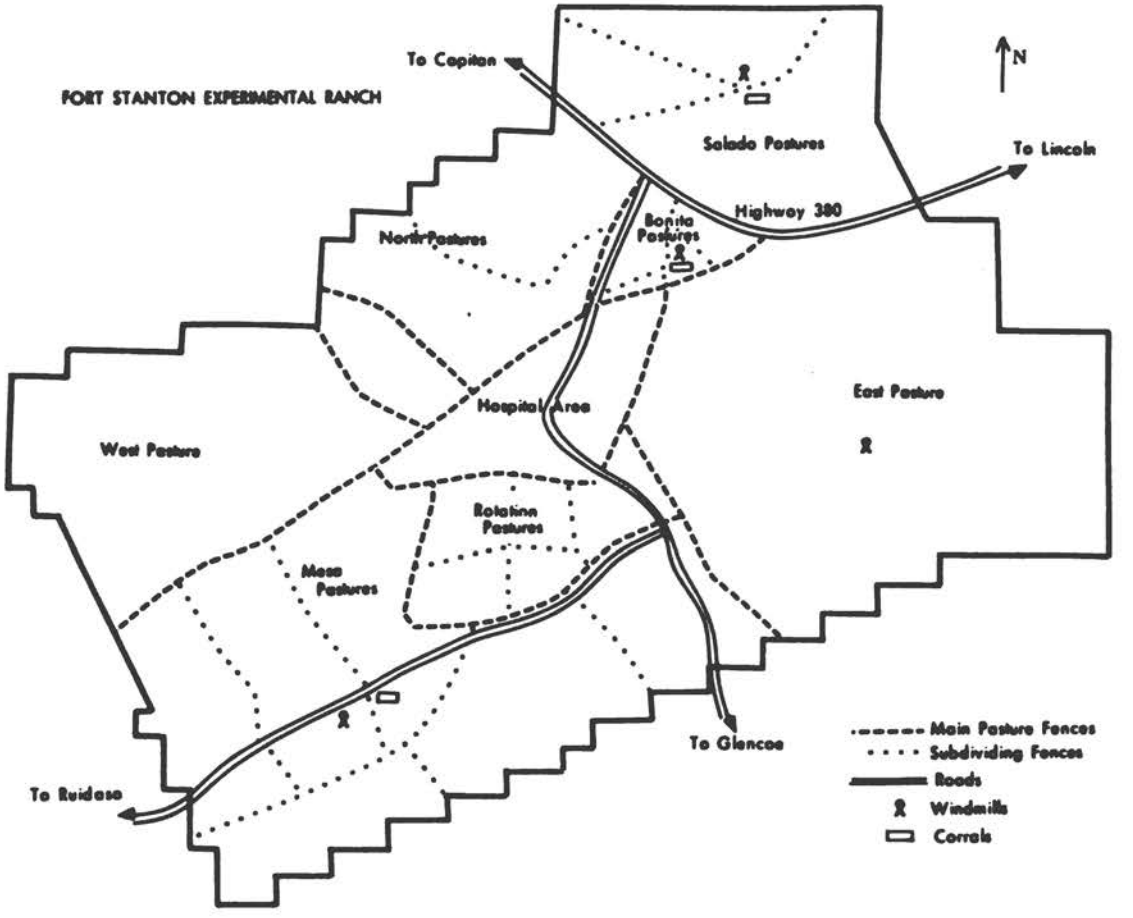

FIGURE 1 General plan of Fort Stanton Experimental Ranch, showing the five major pastures (east, salado, north, west, and mesa), the smaller bonita and rotation pasture areas and the hospital area of state land.

SOURCE: New Mexico State University, undated.

to carry out their studies. Other locations where faculty and students conduct similar research include the state university farm and the Jornada Experimental Range of the Science and Education Administration, U.S. Department of Agriculture, located in the desert near Las Cruces. The New Mexico State University facility at the experimental ranch is also used for short courses, workshops, and field courses for federal and state employees, for private citizens and for students. The state university spends annually about $436,000 for salaries of researchers on the ranch.

ENVIRONMENT OF THE RANCH

The Fort Stanton Experimental Ranch is located in foothills characterized by relatively level mesas, dissected by steep canyons. The area is underlain by the San Andreas geological formation, which is composed of limestone and dolomite of Permian age (280 million years before present). This formation is exposed on the eastern edge of the ranch. On the northwest portion, the San Andreas formation is overlain by undifferentiated Triassic rocks of sandstone and shale.

Most of the surface soils are characterized by clay loam textures. Relatively deep soils (often with caliche at 25 inches [63 centimeters]) support grassland vegetation. Pinyon-Juniper grows on shallow rock soils. The consequence of soil-water relations is that open blue grama (Bouteloua gracilis) grassland forms the principal vegetation of the mesa tops, while Pinyon-Juniper (Pinus edulis and Juniperus spp.) and oak (Quercus spp.) vegetation dominates mesa slopes and higher, steeper terrain.

Fort Stanton Experimental Ranch is located in a part of New Mexico where these two extensive vegetation types, the Pinyon-Juniper Woodland type and the Plains Grassland type, form a natural complex. In New Mexico alone, these types comprise 8.5 and 15.5 million acres (3.4 and 6.3 million hectares), respectively (New Mexico State University, 1976), but these types, and slight variations of them, extend over much wider areas throughout the West. The Pinyon-Juniper Woodland type extends from southwestern Texas to south central Oregon. In New Mexico, Arizona, Colorado, Utah, and Nevada, where it is most abundant, it covers about 60 million acres (24 million hectares) (Gomm and Lavin, 1968; West, 1981). The Plains Grassland type, which extends on to the High Plains of eastern Colorado and the Texas and Oklahoma panhandles, has been grouped with the Great Basin Grassland and the Desert Grassland into the Mixed Prairie (Heerwagon, 1956). These three grasslands form very broad ecotones at their margins. Their soils, topographic positions, and life form compositions remain constant; they differ chiefly in species composition. In Senate Document 199 (McArdle and Costello, 1936) these grasslands were included in the Shortgrass Plains, a grassland encompassing 280 million acres (113 million hectares) that extends from south Texas into Canada just east of the Rocky Mountains. The major contact of the Mixed Prairie Grasslands in New Mexico and elsewhere is with the Pinyon-Juniper Woodland (Heerwagon, 1956).

Pinyons and junipers grow on rocky ridges and the dissected edges of mesas; grasslands occur on the more gently sloping areas at the foot of mesas and on mesa tops (Emerson, 1932).

In the general case the diversity of plant species in this type is rather low. One or two species of trees, two or three shrubs, three to five perennial grasses, about ten perennial forbs, about twenty annuals, and six or so microphytes will be found on a typical hectare (Harner and Harper, 1976). The character of this vegetation type is primarily maintained by periodic burning.

Nearly all of this type of ecosystem has been heavily grazed by livestock--in New Mexico for as long as 400 years. Grazing and restriction of burning has profoundly affected the vegetation, producing stands with higher densities of trees and reduced productivity of grass and forbs. Trees have been thinned by cable, chains, and herbicides, as well as fire, to reduce these trends. But the tree regrowth and the costs of tree removal are such that West et al. (1979) predict most sites will lose their understory production by the year 2000.

Because these vegetation types are located at intermediate elevations and generally receive between 30 and 60 centimeters of precipitation, they produce more forage for livestock and deer than drier desert grasslands and shrublands. In addition to being important for forage production for livestock and habitat for wildlife, they represent extensive watersheds.

The vegetation of the Fort Stanton Experimental Ranch appears to fit well the descriptions of the Pinyon-Juniper Woodland and Plains Grassland types as described by others (Emerson, 1932; Heerwagon, 1956; Gomm and Lavin, 1968; West, 1981). Vegetation on the Fort Stanton Ranch is mainly in the Pinyon-Juniper type, with the Plains Grassland occurring mainly on the mesa. The mosaic pattern of the two vegetation types on the ranch is fairly typical of that found elsewhere in the region. Because livestock prefer to utilize the Plains Grassland type and deer generally prefer the Pinyon-Juniper type, the balance or proportion of the two vegetation types within a pasture may have a marked effect on animal responses. The grazing systems on the Fort Stanton Ranch were designed to include a comparable mix of both vegetation types in each grazing system similar to what might be found on a typical ranch.

The climate is characterized by an average annual precipitation of about 15 inches (37 centimeters) with over 60 percent falling during June, July, August, and September. Temperatures range from a mean minimum of 20°F (-7°C) in January to a mean maximum of 84°F (29°C) in July. The mean annual temperature is 52°F (11°C).

A variety of wildlife is found on the ranch. The primary native large mammals are mule deer (Odocoileus hemionus), which occur primarily in the Pinyon-Juniper habitat, and the pronghorn antelope (Antilocapra americana), which are found in the more open grassland and ecotones of the two types. The fauna also includes several species of game birds, of which the most abundant is the mourning dove (Zenaidura macroura), Mearns quail (Lophortyz montezumae mearnsi), and Merriam's turkey (Meleagris gallapavo merriami). Turkey have been

recorded in fair numbers in past years, but sightings now are sporadic at best. The mule deer population has fluctuated around a density of 10 to 15 deer per section (640 acres, or 259 hectares).

Coyotes (Canis latrans) and bobcats (Felis rufus) are common carnivores. Black bear (Ursus americana) have been seen on the ranch, were relatively common in past years, but now are very rare if not absent altogether. Rodents, lagomorphs, and many species of songbirds and small mammals occur in both vegetation types. No endangered species of vertebrates is known to occur on Fort Stanton Ranch.

The mule deer is an important species to man because of its value in sport hunting. Hunting seasons on Fort Stanton Ranch are set by the New Mexico Department of Game and Fish; bag limits, seasons, and means and methods of taking game animals usually follow those in surrounding areas. However, special consideration is given to regulations for taking wildlfe on Fort Stanton Ranch when New Mexico State University research scientists request it for research purposes.

A small herd of pronghorn antelope formerly occupied the mesa where Site B is proposed. With the addition of fencing for grazing experiments and increased activity in the area, the animals left the area. Antelope gates in the pasture fences were not used by the animals. A herd of antelope numbering around 50 or 60 animals occurs in the Salado Pasture. Its range extends off the experimental ranch to private rangeland to the west.

HISTORY

Fort Stanton was established as a military fort in 1855. In 1896 the post was no longer required and was abandoned by the U.S. Army. The U.S. Marine Hospital Service (U.S. Public Health Service) then used Fort Stanton as a sanitarium for merchant mariners suffering from tuberculosis. This use continued until 1952. At that time the hospital, with 1,320 acres (534 hectares) of land, was transferred to the New Mexico State Department of Public Welfare for use as a state sanitarium. The remaining 26,000 acres (10,526 hectares) was placed under the jurisdiction of the General Services Administration, with the Bureau of Land Management having custodial care. In 1963, the bureau signed an agreement with New Mexico State University to use the area as a livestock, range, and wildlife research station. This agreement was on an annual basis until 1970, when a 20-year lease between the Bureau of Land Management and New Mexico State University was signed.

During the period when the ranch was administered by the U.S. Public Health Service, cattle grazed the area. A population of 1,965 head of cattle was reached in 1919. All livestock were removed from the ranch in 1952, and the range was not restocked until 1964. Hence, the ranch was not grazed by cattle for 12 years. Currently 300 to 400 head of breeding cattle are maintained on the ranch for research purposes.

The Fort Stanton Experimental Ranch was included in the Experimental Ecological Reserve System of the United States in 1977. Sites in this

system were required to be a valid representative of a major ecosystem type and large enough to allow replicated treatments or experimental manipulations. The site must also have a history of research work and must emphasize ecological studies. Such studies require a long-term commitment, and, therefore, the site must be under direct control of a research entity with evidence of institutional support for the facility. Finally, logistic support, such as laboratories, accommodations for research workers, a resident staff, and access to communication and transportation, is needed (The Institute of Ecology, 1977). The Fort Stanton Experimental Ranch fits these criteria and was included in the Experimental Ecological Reserve network of 67 sites for the United States as a representative of a "fescue-mountain muhly prairie" site, on 5,910 acres (2,393 hectares) of land under the management of New Mexico State University. The area of Fort Stanton Ranch of special value to the Experimental Ecological Reserve network is the grass community on the mesa.

In June 1981, the Society for Range Management, the professional society of range researchers and managers, passed a resolution that the President and the Congress of the United States take immediate and affirmative action to protect the physical integrity of several ranch research stations that provide the basis of long-term research vital to the nation's future productivity but that are threatened with severe disruption. Fort Stanton Experimental Ranch was one of six experimental ranches listed in the resolution (Society for Range Management, 1981).

AGREEMENT BETWEEN BUREAU OF LAND MANAGEMENT AND NEW MEXICO STATE UNIVERSITY

The cooperative research agreement between the Bureau of Land Management and New Mexico State University Agricultural Experiment Station was signed June 20, 1970. This agreement states that "Fort Stanton Reservation offers an important opportunity to conduct range and wildlife research which would yield invaluable information not available elsewhere because of the unavailability of range lands similar to those existing at Fort Stanton for research work."

And, "The Bureau and the Station under a cooperative Work Plan originally executed in 1963 (and extended on a year-to-year basis thereafter) have jointly initiated a co-use (livestock and big-game) research program developed and basically implemented by the Station, the preliminary findings of which have been of substantial benefit to both the Bureau and the general public concerned with livestock grazing, wildlife resources, and/or environmental protection."

And, "the Station has submitted to the Bureau a long-range proposed research plan and is desirous of assuring their research tenure at Fort Stanton in order to implement the research plan and to justify the considerable time and money involved."

And, "the Bureau and the Station agree that there is a real need for continued research."

And, "the Bureau and the Station agree that the benefits to accrue from such research undertaken on Fort Stanton lands will continue to be mutually advantageous and to the benefit of the American people."

The research to be conducted on the Fort Stanton Experimental Ranch was to include (but not be limited to) the following:

(a) forage composition and utilization,
(b) livestock production under various systems of grazing and stocking rates,
(c) grazing capacity and forage production,
(d) grazing management,
(e) economics of meat production, range management, range improvement, etc., under various systems of stocking and forage improvement,
(f) water infiltration, runoff, sediment production, and other hydrologic research, including cooperative studies with the Agricultural Research Service,
(g) the effect of livestock grazing, water, and other improvements on mule deer and antelope populations,
(h) utilization of pinyon-juniper-oak range by mule deer,
(i) mule deer and antelope management, and
(j) the effects of livestock grazing systems designed to benefit wildlife habitat.

PROPOSED DEVELOPMENT

The region of New Mexico where Fort Stanton Experimental Ranch is located has become in recent years a growing attraction for recreation from Texas, Oklahoma, the Republic of Mexico, and other areas. Not only is the area an attractive site for second homes because of the mountain environment and recreational advantages of the region, but there are additional attractions that draw visitors--the Sierra Blanca ski development and Inn of the Mountain Gods on Mescalero Apache Indian lands and Ruidoso Downs, a popular quarter horse race track. Visitors may fly into the area and use a small airport adjacent to the village of Ruidoso. This airport is judged to be unsafe for some uses. Therefore, a group of institutions, including the Mescalero Apache tribe, county of Lincoln, village of Ruidoso, village of Ruidoso Downs, and village of Capitan, formed the Sierra Blanca Airport Development Committee (or Sierra Blanca Airport Commission). The Development Committee contracted with Herkenhoff-Parsons, Albuquerque-Los Angeles, for site selection, a master plan, and impact assessment of a new airport.

Among a variety of sites examined by Herkenhoff-Parsons, a mesa on the Fort Stanton Experimental Ranch was selected as having the most attractive elements for a new airport. Actually two sites are under consideration on this mesa. Site B is entirely within the experimental ranch, and its impact is being considered in this report. Site A is adjacent to the ranch, with a small acreage extending onto ranch property. This latter site is not considered in this report.

In June 1978 the group of institutions mentioned above applied to the Bureau of Land Management for conveyance of public lands for development under the Airport and Airway Development Act of 1970 as a proposed Sierra Blanca Airport. On October 26, 1978, the state director of the bureau rejected this request for Site B. The Secretary of the Interior affirmed this decision on June 19, 1979. Recently the Airport Commission has reopened its request for transfer of lands for airport construction.

CONFLICTS IN USE

The major issues that create the need for an evaluation of the research program are the impacts of airport development at Site B on the research. On one hand, the request by the Airport Commission is for a relatively small acreage of what appears to be very extensively used livestock and wildlife habitat. On the other hand, officials of New Mexico State University state that Site B lies in the best open grass range on the Fort Stanton Experimental Ranch, where most of the long-term grazing and ranch management studies are located, and the airport would impact a much larger area than that used for the facility. A summary of the impacts of and airport development by L. S. Pope (August 2, 1978) list eight interferences:

(1) direct use of land in research studies,
(2) isolation of small tracts of land,
(3) elimination of use of a wildlife corridor,
(4) restriction of land use by wildlife,
(5) destruction of long-term ecological studies,
(6) reduction of opportunities for range livestock research,
(7) limiting availability of valuable grassland vegetation for research, and
(8) reduction of the value of funds already invested in long-term research.

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THE FORT STANTON RESEARCH PROGRAM IN A BROAD CONTEXT

THE RESEARCH AND EDUCATION CONTEXT

The Fort Stanton research program is best understood within the context of the agricultural research program of New Mexico State University. The goals of this broad program are described in a booklet focusing on the changing scene in the state of New Mexico (New Mexico State University, 1981). The booklet states that today agriculture is near a billion dollar business in New Mexico, and the Agricultural Experiment Station supports this industry with a staff of 100 people working in 10 departments on 200 research projects annually.

According to the Census of Agriculture (1978), the aggregrate value of agricultural production in New Mexico was nearly $800 million; production of cattle and calves contributed about $510 million to the total and sheep and lambs about $22 million. The contribution of all livestock is about 75 percent of the agricultural product value of New Mexico, which is similar to Colorado and higher than that in Arizona and Texas (Table 1).

TABLE 1 Relative Importance of Agricultural Products Based on Value[a]

	New Mexico	Arizona	Texas	Colorado
Crops	23.6	50.1	32.5	22.2
Livestock	74.6	49.4	62.4	75.6
Poultry	1.8	0.6	5.0	2.3

[a]Census of Agriculture, 1978.

"The value added" is a useful statistic for evaluation of the economic contribution of an enterprise. The value added is the difference between the value of the product at the beginning and end of the production process. For New Mexico in 1979, $449 million of value was added or created in agricultural activities (Kunz and Purcell, 1982). Animal enterprises accounted for 64 percent of the

value added and was the rop ranking agricultural enterprise.

Agricultural research, such as that carried out by New Mexico State University, is designed to enhance the creation of wealth or value, and the created wealth is a major justification for research funding. Bredahl and Peterson (1976) evaluated the return on dollars invested in research projects in the agricultural experiment stations in the United States in terms of the marginal products and the internal rates of return. These results are shown for several broad commodity groups in Table 2. The authors state that "The estimated marginal product of research approximates the long-run marginal product of research, that is, the expected total returns from $1 invested in 1969." Each $1 invested in livestock research would return $41.76. Another way to look at the value of livestock research is that the investment is expected to yield a 46 percent return (the internal rate of return) on investment. The marginal product data were computed for each of the state experiment stations. Livestock research had the highest marginal product in New Mexico at $29.37, with dairy $15.26, cash grains $6.52, and poultry $3.81 per $1 invested in research. If one assumes all of the research at Fort Stanton could be classified as livestock-related research, the $436,000 invested annually in salaries (see Chapter 1) would return at least $12 million in benefits to society.

TABLE 2 Marginal Products and Marginal Internal Rates of Return to Experiment Station Research[a]

	Marginal Products ($)	Assumed Lag (Years)	IRR (%)
Cash grains	14.09	5	36
Poultry	19.58	6	37
Dairy	25.93	6	43
Livestock	41.76	7	56

[a]Bredahl and Peterson, 1976.

Research and education at Fort Stanton Ranch in animal and range sciences and wildlife management is directly relevant to agricultural and wildlife productivity in New Mexico. These programs have the objectives of (1) improving the efficiency of range productivity and providing information on range ecosystem functions, (2) measuring the influence of nutrition on livestock, (3) evaluating factors affecting reproductive performance of ruminants, (4) measuring factors affecting meat quality, (5) developing information concerning genetics and animal breeding to improve the efficiency of livestock production, and (6) evaluating the life history, habitat, and population dynamics

of fish and wildlife species in order to identify practices that can influence their numbers in accordance with management needs. Fort Stanton Experimental Ranch is one of nine research units in the New Mexico Agricultural Experiment Station system but is the only site where an integrated program of cattle production, wildlife, and range management research is carried out.

THE PRESENT RESEARCH AND EDUCATION ACTIVITY

Grazing management research is the central activity at Fort Stanton Ranch and was initiated in Salado Pasture in 1966 (New Mexico State University, undated). In 1969 the "Airport" mesa (a grass runway exists on the mesa) was selected for grazing management, since it provided an integrated unit of 7,500 acres (3,036 hectares), was relatively homogeneous in character, and had experienced 12 years of protection from grazing. The initial study, which lasted 10 years, involved comparison of a four-pasture, one-herd rotation system with continuous grazing at two stocking rates. In 1980 this study was expanded to include a short-duration cell of seven pastures, altering the four-pasture system to accommodate a three-herd system with the cattle combined in one herd during the breeding season.

A variety of other investigations are associated with the grazing studies. These include studies of vegetation cover and plant production, response of vegetation to burning, fertilization, removal of noxious competitive species such as broom snakeweed and cholla cactus, and determination of vegetation response to nongrazing and to broom snakeweed thinning through the use of exclosures. Studies involving the response of vegetation and cattle production to juniper control by cabling and a comparison of areas cabled in 1950 and 1975 also have been made.

Basic to vegetation studies are projects concerning soils and water. For example, genesis and morphology of soils has been examined and a survey of soils has been completed to identify typical pedons. Studies of infiltration and sediment yield from simulated rainfall also have been conducted.

The first research project undertaken at Fort Stanton by a scientist-educator of New Mexico State University dealt with the ecology and management of mule deer. John E. Wood of the Department of Animal, Range and Wildlife Sciences began work there in 1962, and the first publication on the herd appeared in 1966 (Howard, 1966). Since that time, eight students majoring in wildlife ecology and management at New Mexico State University have produced theses for their master's degrees from field research conducted at Fort Stanton Ranch. These eight theses and another four wildlife-related publications in the scientific literature have resulted from work done at Fort Stanton Ranch by faculty members and students of New Mexico State University. Others in the College of Agriculture at New Mexico State University, largely range and animal scientists with peripheral interests in wildlife ecology, have produced information of importance to the management of wildlife in Plains Grassland and Pinyon-Juniper ranges.

Wildlife research has centered on the population ecology and management of mule deer at Fort Stanton Ranch. Eighteen years of census data and other population parameters of the herd have been accumulated since 1964. Data obtained in the early years are reported in theses (Howard, 1966; Evans, 1968; Germany, 1969) and in a bulletin published by the New Mexico State University Agricultural Experiment Station (Wood et al., 1970). Data obtained on the herd in later years are unpublished but are presently being analyzed for a summary paper or monograph on the Fort Stanton Ranch herd (V. W. Howard, Jr., New Mexico State University, personal communication, 1982).

Manipulation of Pinyon-Juniper habitat to increase carrying capacity of this ecological type for both livestock and wildlife has been another thrust of research at Fort Stanton Ranch. Anderson (1972) and Anderson et al. (1974) measured growth response and deer use of fertilized browse at Fort Stanton Ranch. Thompson (1979) studied wildlife use of cabled and natural Pinyon-Juniper Woodland. Bickle (1969) studied the effects of water developments on mule deer.

Other studies have involved trapping techniques for mule deer (Howard and Engelking, 1974a,b), the behavior of a small herd of pronghorn antelope (Engelking, 1969), and reproduction of desert cottontails (Sylvilagus audubonii) (Foster, 1968).

Besides the above-mentioned research projects, Fort Stanton Ranch also has been used for projects for animal production, nutrition, and behavior. These include studies of the dynamics of phosphorus in cattle, role of forbs in cattle diets, and the role of dietary supplementation. Plans are under way to develop a sheep research program at Fort Stanton Ranch in addition to the ongoing cattle and wildlife studies.

The New Mexico State University research program at Fort Stanton Ranch is carried out by 12 faculty, 3 technicians, and 3 secretarial and clerical people. The estimated time commitment is about 13 percent of the total teaching, research, and extension commitment of the faculty, about 15 percent of the commitment of technical staff, and 10 percent of the commitment of the secretarial and clerical staff (Table 3). The estimated annual salary expenditure for these persons, plus 13 graduate student researchers, is about $436,000. For the 12-year period ending in 1976 (New Mexico State University, 1976), an estimated $1.5 million had been spent in field research at Fort Stanton Ranch. Presumably, by 1982 the investment is near $3 million.

The specific location of research projects and facilities, plots, and areas on the "Airport" mesa according to staff of New Mexico State University is shown in Figure 2. This map shows the mesa and rotation pasture areas in Figure 1 in greater detail. In particular, the lower right portion of the mesa in Figure 1 has been divided into short-duration cells in Figure 2.

The research-education program of New Mexico State University at Fort Stanton Ranch has gradually grown into an integrated activity that makes up a substantial part of the university's agricultural-wildlife programs. The work is integrated administratively by being located largely in the Department of Animal and Range Sciences. The research is integrated conceptually by being focused on grazing systems

TABLE 3 Duty Assignments of New Mexico State University Department of Animal and Range Sciences Personnel, 1982

Class and Name	Time Assignment (%)								
			Research						
	Teaching	Extension	Total Research	Fort Stanton	College Ranch	Clayton Center	On-Campus	Other Locations	Other
FACULTY									
Allison		75	25	25					
Donart	47		35	35					18
Holechek	42		28	5			13	10	30
Howard (Wildlife)	53		47	47					
McDaniel		50	50	10	10		10	20	
Nelson	31		57	42		10	5		12
Parker, E.			100	100					
Pieper	56		30	30					14
Ross	43		57	37			20		
Ruttle	57		38	15			15	8	5
Wallace	47		53	53					
Wood	49		35	35					16
Allred	54	25	6					6	15
Armstrong	75	25							
Beck	58		32		32				10
Burcham	74	26							
Ellis		100							
Foster		100							
Galyean	49		51			10	41		
Grigsby			100				100		
Hallford	62		38				38		
Kiesling	35		35		14	11	5	5	30
Leighton	33		67		14		53		
Lofgreen			100			100			
Miller	24		66				66		10
Parker, R.		100							

TABLE 3 (continued)

Class and Name	Time Assignment (%)								
			Research						
	Teaching	Extension	Total Research	Fort Stanton	College Ranch	Clayton Center	On-Campus	Other Locations	Other
FACULTY Continued									
Rankin	46		34		34				20
Ray	42		58				58		
Roberson	33		37				37		30
Sachse		100							
Schickedanz		100							
Smith	44		56				41	15	
Thomas	78		22				22		
Zartman	22	78					78		
TOTAL	11.54	7.01	13.35	4.34	1.04	2.31	5.02	0.64	2.10[a] (34.00)
TECHNICIANS									
Byrum	80		20				20		
Gascoigne			100	50		10	25	15	
Jones			100	100					
McNeely	13		87	70	17				
Wright			100	100					
Baily			100		100				
Berkompas	100								
Clement	100								
Copley			100			100			
Crisman			100			100			
Eisen			100				100		
Freudenberger			100					100	
Garcia			100			100			
Gardner			50				50		50
Head			100				50	50	
Holcomb			100			100			
Morrical			100				100		

TABLE 3 (continued)

Class and Name	Time Assignment (%) Teaching	Extension	Research Total Research	Fort Stanton	College Ranch	Clayton Center	On-Campus	Other Locations	Other
TECHNICIANS Continued									
Rockhill			85				85		15
Schafer			100			100			
Topliff									100
Trujillo			100				100		
TOTAL	2.93	0	16.42	3.20	1.17	5.10	5.30	1.65	1.65 (21.00)
SECRETARIAL/CLERICAL									
Daugherty	50		50	40			10		
Gomez	25	25	50	35			15		
Tellez	20		80	40		20	20		
Bateman		50	50				50		
Jamison		100							
Burns		50	50				50		
Lawson	50		50				50		
Morales	12	50	10				10		28
Perterson			60				60		40
Raines			100			100			
Young			100		30		70		
TOTAL	1.57	2.25	6.30	1.15	.40	1.30	3.45	0	0.68 (10.80)

[a]Of this 2.1, 2.0 is BIFAD or Title XII within this department. Assignments for individual faculty vary yearly. If BIFAD were cancelled the Fort Stanton assignment of 4.34 would likely be charged to 4.86 SY.

In addition to faculty, technicians, and secretaries/clerks, at least 15 graduate students have research program at the Fort Stanton Experimental Ranch.

in the Plains Grassland, Pinyon-Juniper vegetation. Essentially all the work at Fort Stanton Ranch that does not directly deal with grazing systems contributes to an understanding of grazing in this special environment. While the university does not have a systems model to guide the direction of research (system modelling techniques are only gradually being used in range science research), a conceptual model is apparent, first, for the overall research of the department and, second, for that part of the research at Fort Stanton Ranch. We have diagrammed this conceptual model to illustrate the research program in its real complexity (Figure 3). The main element is the interaction of grazing cattle and the vegetation providing feed for these livestock. The output of interest is growth or yield of cattle. Central to understanding the ability of vegetation to produce nutritious forage in this relatively dry environment are the plant response studies and the plant ecology investigations. The ecology studies provide the fundamental data, and the response studies focus on feedback of cattle grazing on the plants. Central to understanding cattle production are nutrition and behavior studies. This is the core of the research system.

Next, the environment within which this core resides must be understood. First, soil inventories have been made as a basis for understanding plant growth. Fertilization studies have shown how these soil factors can be manipulated by management. Competition between edible and nonedible (by cattle) plant species has also been studied, and the vegetation has been manipulated by cabling and burning to alter the competitive relationships through management. In turn, cattle grazing and cattle tramping can both influence the plant cover on the soil and the physical characteristics of the soil surface, which can change the water-holding capacity of the soil, and, in turn, the capacity of the soil to support plant production. Therefore, watershed studies are being carried out to determine the effect of simulated rain on soil movement and stability under different grazing treatments.

Further, the cattle also have animal associates in the system, as do the herbage plants. These wildlife species interact with cattle and provide additional use of the range. Therefore, a variety of wildlife studies have been carried out to determine, first, how many animals there are and where they live and, second, how management of the range for cattle production affects the wildlife populations.

Finally, the cattle-grass core in this system does not exist in a vacuum. Rather the economic world requires appropriate mixtures of cattle and grass in grazing systems to produce the optimum yield of product without destroying the basis of production--the range. Therefore, the core research is expanded into study of various grazing systems. As new systems are developed and applied in New Mexico or elsewhere, the researchers at Fort Stanton Ranch incorporate these concepts into their experimental design. This means that they build upon the fundamental knowledge collected over years of study and address questions of direct practical significance to society. While a rancher faced with a reclining economic situation and attracted to a new grazing system discussed in a journal or experiment station report

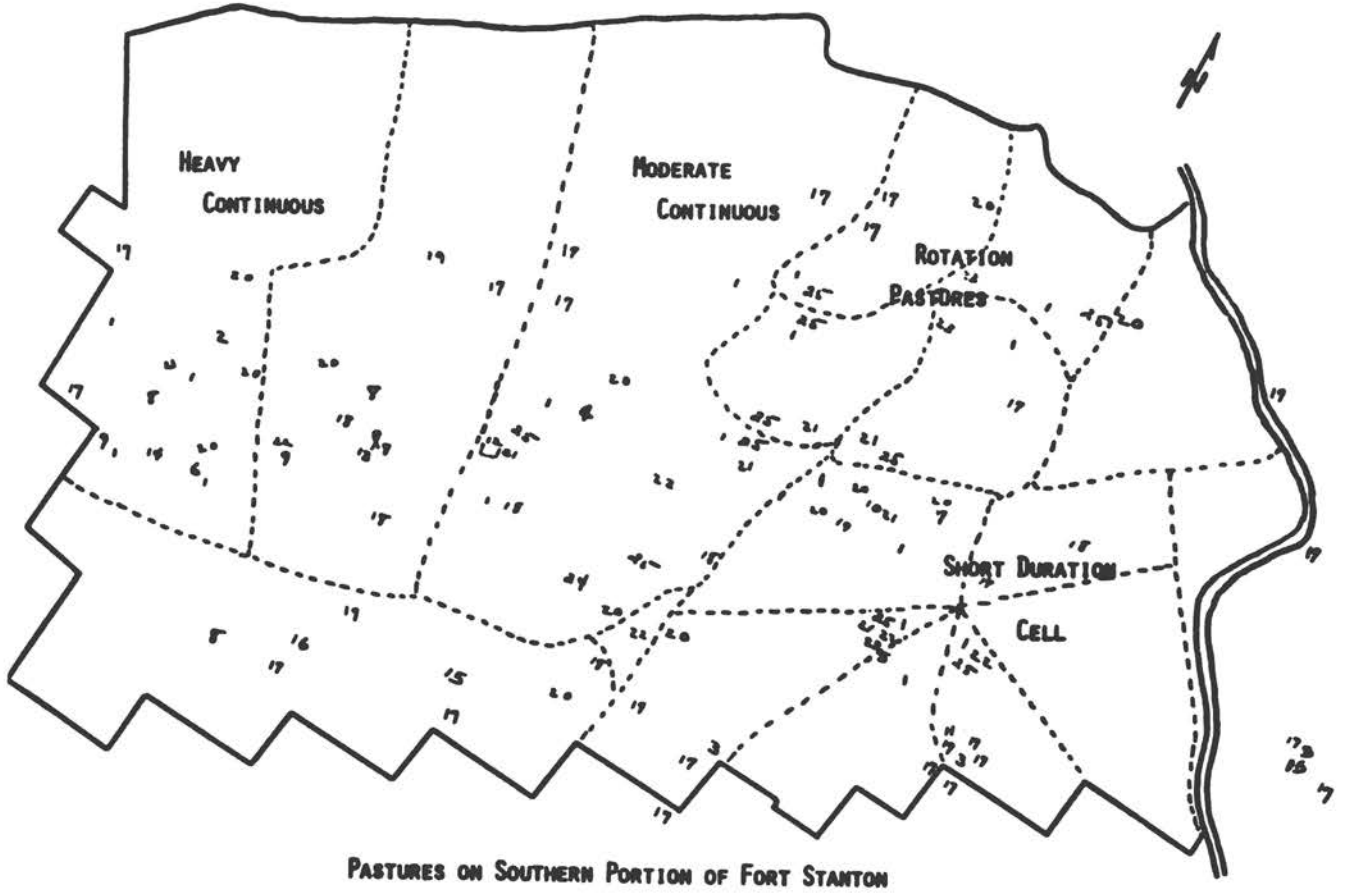

FIGURE 2 Specific locations of research sites and facilities on "Airport" mesa. Numbers indicate locations on the map.

1. Location for sampling vegetational cover and composition and herbage production.
2. Exclosure to evaluate effect of season of use and rest on vegetation.
3. Areas cabled for Pinyon-Juniper control in 1975. They are currently being evaluated for vegetational and wildlife responses to the cabling.

4. Area used to evaluate response of vegetation to burning and fertilization.
5. Deer-proof exclosure erected by BLM. Currently being used to evaluate grazing use and rest on fourwing saltbush.
6. Cattle-proof exclosure used to evaluate grazing impact.
7. Area used to measure growth rate of cholla cactus.
8. Area used for study of herbicidal control of broom snakeweed.
9. Exclosures used to evaluate influence of different densities of broom snakeweed on grass production.
10. Recording rain gauge and weir to measure runoff--maintained by USDA/SEA.
11. Site used in Pinyon-Juniper ecology study.
12. Corral and storage shed.
13. Windmill and well drilled by BLM. This well provides water for all livestock on the airport mesa.
14. Storage tank for water from well.
15. Deer-proof exclosure.
16. Cattle-proof exclosure.
17. Deer pellet and browse transects--used to monitor changes in deer density and important browse species.
18. Game watering units.
19. Soil genesis and morphology study.
20. Typifying pedons for soil survey used in soil-plant-animal studies.
21. Infiltration and sediment yield studies.
22. Blue grama response studies in relation to grazing management.
23. Fourwing saltbush response studies in relation to grazing management.
24. Western wheatgrass defoliation studies.
25. Specific locations of cattle diet collections.

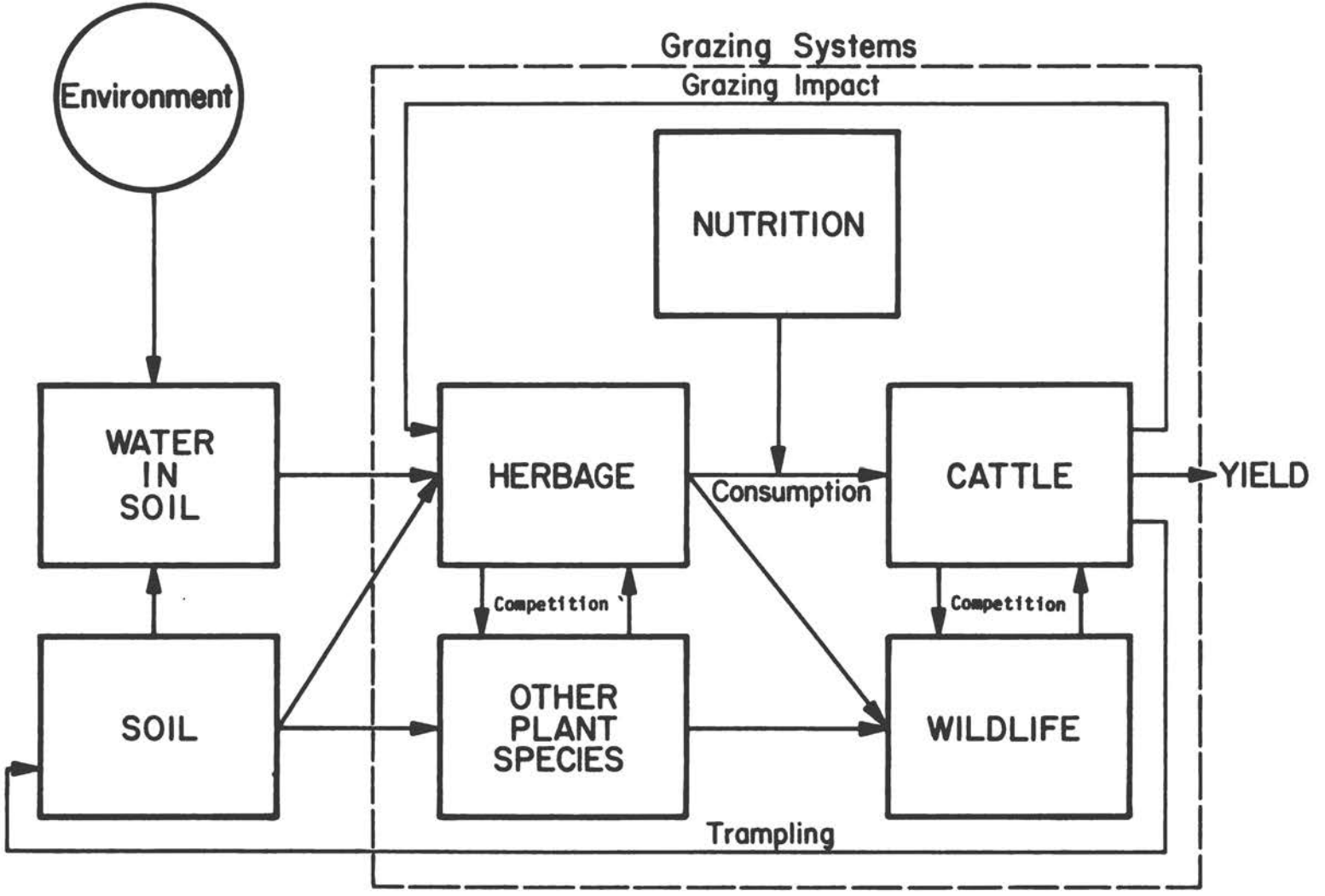

FIGURE 3 A conceptual diagram of the integrated research program of New Mexico State University at Fort Stanton, New Mexico.

may not appreciate the nuances of the system model in Figure 3, he will appreciate the information on costs and benefits of a new system compared to old systems collected at a place that is understood biologically and ecologically. The social value of long-term work at a site where the public can visit, study, and compare public supported findings against their own unique local conditions provides the confidence to experiment with new technology. This has been the great power of the Agricultural Experiment Station system countrywide and is one reason why American agriculture is so productive.

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3

DESCRIPTION OF SITE B

As mentioned in Chapter 1, a variety of sites was examined for a new airport, and a site on the mesa (the "Airport" mesa) at Fort Stanton Ranch was deemed among the most suitable. This site was termed Site B. The description of Site B is based on data presented to the Sierra Blanca Airport Development Committee by Herkenhoff-Parsons in the Sierra Blanca Airport Master Plan in 1975 and 1976. Herkenhoff-Parsons determined the requirements for an airport based on projected growth, which in turn is based on an analysis of a number of economic, demographic, and social indicators. Trends are presented for four years (1980, 1985, 1990, and 1995). For example, it is estimated that in 1980 there will be 423,500 tourists in the area, of which 42,400 will be air passengers. In 1995 these numbers are predicted to increase to 988,000 total tourists and 177,200 tourist air passengers. Based on a series of such estimates, plus data on airport requirements (Table 4), Herkenhoff-Parsons developed an airport layout module (Figure 4). The layout for the module comprises approximately 975 acres (395 hectares). They state that this "is the minimum area and boundary configuration required to satisfy the established spacial requirements. Master planning of the selected site will most likely vary this acreage upward to provide for ancillary development areas such as protective areas, revenue producing commercial and industrial lease plots, government agency lease areas, aviation related services, storage and industrial activities and so on," (Sierra Blanca Airport Master Plan, 1975a).

SPATIAL REQUIREMENTS

The spatial requirements that underlay the selection of the airport layout module are described in the Sierra Blanca Airport Master Plan, Volume 1 (1975a). Based on the projected airport use and type of plane capable of satisfying that use, Herkenhoff-Parsons calculated runway length requirements and other needs. They recommended an ultimate primary runway length of 12,900 feet (3,909 meters) with development stages beginning with an initial 8,600 feet (2,606 meters) and an intermediate stage of 9,700 feet (2,939 meters). A crosswind runway of 6,500 feet (1,970 meters) is also

TABLE 4 Air Traffic Forecast Data and Facility Requirements Summary[a]

Item Description	1980	1985	1995
A. FORECAST DATA			
Annual Aircraft Operations	36,639	46,300	75,617
Commuter Carrier	5,194	6,170	10,186
Commercial Charter	85	110	236
General Aviation:			
Executive Jet	941	1,200	1,956
Light Twin-Engine and Single-Engine Piston	30,419	38,820	63,239
Peak Hour Aircraft Operations	43	53	84
Commuter Carrier	6	7	11
Commercial Charter	1	2	2
General Aviation:			
Executive Jet	1	1	1
Light Twin-Engine and Single-Engine Piston	33	43	69
Based Aircraft (50% twins, 50% single, 20% twins are over 12,500 lb)	23	31	51
Business Jets	1	2	5
Twin Engine piston over 12,500 lb	1	2	5
Twin Engine piston under 12,500 lb	4	5	9
Single Engine, 4-place and larger	11	14	22
Single Engine, 3-place and under	6	8	10
Passengers			
Commuter Carrier and Charter:			
Annual	47,460	75,400	188,200
Peak Hour	144	318	477
General Aviation:			
Annual	100,400	136,100	247,700
Peak Hour	109	150	270
B. FACILITY REQUIREMENTS:			
Runway Lengths:			
Primary (L.F.)	8,600	9,700	12,900
Crosswind (L.F.)	6,500		
Runway Widths:			
Primary (L.F.)	150	150	150
Crosswind (L.F.)	75	75	75
Hangar Apron Area (sq yd)	17,355	37,885	57,655

TABLE 4 (continued)

Item Description	1980	1985	1995
B. FACILITY REQUIREMENTS (continued)			
Unhangared Apron Area:			
Tie-down Ramp (sq yds)	52,170	66,600	108,410
Public Apron (sq yd)	31,610	39,790	64,700
Terminal Building Area (sq ft)	29,300	54,500	87,100
Gate Positions	2	3	4
Vehicle Parking Areas (sq yd)	10,590	19,425	31,196
Vehicular Traffic-Peak Hour (Vehicles)	36	67	106
Access Road (Number of Lanes)	2	2	2
Water Storage (M-Gal.)	630		1,650
Electric Power (KVA)	500	1,000	1.500

[a]Sierra Blanca Airport Master Plan, 1975b.

required. Pavement width, gradients, and navigational aids are designed to meet minimum standards for a Basic Transport Precision Runway and Federal Aviation Administration design standards. Additional space needs include hanger and tie-down space (experience at Ruidoso Municipal Airport shows that all based aircraft occupy hanger space due to climatic conditions), terminal building, access roads, parking, and so on. The "minimum airport boundary" needed to contain the required facilities is approximately 950 acres (385 hectares), with the total land area required under specific site conditions most likely being higher. The Environmental Impact Assessment (Sierra Blanca Airport Master Plan, 1976b) indicates that approximately 2,000 acres (810 hectares) (Sierra Blanca Airport Master Plan, 1976a, p. V-10) of experimental range will be removed for the airport facility.

Site B is shown imposed on the Fort Stanton range map (Figure 5) and on the topographic map in Figure 6. The first phase of construction is estimated to require about 500 acres (202 hectares) (Sierra Blanca Airport Master Plan, Environmental Impact Assessment Report, 1976b, p. V-13), although the actual acreage required by each phase differs depending upon the published source of the estimate. The estimate of the space required by this airport is further confused by recent communication with the Sierra Blanca Airport Commission (F. R. Heckman, Jr., Chairman, Sierra Blanca Airport Commission, letter to C. W. Luscher, 1982), which indicates that the maximum acreage

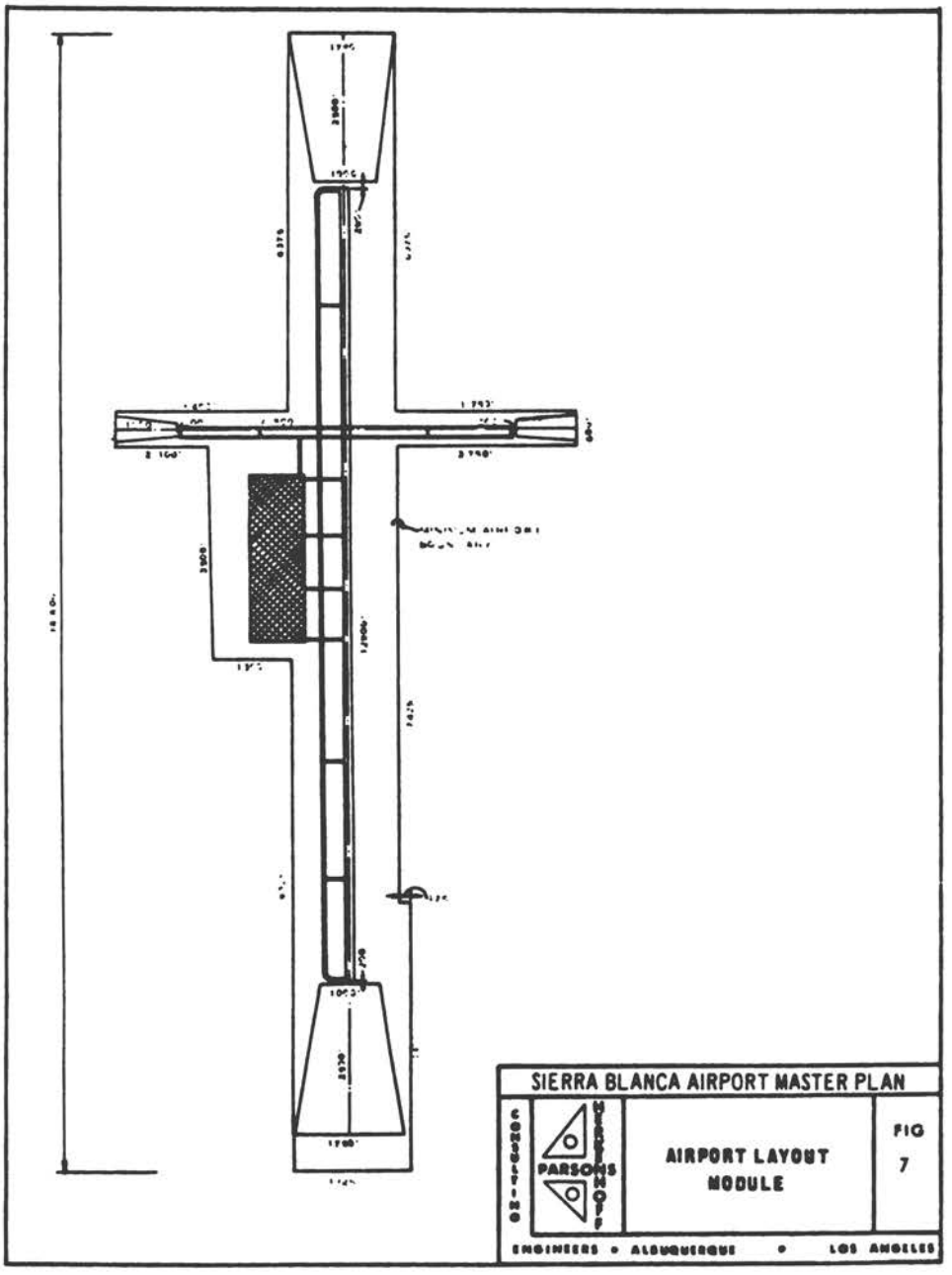

FIGURE 4 Airport layout module, from Sierra Blanca Airport Master Plan, 1976b.

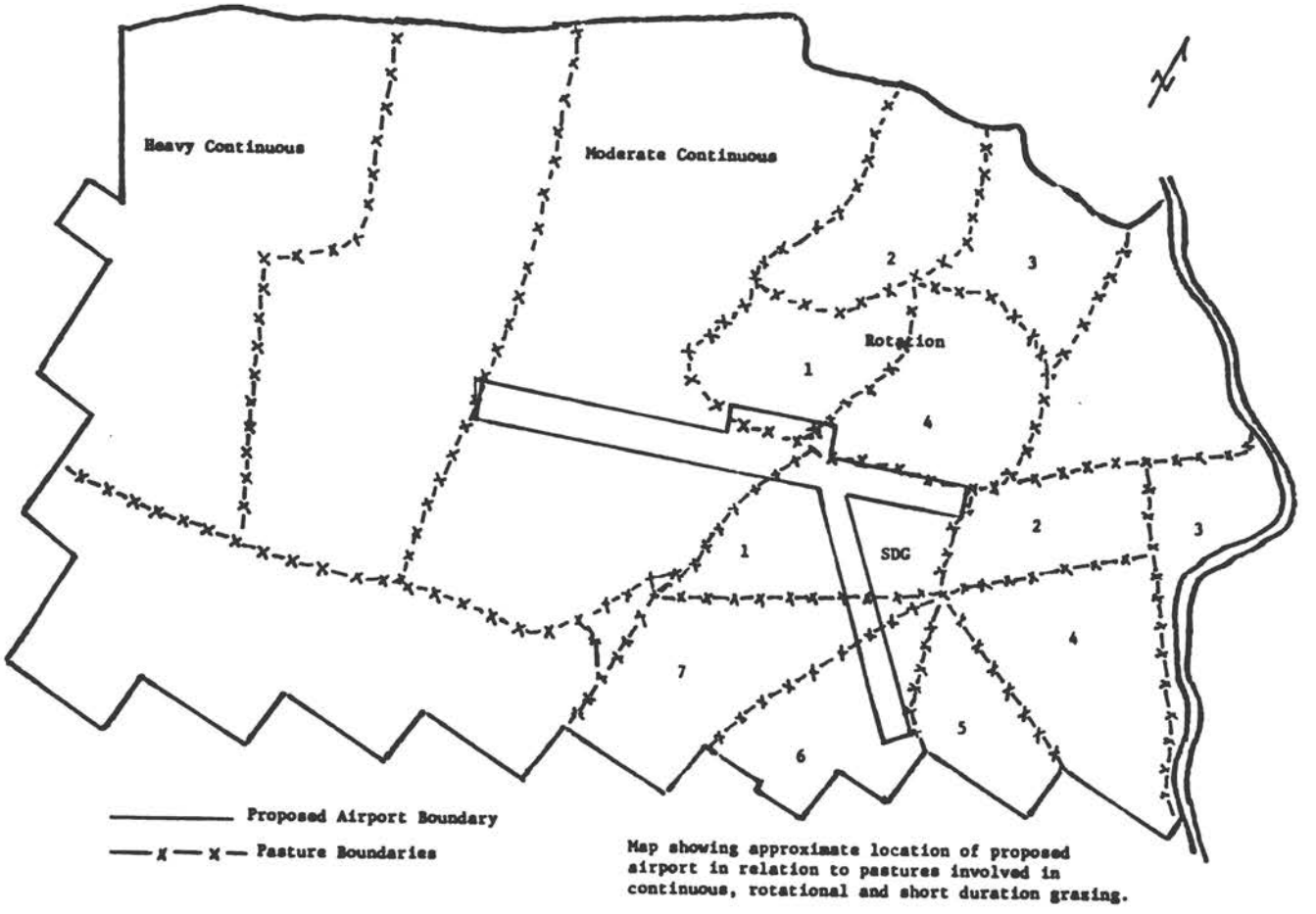

FIGURE 5 Location of Site B on the mesa pasture area at Fort Stanton Experimental Ranch. The map was provided the committee by New Mexico State University. The actual length and position of the runway is approximate. The object of the map was to show the relation of the proposed Site B airport to the various pastures on the mesa.

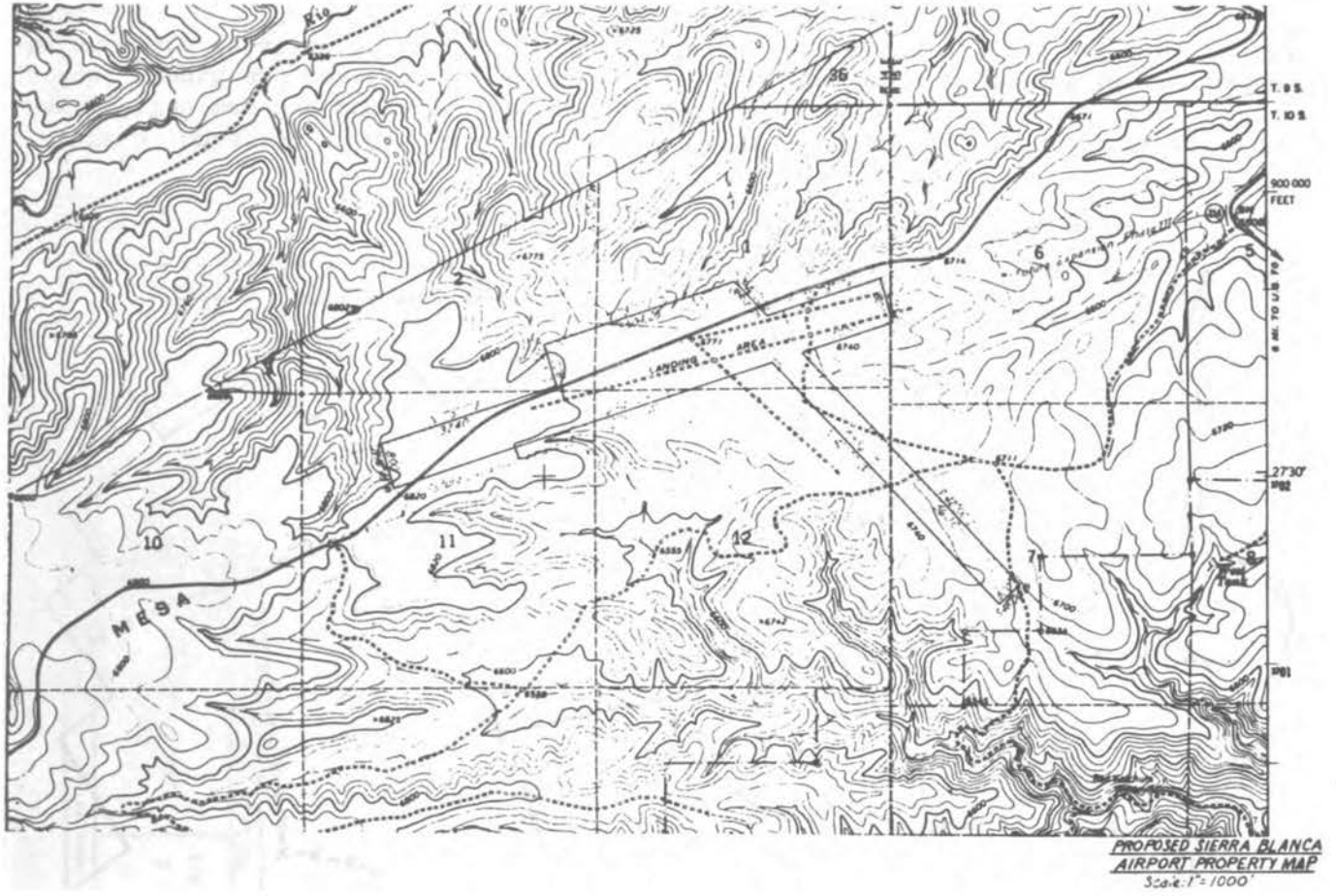

FIGURE 6 The location of the proposed Site B airport at Phases I, II and III on the topographic map of the mesa pasture area of Fort Stanton Ranch. This map was supplied the committee by the Bureau of Land Management and represents the request of the Sierra Blanca Airport Commission.

requested in a phased development is as follows:

Phase	Completion Date (yr)	Area
I	1984-1985	283.34 acres (114.6 hectares)
I and II	1990-1995	405.34 acres (164.1 hectares)
I, II, and III	2000-2010	512.34 acres (207.4 hectares)

The legal description for the phase or stage I development above is shown in Table 5, and the map showing this phased development is Figure 6. Not only do these various requests differ in quantity, but they also differ from the airport layout module. Further, it should be noted that this latest estimate does not account for water facilities, for sewage treatment, and for movement of the county road that will be displaced. Nevertheless, while the actual area required for an airport is unclear, its location on the "Airport" mesa is clear and is the key element in evaluating impact on the research.

IMPACT ASSESSMENT

There are other elements of airport construction and maintenance that require land and affect research. These are suggested by the Environmental Impact Assessment (Sierra Blanca Airport Commission, 1976b), but are not discussed in detail. For example, for Site B substantial fill is required to build up the runways to meet the plan (Figure 7). The location of fill is not discussed in the Master Plan documents, nor are the impacts from digging for fill evaluated. Thus, the impact assessment is inadequate to show the scale of impacts of the construction on the ranch.

The Environmental Impact Assessment discusses impacts of the airport in terms of noise, water pollution, visual pollution, and impact on range and wildlife studies, on wildlife, and on the Fort Stanton caves. Approximately 1,800 acres (729 hectares) are estimated to be noise impacted. The noise analysis is entirely in human terms. It does not address impact of noise on cattle. In terms of wildlife the report states (Sierra Blanca Airport Master Plan, Environmental Impact Assessment Report, 1976b, p. V-11) that a total of about 1,500 acres (607 hectares) lies in the noise impacted area, outside of the airport boundary. All of this area falls in an area with a predicted Noise Exposure Forecast value of less than 35. For residential and educational construction, a rating of greater than 35 indicates that new construction and development should not be undertaken in the area. Presumably the behavior and physiology of cattle will be equally impacted in such an area.

TABLE 5 Description of Proposed Sierra Blanca Airport Property, Stage I[a]

A tract of land located within Sections 1, 2, 11, and 12, Township 10 South, Range 14 East, N.M.P.M., and within Section 7, Township 10 South, Range 15 East, N.M.P.M.--more particularly described as follows:

Beginning at a point on the east line of Section 1, Township 10 South, Range 14 East, whence the corner common to the northeast corner of said Section 12 and the southeast corner of said Section 1 lies south 0°01'East approximately 1,160 feet; from said point of beginning running the following courses and distances:

South 73°17'W, a distance of 1,700.00 feet;
Thence S42°00'E, a distance 5,600.00 feet;
Thence S48°00'W, a distance 500.00 feet;
Thence N42°00'W, a distance 5,836.17 feet;
Thence S73°17'W, a distance 6,947.03 feet;
Thence N16°43'W, a distance 800.00 feet;
Thence N73°17'E, a distance 3,240.00 feet;
Thence N16°43'W, a distance 800.00 feet;
Thence N73°17'E, a distance 3,504.25 feet;
Thence S42°00'E, a distance 884.75 feet;
Thence N73°17'E, a distance 2,077.87 feet;
Thence S16°43'E, a distance 800.00 feet to the point and place of beginning, containing 283.34 acres more or less.

[a]Provided by F. R. Heckman, Jr., 1982.

Water will be required for normal usage plus fire protection. The water storage capacity dictated by the National Fire Insurance Underwriters for fire protection is estimated to be 630,000 gallons of storage in 1980 (the initial starting date in the Master Plan) and 1,650,000 in 1995. For the basic supply two wells are proposed, preferably in the vicinity of Rio Bonito Creek, approximately 1 mile north of the site. Emergency water to fill the water storage tank if water is required for a fire is to come from a connection to the existing transmission line to Fort Stanton Hospital. Peak water demand for passenger and employee usage was estimated to be 7,890 gallons per day in 1980 (the initial starting date in the Master Plan), increasing to 23,250 gallons per day in 1995. The Master Plan recommended an initial 1-million-gallon reservoir capacity be constructed and a 650,000-gallon reservoir be planned after 1985. The Master Plan calls for an increase in well capacity at peak development but does not describe how well capacity will be expanded.

Control of runoff from paved runways and terminal areas on the mesa to the offsite areas is to be affected by "rigid adherence to

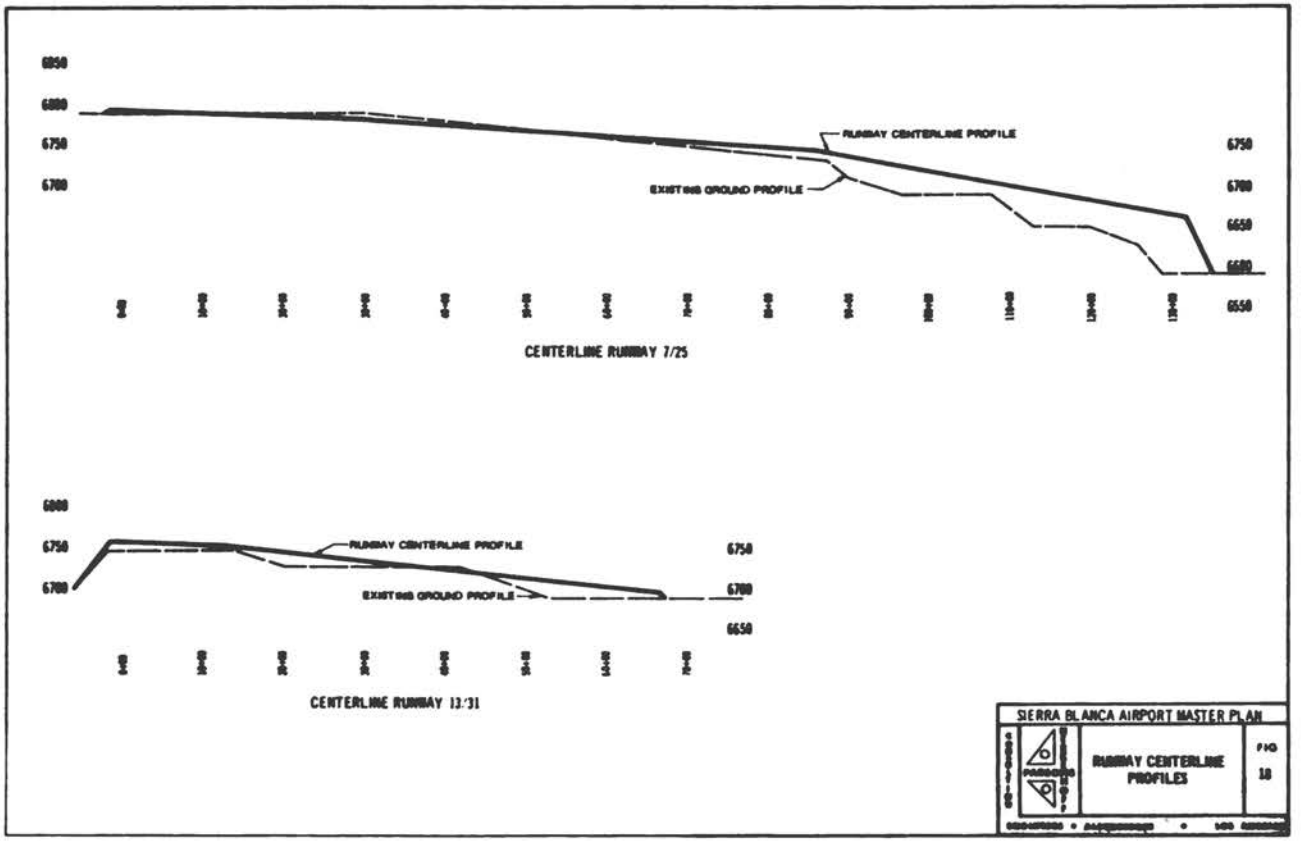

FIGURE 7 Runway center profiles in relation to the existing ground profile, indicating the amount of fill required to bring the runway up to the proper elevation.

SOURCE: Sierra Blanca Airport Master Plan, 1976a.

established engineering hydrologic practice." The airport drainage plan feeds water from the pavement into natural swales and gullies with no analysis of the capacity of these water courses to carry an increased load, except for the comment that water handling is "not anticipated to cause any noticeable change in surface or groundwater flows, potential, or quantities," (Sierra Blanca Airport Master Plan, Environmental Impact Assessment Report, 1976b, V-15).

Sanitary water disposal will be by a septic tank-drain field system. But when growth reaches a need for 14,000 gallons per day (about 1985 in the planned growth beginning in 1980), a more efficient system will be needed for a waste water treatment facility.

These comments are not meant to be a detailed, authoritative analysis of impacts of the airport on the ranch. Rather, the object is to show that there is considerable uncertainty in the size of the area required, the nature of proposed developments, and the impacts of development on the environment. Such uncertainty affects our evaluation of the impacts on research, because research has both temporal and spatial features. Here we will stress the general and temporal impacts of development on research and not include detailed plot by plot analysis of impacts across the mesa where Site B is located.

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Sierra Blanca Airport Master Plan. 1975a. Technical Appendix Volume I. Airport Requirements.

Sierra Blanca Airport Master Plan. 1975b. Technical Appendix Volume II. Site Selection.

Sierra Blanca Airport Master Plan. 1976a. Technical Appendix Volume III. Airport Plans.

Sierra Blanca Airport Master Plan. 1976b. Environmental Impact Assessment Report.

4

BROAD AND LONG-TERM IMPACTS ON RESEARCH AT SITE B

The impacts of constructing an airport on Site B fall into two general categories, direct and indirect. Direct impacts include removal of land presently being used for the grazing experiments, elimination of study plots on the site, changing the water runoff characteristics on the site and consequent overland flow down slope, and creation of a barrier to movement of livestock and wildlife. Indirect effects may result from development of utilities to service the airport, increased human presence and unauthorized activity on the experimental ranch, and increased noise and traffic. The direct effects are more easily subject to evaluation than are the indirect effects.

The Fort Stanton Ranch has been divided into different areas with each area having a designated research priority. Site B is located within 7,000 acres (2,834 hectares), which has been designated primarily for range management research. Animal science and wildlife management are the dominant research priorities on the remainder of the ranch.

PHYSICAL REDUCTION IN SIZE OF PASTURES AND EXPERIMENTS

Establishment of an airport at Site B would involve only a few hundred (283 to 512) acres and hence only a small percentage of the entire 26,000-acre (10,526 hectares) Fort Stanton Ranch. This may seem a trivial loss in terms of size or proportion of the entire research facility, and it would be, if not for the configuration and specific location of Site B. Had the entire acreage of the airport site been restricted to a corner of the ranch and one pasture, mitigation might be feasible. This is not the case with Site B. It completely bisects the moderate continuous pasture and projects into portions of Pastures 1 and 4 of the rotation pastures, all part of the long-term continuous versus rotation grazing study. Site B also bisects three of the six pastures in the short-duration grazing study. Loss of acreage per se is probably consequential only in the case of Pastures 1 and 6 of the latter study. But bisection of the three pastures by the airstrip would essentially require relocation of the experiment.

One of the unique features of Fort Stanton Ranch is that it has pastures of sufficient size to accommodate commercial size herds of livestock. This is important for grazing studies and definitely adds to the credibility of research carried out at Fort Stanton Ranch.

In addition to reducing the effective size of the grazing systems pastures and altering the balance of vegetation types in the treatments, there would be other significant effects. Several small study plots and transects and a long-term exclosure would be physically removed by the airport. Because of limitations in funds and manpower, sample sizes in this kind of research are often established at a minimum level. In our judgment elimination of these study plots would adversely affect the quality and utility of the data obtained from the remaining portions of these studies.

IMPACT ON KEY ELEMENTS OF RESEARCH

Officials of New Mexico State University have pointed out that Site B is located on the most productive vegetation type on the ranch. Because Fort Stanton Experimental Ranch is not a private livestock operation with a profit motive, the productivity of the Site B location is not as important as other considerations. The main objective of the ranch is to conduct research and extrapolate research results to those areas and users where the results are applicable. Thus, the real importance of the mesa site is not its productivity, but the fact that it is the best and most extensive representative of Plains Grassland on the ranch (Groce and Pieper, 1967). This vegetation type extends over 15.5 million acres (6.3 million hectares) of New Mexico and many more millions of acres in Arizona, Colorado, and Texas.

Location of an airport at Site B would essentially terminate the long- and short-term grazing studies and most ancillary animal and vegetation response studies associated with the grazing studies. We agree with New Mexico State University officials that there is no conceivable way to continue the present grazing studies on the same site once construction is initiated. Only partial results would be forthcoming from the long-term continuous versus rotation studies, and, without replication in time prescribed in the study plans, the results obtained thus far would be weakened considerably. Conclusion of the short-duration grazing studies at this date with only 2 years' data would be tantamount to having no data at all. The grazing studies could be located elsewhere, although probably not at Fort Stanton Ranch because of the lack of alternative representatives of the Plains Grassland type (Groce and Pieper, 1967). Relocation of the grazing studies would entail considerable cost for site acquisition, investment in facilities, and the loss of the years invested in studies at Fort Stanton Ranch. The last is neither recoverable nor transferrable (see below).

If an airport were built at Site B and New Mexico State University attempted to continue the long-term grazing studies by redesign (despite the difficulties envisaged above), it would appear that the ratio of Pinyon-Juniper range to Plains Grassland range would be

changed considerably. The effects of this change in ratio of range types are several. First of all, no continuity in results should be expected between the old and new studies. Secondly, the new study design may not fit the original objectives (i.e., if study objectives were couched in terms of the existing Pinyon-Juniper and Plains Grassland mix, would they still be pertinent to the new mix of range types?). Thirdly, loss of the productive mesa from the study without commensurate increase in pasture size would require a reduction of livestock numbers that would affect the statistical validity of the data.

Compared to the impact on the research, the impact on water developments, fences, and corrals located in the vicinity of Site B will be of minor importance, although significant in monetary terms.

BARRIER EFFECT

Location of an airport at Site B would create a "barrier" that would have several impacts. We have already described how the airstrip would bisect several of the pastures, thereby seriously curtailing their usefulness in the ongoing research. In addition, the airstrip would form a barrier to movement of mule deer between cover of Pinyon-Juniper stands on Rio Bonita Creek on the northwest side of the mesa through a natural, low-lying corridor across the mesa to similar favored deer habitat on east exposures of the mesa. This disruption of deer movement patterns in the vicinity may affect current studies of deer in such a way that the studies would have to be concluded, perhaps prematurely, in terms of study objectives.

TIMING IN RELATION TO CLIMATIC CYCLES

People who lack an understanding of southwestern rangeland, its climate and ecology, may have difficulty understanding why officials of New Mexico State University are so adamant about retaining Fort Stanton Ranch and so reluctant to establish a new facility to continue the current studies. One of the primary reasons for the New Mexico State University attitude is that grazing studies by their very nature must be long term to produce reliable results. This is true for western rangelands as a whole, but especially in the Southwest where annual precipitation is low and highly variable. Drought is frequent and recovery from drought slow (Nelson, 1934; Herbel, et al., 1972; Cable, 1975). Thus, many years of data are required to produce reliable results from experiments. Most range researchers design grazing experiments to extend through at least two wet and two dry cycles as a minimum, or from 12 to 20 years, depending on length of the cycles (S. C. Martin, University of Arizona, personal communication, 1982; L. B. Merrill, Texas Agricultural Experiment Station, personal communication, 1982). Because of the large investment of time and money involved in grazing studies and the time required to repeat those studies once disrupted, it is not difficult

to understand the reluctance of New Mexico State University officials to relinquish Site B.

Gerald B. Thomas, president of New Mexico State University, stated in a presentation to this committee in June 1982 that it would not be possible for the university to undertake similar long-term grazing studies at another site if the decision on Site B was in favor of airport development. In the committee's opinion financial considerations and the time required to reach the current phase of research at Fort Stanton Ranch would be the overwhelming factors in such a decision by the university, not the availability of other sites suitable for this kind of research. Judging by the trend of range research funding in the United States over the past 20 years (Klemmedson, 1980), President Thomas' statement seems realistic.

DISTURBANCE

It has been stated by the Sierra Blanca Airport Commission (F. R. Heckman, chairman, personal communication, 1982) that the acreage required for the airport is really quite small and that this should not constitute a critical loss to the acreage of the ranch. However, the actual acreage lost is only one factor when considering the impact of an airport at Site B on the research program at Fort Stanton Ranch. We have considered that factor and the effect of bisecting pastures above. Another factor to consider is the disturbance caused by jet airport situated in the middle of the experimental ranch. Although it is difficult to evaluate, the airport would create a disturbance factor that would become a part of the environment of the experimental area. This new environment would be completely atypical of conditions characteristic of the Pinyon-Juniper and Plains Grassland vegetation types found elsewhere in the region (i.e., few other examples of these vegetation types have jet airports nearby). Hence, the research site would be less representative of the vegetation types on which it is situated, and the ability to extrapolate the research results from Fort Stanton Ranch with the airport in place would be reduced.

TRANSFERABILITY AND CONTINUITY OF RESEARCH AT AN ALTERNATIVE SITE

The reluctance of New Mexico State University officials in giving up Site B at Fort Stanton Ranch is based on the fact that they would lose the research investments in the long-term studies without being able to reap the full benefits of the studies to date and that they would be unable to initiate such studies again elsewhere. Selection of a new comparable site to continue the current studies with the expectation of transferring data from one site to another (i.e., coupling the data for the two sites) is not possible. The committee has no knowledge that this has ever been attempted in any kind of ecological research. In our opinion no prudent scientist would even suggest this.

THE IMPACT OF HUMAN USE

Location of an airport at Site B would cause a considerable increase in the amount of human use of the immediate area. Despite assurances of the Sierra Blanca Airport Commission that plans by Herkenhoff-Parsons are complete, it seems only logical to expect gradual encroachment of human use and development in the vicinity of the airport. This will have a variety of serious impacts (vandalism, disturbance, poaching, etc.) on the research of New Mexico State University if they elect to retain the Fort Stanton Ranch. Many of these impacts could compromise the validity of research conducted at the site. The argument used above under "DISTURBANCE" that the site becomes atypical is also valid here.

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5

IMPACTS ON SPECIFIC RESEARCH PROJECTS

GRAZING SYSTEMS

The grazing system research is directed toward understanding the relation between cattle and range at a simulated commercial scale. The design of the grazing system studies seems adequate for this need and is of relatively high quality. It is less adequate to demonstrate the basic principles of grazing systems. More intensive research designs are required to support these objectives.

Development of the airport on Site B would severely impact the existing grazing systems study. It would alter the size and composition of some pastures to an extent that continuation of the study would not be justified. Data obtained from the altered pastures would not provide valid comparisons of grazing systems and would not be publishable.

Relocation of the grazing systems study to another part of the ranch would require a change in designated research priorities for other areas. Considerable expense would be involved in redesigning and rebuilding the study. Several years would be lost in the transition, if it were made. Applicability of data generated from present and past studies to a new study would vary. Basic research data such as intensive plant growth and development and plant physiology studies should be broadly applicable. Site-specific data such as stocking rates and levels of animal production would require recalibration on a new site. Diet studies should have general applicability, although it might be necessary to repeat some of this work.

The effects of grazing treatments require many years to develop, and they persist for extended times. This long-term aspect of grazing systems research is an important consideration. The grazing systems study was initiated in 1969, and the first publication, covering 8 years, was in 1978 (Pieper et al., 1978). During the May committee meeting in Las Cruces, New Mexico State University scientists indicated that the second summary publication is now being prepared. The short-duration grazing system that has been developed and operated for a year and the control treatment (moderate continuous grazing) would be effectively eliminated by an airport development at Site B. This research could be relocated, but relocation would result in considerable expense and many years' delay in obtaining usable results from the study.

The recent inclusion of short-duration grazing in the grazing systems study is a response by New Mexico State University to current needs for information by the Bureau of Land Management, Forest Service, Soil Conservation Service, ranchers, and other rangeland managers. The ability of New Mexico State University to respond to this need and future research needs is contingent upon the maintenance of a viable grazing management research program. Such a program consists of many elements, including an adequate land resource; physical developments such as fences, water, pens, roads, offices, and laboratories; adequately trained research scientists and support personnel; adequate access to and control of land and other resources by the researchers; and adequate funding. Stability is a prime ingredient required to give administrators and researchers the incentive to build and maintain a viable research program.

A point that must be kept in mind evaluating various aspects of the research is that they are designed to measure response to grazing systems inputs. Thus, the plant and animal response studies and watershed research in the area impacted by Site B are oriented and based on the cumulative effects of grazing systems. If Site B is developed and the grazing systems study is seriously damaged, there will be secondary effects on the various intensive supporting studies.

PLANT RESPONSE STUDIES

An integral part of any grazing study is an investigation of the effects of the various grazing treatments on the vegetation communities and on individual plants. A perusal of lists of published papers, graduate theses and ongoing research demonstrates that the New Mexico State University researchers have carried out many of these kinds of studies (Seefeld, 1974; Pieper and Donart, 1975; Pieper et al., 1978; Van Eys, 1978; Pfister, 1979; Pieper, 1980). In addition they have been active in studying plant responses to a variety of other physical and biological agents that may cause stress to range plants and communities under certain conditions, but favorable reactions under other conditions (Dwyer and Pieper, 1967; Pieper, 1971; Pieper et al., 1973; Pieper and Donart, 1975; Wallace and Foster, 1975). These include drought, fire, various range improvement practices, fertilization, and combinations of these (including grazing). Many of these studies are of short duration or have been concluded, hence would not be affected by building of an airport. Those plant response studies that are associated with the long- and short-term grazing studies would be impacted by airport construction.

Plant response studies are never completely finished, as knowledge concerning species' behavior never ends. Many plant studies have been conducted at Fort Stanton Ranch, and much information has been obtained to help in the interpretation of vegetational response of specific grazing and manipulation practices of this vegetation type. The botanical composition of the various pastures and their utilization by livestock under different grazing regimes with and without added fertilizer have been determined (Pieper, 1970; Allison et al., 1977;

Donart et al., 1978). The probable reaction of Plains Grassland to prescribed burning and its rate of recovery to preburn productivity have been researched (Dwyer and Pieper, 1967). The effect of fire on walking stick cholla (Dwyer and Pieper, 1967) and response of fourwing saltbush to frequency and intensity of defoliation have also been studied (Pieper and Donart, 1978).

Opportunities to study the effects of drought occurred in 1971, 1972, and 1974 and yielded much information on vegetation and livestock. Only long-term studies with a previous history of data on both animal and plants would have made this possible. The recurrence of drought is unpredictable; thus, studies dealing with drought effects are fortuitous accidents. Effects of drought and how to cope with them are probably of greater importance to rangeland management in the Southwest than any other region (Pieper and Donart, 1975; Wallace and Foster, 1975).

The knowledge that widespread and serious invasion of broom snakeweed and goldeneye can be triggered by drought and that all range weed problems are not necessarily due to mismanagement is the result of long-term monitoring of the range under known grazing practices. A real value of this type of research is the ability to capitalize on the occurrence of random events such as drought with studies that yield valuable but seldom obtained knowledge on the effects of these events.

Many of the plant response studies conducted at Fort Stanton Ranch can be or could be conducted elsewhere and independently of the grazing trials, but increased information is obtained when the two types of studies are conducted jointly. In addition to grazing studies, the long-term study of the exclosure, protected for nearly 30 years, would be terminated with the construction of the airport on Site B. This would be a significant loss, as areas protected from disturbance as long as this are scarce due to lack of continued fence maintenance in the West. Exclosures are extremely valuable from an ecologic and land management viewpoint, as they provide a comparison with adjacent nonprotected areas to assess impact of use.

In addition to the impact on physical facilities of range improvement that directly influence livestock movement and animal welfare, research on range improvements that deal with vegetation also will be affected. An example is the planned interseeding of Plains Grassland range with a forage species to provide early forage to extend the period of nutritious forage for greater animal productivity (G. B. Donart, New Mexico State University, personal communication, 1982). This type of research usually is conducted first in small experimental plots and this is followed by studies on a larger scale, frequently as part of a grazing or management system study that does not seriously disrupt livestock operations. The same would be true for range weed control research where herbicides, prescribed burning, or mechanical means are involved.

We believe the quality of plant response research at Fort Stanton Ranch has been good. A review of this research (Bekele et al., 1974; Pieper et al., 1975) demonstrates rigid attention to the principles of experimental design and analysis of data. (In fact this statement

applies rather generally to all kinds of research conducted at Fort Stanton Ranch.) Much of the research has been done in considerable depth, e.g., the fertilization research (Kelsey et al., 1973; Anderson et al., 1974; Havstad et al., 1979; and others), research on nutritive quality of forage (Hatch et al., 1968; Cordova and Wallace, 1975; Arocena et al., 1979; and others), and the autecological research (Pieper et al., 1974, 1975; Pieper and Donart, 1978; Lymbery and Pieper, 1982; McDaniel et al., 1982). It does not appear that airport construction would seriously impact the fertilization research, since it seems to be at a termination point.

It is important to emphasize again that it is the interaction between the plant and animal studies that has made the research at Fort Stanton Ranch much more than a list of individual studies. Each study was designed to answer questions that were raised in previous studies, and collectively the information derived is significant in developing and interpreting grazing systems that are currently in use in the Southwest.

The plant studies have been closely and carefully coordinated with grazing and animal studies from the outset with the overall objective of producing more and better-quality range forage for the purpose of increasing livestock production. This is easily seen if one reviews the chronological order of plant research efforts at Fort Stanton Ranch.

The research has been orchestrated in such a manner that the primary objective was continuously in focus. Prior to the establishment of grazing studies, utilization patterns and basic soil-vegetation relationships were researched (Hatch et al., 1968; Pieper, 1970; Pieper et al., 1971). Early research emphasized what resources were available, how much, where, and of what nutritional quality for livestock use. This type of research was accompanied by studies investigating animal diets, dry matter intake, and digestibility of range forage species during various seasons of use with esophageal-fistulated animals (Thetford et al., 1971).

With increasing forage production as a major objective, research on range fertilization with nitrogen supplement was undertaken because this had not been tested under Southwest conditions (Dwyer, 1971). It was found that fertilization with 40 pounds of nitrogen per acre (43 kilograms per hectare) more than doubled the annual forage production. Research on burning, with and without supplemental nitrogen, indicated that forage production was not enhanced by the use of fire as in tall grass prairie vegetation (Dwyer and Pieper, 1967). It was found that burning was damaging to young invading cactus plants (less than 6 inches [15.2 centimeters] in height) and to young juniper (less than 4 feet [1.2 meters]) but not to larger plants.

Having established that addition of nitrogen increased forage production, testing of the interaction of fertilization and defoliation of plants was conducted. Results indicated that nitrogen fertilization produced no beneficial effect on production if plants were frequently and severely defoliated (Bekele et al., 1974). To benefit from nitrogen addition, grazing would need to be delayed or be of an intensity that top growth of blue grama would not be severely and

continuously grazed. These findings required adjustments in their grazing studies if benefits of fertilization were to be realized.

It was found that fertilization of Plains Grassland range increased the crude protein content of green forage, but this did not carry over to dormant, dried plant material. The higher crude protein content increased animal gain during the growing season. It was suspected that higher intake of fertilized dormant plant material was responsible for animals being able to get a maintenance level of crude protein in contrast to unfertilized Plains Grassland range (Havstad et al., 1979). Lactating cows required protein supplement during this stressful period, however.

To overcome the low crude protein diet during spring when native grasses are dormant, the plant research effort is shifting toward increasing production of early forage by interseeding cool season grasses. It is during this period that livestock in the Southwest undergo great stress and lose rather than gain weight because of lack of green feed on native range.

The range research program of New Mexico State University is well coordinated and integrated with plant and animal scientists working toward a common goal of increased sustained livestock production. The information obtained from animal studies is used by plant researchers to design studies that would produce more and better-quality forage. In turn, this information is used to develop and adjust the various systems of grazing that are being investigated at Fort Stanton Ranch.

The plant studies are highly applied and closely integrated with grazing and animal investigations (Figure 2). The benefits of this research will become increasingly valuable and more widely applicable as more Plains Grassland range moves to a higher ecological status in the Southwest because of improved range condition. Loss of the grazing studies at Fort Stanton Ranch would terminate a long-term, integrated vegetation-grazing approach that is important to truly assess grazing systems.

WATERSHED RESEARCH

The research program in watershed management at New Mexico State University is relatively new and without any published results to date; therefore, it is difficult to evaluate the adequacy of the research. Several studies are in progress that are integrated with the grazing studies, and there is the prospect for some interesting results. The real value of this research will depend on overcoming sampling variability and interpretation problems that are particularly troublesome in watershed management research (Dunne and Leopold, 1978).

Because the watershed program is new and relatively small, the impact of locating an airport at Site B would be less important for watershed programs than for range and livestock programs. Moreover, Fort Stanton Ranch is not the only location in the Southwest where watershed management research is under way.

EFFECTS ON WILDLIFE RESEARCH

The quality of wildlife research is generally good, and it is relevant to the needs of wildlife resources and primary land-use programs in the region. The work with mule deer and its habitat is especially valuable in a rangeland-livestock economy where various kinds of grazing systems and range improvements (for livestock) are being tested and used. Most land grant and other universities in the southwestern United States have similar research programs. These attempt to integrate management of big game animals into programs of management for livestock on range and forest habitats. Moreover, more attention is now being given in research to nongame species and to recreational aspects of rangeland habitats. Universities with wildlife rangeland research programs similar to that at Fort Stanton Ranch include the University of Arizona, Utah State University, the University of Nevada at Reno, the University of California at Berkeley and Davis, Texas A&M University, Texas Tech University, and Colorado State University. Governmental agencies also are involved in wildlife-rangeland research. These include the U.S. Forest Service at its several forest and range experiment stations, the Bureau of Land Management (largely through contractual arrangements with universities and private environmental consulting companies), the U.S. Fish and Wildlife Service, and most state game and fish departments. New Mexico State University wildlife scientists are well acquainted with the programs of research of other universities and agencies. However, while their own research efforts are more or less similar in scope and goals, their projects are not redundant, because they are being conducted in particular geographical and ecological areas and in the contexts of various management and husbandry practices. Everything considered, the New Mexico State University research staff and students are conducting studies that are germane to problems relating to conflicts in land-use allocations and to society's desire for multiple use of the land.

As indicated previously, most of the wildlife research is of short-term and closed-end type. The research dealing with Pinyon-Juniper habitat management and the project monitoring the mule deer herd is of long-term character and valuable. The ecology and management of deer in the cell grazing system is not expected to yield results because deer do not use most of the area.

For all practical purposes, the research on the important species of wildlife and their habitats on Site B was compromised when the mesa was extensively cross-fenced. Although antelope negotiate barbed wire fences by crawling under the lower wire if it is 16 inches (40.6 centimeters) or more in height from the ground, they prefer habitats that are unobstructed by physical barriers. Pronghorn antelope are fleet animals whose normal habitats are open plains and grasslands, and their escape from danger is made largely by running. Impediments to this characteristic behavior will cause them to vacate otherwise acceptable rangeland habitat. The small herd of antelope that formerly occupied the mesa no longer occur there, in part because of the fencing and perhaps in part through a serious poaching incident a

few years ago (V. W. Howard, Jr., New Mexico State University, personal communication, 1982).

Mule deer use the mesa at Site B very little, if at all, and then only in the nighttime hours when an occasional animal comes up from the canyon floors and slopes to feed. The range and wildlife scientists working at Fort Stanton Ranch stated deer use parts of the pasture in the cell of the short-duration grazing system that extend off the mesa onto the slopes supporting Pinyon-Juniper habitat. Aside from the scarcity of deer using the cell grazing system, the design of the experiment lacks the rigor needed to measure mule deer responses.

The airport thus could be constructed at Site B without serious harm to ongoing studies of the two major species of wildlife, mule deer and pronghorn antelope. That is to say, it would not usurp any of the important deer and antelope habitat on the site itself.

The effects of increase in disturbance through construction and use of access roads, runways, lighting and other utilities, airport support buildings, and low-flying aircraft is largely unknown. White-tailed deer and, perhaps to a lesser extent, mule deer become habituated to noise, lighting, and man-made disturbances that offer no harm to the animals. In some cases, deer can even become nuisances to airports because they are attracted to the ungrazed range sites alongside runways. In such instances, deer pose serious problems to aircraft using the airport. Fences are often constructed to exclude them.

On the other hand, the number of people visiting and using the airport area are projected to increase manyfold (Table 4), and the amount of poaching of deer and other wildlife will surely increase. If housing developments or a business community develops in concert with the airport, we would suspect that the deer herd will be greatly reduced in the Fort Stanton Ranch area.

Movement of deer through the corridor from each side of the mesa at Site B will be eliminated. The runway system will pass through the corridor. An influx of deer in the winter season appears to be a regular occurrence in recent years, and the deer herd almost doubles in numbers (V. W. Howard, Jr., New Mexico State University, personal communication, 1982). The source of these animals is not entirely known, but it appears they come from surrounding ranches from some distance away. The corridor is not necessarily a migration route of the deer; rather, it seems that deer within the confines of Fort Stanton Ranch use this route in local movements. The long-term effects of blockage of this barrier is not expected to be serious.

Everything considered, it is our judgement that location of an airport at Site B would have little impact on the wildlife research program. Arrangements can be made in project designs to offset or mitigate negative effects. The attendant disturbances to the airport operations may have some effects on the deer herd, and, if development of residential and business parks occurs, the mule deer and antelope herds may be lost from neighboring areas to Fort Stanton Ranch.

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6

UNIQUENESS AND VALUES OF FORT STANTON RANCH RESEARCH

UNIQUE FEATURES

The question of the geographical uniqueness of Fort Stanton representing the Plains Grassland and Pinyon-Juniper Woodland ecosystems is a major objective of this report, but in addition there are other questions relating to the role of this research in range and wildlife science, the economic value added by this research to the Southwest, and the significance of the research to New Mexico State University. Together, answers to these questions provide a basis for judgement about the significance of the studies at Fort Stanton Ranch.

The question of geographical uniqueness was address by L. S. Pope (1978), Dean of the College of Agriculture, New Mexico State University, who stated that results of Fort Stanton Ranch are applicable to the 8.5 million acres (3.4 million hectares) of Pinyon-Juniper rangeland and 15.5 million acres (6.3 million hectares) of Plains Grassland in New Mexico, as well as 55 million acres (22 million hectares) of range in Arizona, Colorado, and Texas. The validity of this statement depends on the kind of research results being extrapolated, the specificity of conditions under which research was conducted, and the extent of replication and precision of experimental results. We believe that results of many of the studies being conducted would apply to the particular vegetation types represented at Fort Stanton Ranch, wherever they might be found, but especially in the southern extension of Pinyon-Juniper and Plains Grassland vegetation types (i.e., New Mexico, Arizona, West Texas, and the Republic of Mexico). Some research (especially involving principles) would apply even further, e.g., to all of the Pinyon-Juniper or Mixed Prairie (Heerwagon, 1956), depending on the precision of results expected.

Fort Stanton Ranch is unique in other respects. It is the only experimental ranch of its kind with grazing studies being conducted on the complex of vegetation types found there. No other grazing studies are being conducted in the Pinyon-Juniper Woodland type anywhere in the United States. Hence, the research program at Fort Stanton Ranch has more than local or regional importance. Range scientists, managers, and practitioners look to Fort Stanton Ranch for new knowledge on the Pinyon-Juniper Woodland type just as they have sought information from Santa Rita Experimental Range about the Semidesert Grassland types or from Starkey Experimental Forest about Western Conifer ecosystems.

Grazing research is under way elsewhere on the Shortgrass Plains by the Agricultural Research Service at the Central Plains Experimental Range near Fort Collins, Colorado, and at Cheyenne, Wyoming (W. A. Laycock, USDA/ARS, Fort Collins, personal communication, 1982). Moreover, range research at the Southeastern Colorado Research Center at Springfield, which has included grazing studies since 1965, is being reoriented to include a broad array of studies including grazing studies (L. R. Rittenhouse, Colorado State University, personal communication, 1982).

These three locations and Fort Stanton are all included within the extensive Shortgrass Plains (McArdle and Costello, 1936); however, the Colorado and Wyoming locations all include buffalo grass (not found at Fort Stanton Ranch) as a codominant with blue grama and no species of Hilaria, which are common in New Mexico and have significantly different precipitation distribution patterns. Further, the Springfield experimental range is probably on the ecotone of the Mixed Prairie type described by Heerwagon (1956) and that portion of the Shortgrass Plains characterized by the northern Colorado and Wyoming study sites.

Grazing management and watershed management studies have recently been reinitiated at Rio Puerco, New Mexico, northwest of Albuquerque. This is an area of semiarid grassland and sagebrush that lies at a lower elevation and with more arid conditions (8 to 12 inches [20.3 to 30.5 centimeters] annual precipitation) than found at Fort Stanton Ranch. The Forest Service and Bureau of Land Management are cooperating in these studies (D. G. Scholl, Rocky Mountain Range and Forest Experiment Station, personal communication, 1982).

It appears that several experimental areas, including Fort Stanton Ranch, are contributing to knowledge of the Shortgrass Prairie in the broad context, but that research at Fort Stanton Ranch is uniquely applicable to the Plains Grassland of that portion of the Southwest, just as research at the Eastern Plains Experimental Range is fulfilling a specific need for eastern Colorado and southern Wyoming.

Fort Stanton Ranch is also unique in having had a 12-year nonuse period prior to initiation of the grazing studies. This technique has been commonly employed in watershed management research to calibrate experimental watersheds (Dunne and Leopold, 1978). The rest period would be valuable for grazing studies to allow recovery from any effects of drought and/or grazing before the implementation of grazing treatments. Undoubtedly, the practice would be more commonly used on grazing studies if it were not so costly. Few range researchers could establish an experimental area and then wait 12 years--or even half that--before beginning their investigations.

Fort Stanton Ranch has two key attributes. The first is its size. Very few state universities have sufficient land at their disposal to conduct herd-size grazing studies. This is very important to users of research results; they are very reluctant to endorse and apply research results that have been obtained under conditions that differ greatly from normal ranch operating conditions.

The second key attribute is the character of the vegetation. As described above, the vegetation types found at Fort Stanton Ranch are

extensive in their occurrence and are important for their range, wildlife, and water resources wherever they occur.

The New Mexico State University has made good use of the Fort Stanton Experimental Ranch with a research program that manifests both breadth and depth. The university has allocated a substantial percentage of its scientific manpower and its research budget for work at Fort Stanton Ranch. The research has emphasized range, animal, and wildlife resources, but has also included studies in soil science, economics, and watershed management. In the past 15 years, 57 papers have been published on research at Fort Stanton Ranch. These were about evenly divided between refereed journals and Agricultural Experiment Station bulletins. The Fort Stanton Experimental Ranch also serves education in many ways. The research conducted provides basic information that is disseminated through journal publications, state publications, field day reports, tours of the ranch, talks at meetings, and informal classes in colleges and universities. The use of graduate students in the research program serves a dual purpose of generating research information and furthering the education of the students. Fifty-one graduate theses and dissertations were completed with research conducted at Fort Stanton Ranch. The public and private sectors benefit from this field experience the students obtain when the students enter the job market. Universities from outside of New Mexico regularly bring students to Fort Stanton Ranch for first-hand observation of the grazing management research programs. New Mexico State University has been active in using the Fort Stanton Experimental Ranch for educational purposes at all of the levels previously discussed. Elimination of the grazing systems research would not preclude these educational activities, but it would greatly reduce the value of the educational experiences.

RELEVANCE TO RANGE MANAGEMENT

Research directed toward an evaluation of various rotational grazing systems is important and timely. The Bureau of Land Management and Forest Service have set up many grazing management plans with some form of rotation grazing as part of the system. Ranchers are being told of the increases in productivity they can expect if they would adopt a high-intensity, short-duration rotation grazing system. Some range scientists report that these systems are no better for livestock production than continuous grazing systems on many rangelands found in the West. Further, wildlife biologists are concerned about the impact of systems on wildlife. Animal scientists argue that the rest-rotation systems are concerned only with the impact on vegetation and have neglected to include the impact on animal performance. There are varied opinions on where these grazing systems should be imposed, if at all, and what one can expect in vegetational response from such a change in management. Yet few studies are being conducted in the West to get answers to these questions. The grazing studies at Fort Stanton Ranch are important in that they address these issues and provide meaningful data to be used in making rangeland management decisions.

A decision to adopt one of these systems usually will cost the government and/or the ranchers many thousands of dollars. For example, Gutierrez (1982) showed that the required investment on New Mexico cattle ranches ranged from $7,931 for the rest-rotation, small ranch grazing system to $517,691 for the rest-rotation, irrigated pasture, extra large ranch grazing system. It is important that ranchers have the best-available information to use in making capital investment decisions on grazing systems. At the present time there is a significant lack of basic biologic and economic information to evaluate the cost-effectiveness of these grazing systems. The research on the "Airport" mesa by New Mexico State University is one of the few studies being done in the West to provide these needed data. The data are valuable regardless of how the research results turn out.

Suppose the research shows that carrying capacity can be increased by 50 to 100 percent if a short-duration grazing system is put into effect. If all of the land that the Fort Stanton range studies represented were changed over to this new system, many thousands more animal-unit-months of grazing might be produced off of the same acreage of rangeland. To the extent that this grazing system could be installed at costs lower than the expected increase in returns, there would be increased profits to the ranchers and ranching communities.

An example of the need for research to guide management is the recent advent of short-duration grazing (SDG) in the United States (Savory, 1978). The claim has been made that these systems will allow stocking rates to be doubled or even tripled and still improve vegetation and livestock performance. Existing research data are not adequate to either support or refute this claim. Many ranchers are eager to apply this method of grazing in anticipation of receiving increased levels of production. To obtain the types of data needed to evaluate the long-term effect of grazing requires the application of treatments through different weather cycles. New Mexico State University has responded to this need by implementing a short-duration grazing system on the Fort Stanton Experimental Ranch.

Why is it important to evaluate SDG at this location? One of the major problems incurred in evaluating grazing treatments is the availability of adequate controls. Determining the carrying capacity of an area requires several years of controlled grazing at different stocking rates while monitoring vegetation, livestock, and weather. The previous research conducted in this area provides a baseline for comparison to short-duration grazing. Moving to a new location or changing the site relations in the pastures at the present location would require reestablishment of the carrying capacity. Data collected over the past 18 years would not be directly applicable.

Once the long-term grazing studies are completed, then the economist can use the data and determine if implementation of the system is economically feasible from the rancher's or agency's point of view.

Results of the Fort Stanton Ranch study could very well be just as important if they found that the expected increases in benefits of the grazing system when compared to continuous grazing would not pay the cost of the change. In this case, ranchers and/or government agencies

would have the data needed to make the decision not to implement a new system of grazing. The savings in not implementing the system could amount to millions of dollars (Gutierrez, 1982) if applied throughout the West.

The value of the integrated research program on the Fort Stanton Ranch greatly exceeds the value of individual studies considered singly. In the past, research has often been approached on a fragmented basis with the primary emphasis being placed on individual studies to make simple treatment comparisons. However, with the development and application of the ecosystem approach in research, it becomes necessary to consider many components of the system and their interactions. This requires information about soils, climate, vegetation, livestock, wildlife, and their interactions. Future progress in range research will depend heavily upon the ability of researchers to utilize the systems approach. Because of the significant amount of research already conducted on this location, there is a great amount of information available. This makes the Fort Stanton Ranch an excellent location for putting all this information together and demonstrating the value of integrated rangeland research (Klemmedson et al., 1978).

The research on wildlife populations and habitat at Fort Stanton Ranch is important in several respects: (1) it has been a long-term effort and a valuable data base has been accumulated on the mule deer herd; (2) the land and land-use program is controlled by New Mexico State University, which is essential to a long-term, continuous research effort; (3) the vegetation is representative of a very large part of the rangelands of New Mexico and the Southwestern United States, and there appears to be no other comparable area available to New Mexico University for research on range-wildlife-livestock interactions; and (4) the past history of use (livestock, human, etc.) is known for several decades previous to the advent of research by New Mexico State University scientists.

Among the research projects dealing with wildlife, the research on mule deer in the Pinyon-Juniper habitat is especially valuable. With perhaps the exception of Fort Bayard, where research on mule deer has been conducted since the early 1960s by the New Mexico Department of Fish and Game, no other long-term population records of mule deer in New Mexico are available. The 18-year data bank on mule deer in Pinyon-Juniper rangeland rivals any study of mule deer in the Southwest. A decline in mule deer numbers in the mountain and desert West has occurred since the 1960s (Workman and Low, 1976), and the data on the Fort Stanton Ranch herd reflect these trends.

The other studies on wildlife at Fort Stanton Ranch are important, but do not have the special long-term character of the mule deer studies. No particular plan or continuity in design seems to underlie these studies. Moreover, the emphasis on range-livestock research has not always considered wildlife needs in study designs. The foremost example of this deficiency lies in the fencing of antelope from use of the mesa at Site B. To be sure, some priorities in research thrusts are necessary, and the priorities in this case have favored the economically important livestock industry.

A good measure of the relevance of research at Fort Stanton Ranch is to compare current research and recently completed studies with statements of research needs in the various fields of science covered by the Fort Stanton Ranch program. When this is done, one finds that a large percentage of current and recently completed studies at Fort Stanton Ranch fall within the categories that have been considered high priority by those who have recently reviewed research needs (Great Plains Agriculture Committee, 1976; Western Regional Task Force, RP 2.06, 1977; Joint Task Force, 1978; National Cattleman's Association, 1979; Larson et al., 1981; USDA Science and Education Administration, 1981). These categories include (1) determination of long-term effects of intensive management on water quality and yield from different kinds of forest and associated rangelands; (2) increase in our capability to integrate various forest range management techniques to enhance a variety of resource uses, while minimizing adverse environmental effects; (3) methods to predict the consequences of management practices on the fundamental parts of the hydrologic cycle; (4) development of effective techniques for improvement of rangelands and their multiple resource values, including the integrated use of grazing systems, seeding, fertilization, noxious plant control, pasture crops, and structural developments; (5) increased knowledge of range plant ecology and physiology; and (6) interaction between grazing systems and wildlife production on rangelands. Moreover, analysis of the research program at Fort Stanton Ranch demonstrates that New Mexico State University researchers recognize the need to integrate their research with these national objectives and contribute to understanding the impacts of rangeland use on the multiple resources and values of rangelands (Klemmedson et al., 1978).

We believe that the research program does have special value to New Mexico State University. It would be difficult to judge otherwise, based on the intensity of the faculty and graduate student research effort that has taken place at Fort Stanton Ranch over the past 15 years. New Mexico State University has the opportunity to go even farther with integrated research. They should capitalize on this opportunity.

One of the real values of having a facility like Fort Stanton Ranch is that the research staff can build a "pool of knowledge" from which to launch new research. That's the way science works. It's like building a jigsaw puzzle or a brick house. Each piece of knowledge adds to the value and understanding of the whole. This type of in-depth integrated research program is valuable to participating faculty, because it allows them to concentrate their research efforts and build expertise rather than spread themselves thinly over a diverse area of research interests. This kind of research program is valuable to faculty and students alike in that it helps them to see how the diverse parts of an ecosystem fit together and function as a whole. Thus, it has educational value. This has been demonstrated over and over again at centers for agricultural and ecological research around the world (e.g., Rothamsted Experiment Station, Oak Ridge National Laboratory, Hubbard Brook Experimental Forest).

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CONCLUSIONS

In the preceding chapters the objectives of the Fort Stanton Ranch research program have been described and the impacts of airport construction on the "Airport" mesa have been discussed. This analysis has led the Committee to several conclusions:

(1) The research at Fort Stanton Ranch is an important and substantial element in the work of the Department of Animal and Range Sciences. It represents a large monetary commitment by New Mexico State University. Construction of an airport at Site B would materially affect this program and the department by reducing or eliminating the grazing and associated studies on the mesa and reducing faculty and student activity at Fort Stanton Ranch.

(2) The Fort Stanton Ranch research program is an integrated long-term study of plant-animal interaction with several grazing systems. Disruption of the research at this stage will prevent full use of the investment of the university at the site, will materially reduce the value of the individual projects, and will essentially reduce the grazing studies, especially the short-duration cell study, to zero. These impacts will, in turn, prevent the university from applying techniques of systems analysis to integrate all the individual studies into an explanatory predictive model of grazing in Shortgrass Prairie.

(3) Fort Stanton Ranch, because of its location and size, is an unusual facility for grazing research. It is representative of two broad and important types of vegetation in the Southwest. No other active stations have grazing research programs operating in this mix of vegetation types. The uniqueness of Fort Stanton Ranch has been nationally recognized by its designation in the Experimental Ecological Reserve System. Use of the mesa for airport construction would eliminate an important public reserve for present or future research use.

(4) The prime research projects that will be disrupted by airport construction on the mesa are the core studies of the integrated program--the grazing management studies. These include the continuous, deferred rotation and the short-duration grazing comparisons, the plant response studies, and the exclosure studies. Most of these studies cannot be easily moved and would probably be terminated. The committee sees no way to mitigate the effect of the airport on these research projects.

(5) Other research projects will be impacted by the airport construction, but not so seriously that they will be terminated at Fort Stanton Ranch. These include the wildlife programs, the plant competition studies, the study of control of noxious plants, and the watershed studies.

(6) It is unlikely that the university could move the integrated program to some other site if airport construction was approved. First, no other comparable site is obvious and available. Second, if a site was available it would require a large investment of time and money to rebuild facilities and the base of information required to undergird the core studies. And third, the faculty would have to be motivated to repeat work already begun, but prematurely terminated.

(7) Disruption of research after individuals have committed a substantial personal effort to the baseline studies, experimental design, and initial observations is a serious matter. Scientific work of this type is slow and tedious and cannot be picked up and moved from site to site. Disruption of the research program could have adverse effects on the morale and professional careers of the faculty and graduate students of the Department of Animal and Range Sciences and reduce their overall effectiveness.

(8) All of these impacts would serve to reduce the efficiency and productivity of the Department of Animal and Range Sciences in one of its prime roles as a generator of tested ideas and concepts of ranch management for the livestock industry of New Mexico. This industry is of major economic importance to the state and involves a large number of citizens directly and indirectly through all the subsidiary activities supporting agriculture and ranching. Fort Stanton Ranch has a unique value to ranching interests, since it is a realistic size to test grazing systems, and it represents a widespread vegetation type. The research on the Fort Stanton Ranch directly compares grazing management systems, and rests on a firm foundation of basic biological and ecological research on cattle, plants, soils, and wildlife.