Research Natural Areas

USDA Forest Service, Rocky Mountain, Intermountain, Southwestern and Great Plains States

SEARCH RNAs BY

County

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A cooperative project of the

USDA Forest Service Northern Region, Rocky Mountain Region, Southwestern Region, Intermountain Region, Rocky Mountain Research Station, and the Montana Natural Heritage Program

ELGIN

General information S.USNAHP*86

- Created: 1974
- Size: 600 (acres)
- Elevation Range: 4960 - 5100ft
- Location: *This RNA is located along the west side of Canello Hills to the south of Sonoita, Arizona. The RNA is comprised of National Forest, state and private lands. About 280 acres are within the Coronado National Forest and about 140 acres is state land. The remainder resides within the Audubon Society's Research Ranch at Elgin.*

Site Description

Elgin RNA occurs in the transition zone between southwestern grasslands and oak savanna. Common oaks in the area include Mexican blue oak (Quercus oblongifolia) and Emory oak (Q. Emoryi). A diversity of grasses are present and include: blue grama (Bouteloua gracilis), sideoats grama (B. curtipendula), plains lovegrass (Eragrostis intermedia) and kane beardgrass (Andropogon barbinodis). Topography in the RNA varies from relatively flat ridges to a rolling terrain with slopes up to 35%. The RNA is shared between the Coronado National Forest and the National Audubon Society Research Ranch at Elgin. Past grazing of this site is evidenced by the presence of species such as mat muhly (Muhlenbergia richardsonis) and shrubby cinquefoil (Potentilla frutiosa).

Climate and Enviromental Information

Data not Available

Vegetation - Elgin

Grama-Tobosa Prairie (K 48)

ESTABLISHMENT REPORT
ELGIN RESEARCH NATURAL AREA
Coronado National Forest
Santa Cruz County, Arizona
November 5, 1973

NARRATIVE REPORT

I. Principal Distinguishing Features

The proposed Elgin Research Natural Area is an open grassland containing shortgrass species. The topography varies from relatively flat ridges to a rolling terrain with slopes up to 35%. The area has been grazed in previous years but no grazing has occurred during the past four years.

II. Location

The following is a description of the Elgin Research Natural Area:

State Land; all of the $NE\frac{1}{4}$ Section 23, T. 22 S., R. 18 E., lying east of the unimproved road, approximately 140 acres.

Private Land; all of the $SE\frac{1}{4}$, all of that portion of the $SW\frac{1}{4}$ lying east of the unimproved road, all in Section 23, T. 22 S., R. 18 E., approximately 180 acres.

National Forest Land; all of the $E\frac{1}{2}$ of the $W\frac{1}{2}$ of Section 26 lying east of the unimproved road; $W\frac{1}{2}$ of the $E\frac{1}{2}$ lying west of the allotment boundary fence, all in Section 26, T. 22 S., R. 18 E., total 280 acres.

140 acres State
180 acres Pvt.
280 acres N.F.

Total acres proposed - - - 600 acres

The 140 acres of State land is included in this proposal to show how it lies contiguous to the remainder of the Natural Area. However, negotiations for inclusion of this parcel in the proposed Natural Area will be conducted by the Research Ranch and the State of Arizona.

That portion described and shown as private land in Section 23 is owned by the Research Ranch. It is their desire that this be included in the proposal as described in Supplement No. 1 to the Memorandum of Understanding.

III. Area by Cover Types

The cover type on this area, containing 600 acres, is K-34 grama-tobosa (Bouteloua-Hilaria). The present vegetation condition is reflecting the past grazing use on the area, thus, the composition is not what could be expected under natural conditions. However, under protection from grazing by domestic livestock, the cover will gradually change to one that will meet the K-34 standards. Moderate slopes and rolling hills contain grasses dominated by hairy grama (Bouteloua hirsuta), side-oats grama (B. curtipendula), plains love-grass (Eragrostis intermedia), wolftail (Lycurus phleoides), and green sprangletop (Leptochloa dubia). Alkali sacaton (Sporobolus airoides) is dominant on canyon floors. Scattered oaks occur in the deeper soils of shallow canyons where climate is moderate by decreased wind and absorbed radiation, and greater soil moisture. On the slopes and ridges, widely scattered shrubs occur, e.g., beargrass (Nolina microcarpa), senecio (Senecio longilobus), and false mesquite (Calliandra spp.).

IV. Physical and Climatic Conditions

A. Topography

The topography is flat to gently rolling with some slopes approaching approximately 35% for short distances. The mean elevation is 5,000 feet above sea level and does not vary 100± feet from this mean. The drainage is north and east via the Babocomari River into the San Pedro River. The attached photos illustrate the gentle topography that is characteristic of the area.

B. Climate

The area receives an average precipitation of approximately 17 inches per year. This can be further broken down to 6 inches in the winter, October through April, and 11 inches in the summer, May through September. The climate is warm with the average temperature ranging from 20° F. to 100° F. with a seven month growing season.

C. Soils

About one half of the area is white house gravelly loam 0 to 10% slopes and the other half is 10 to 35% slopes of white house gravelly loam. These are dark colored, deep, well developed

soils formed from old alluvial fan deposits. About 3 inches of brown gravelly loam surface overlies 46 inches of reddish brown clay loam or clay subsoil. The substratum is gravelly and cobbly, mixed old alluvium. The surface ph is 6.8 and subsoil ph of 7.2. The surface coarse fragment cover is 15 to 35% gravel.

Range Production - Moderately High

Hydrologic subgroup - D2

Erosion Hazard - Low to High (depending on slope)

V. Description of Values

A. Flora

This proposed research natural area offers the following opportunities in vegetation research.

1. The research natural area within the short grass association near the southern and western extremities of the normal range for this association.

2. Provides a suitable area where natural trends in vegetation change can be studied following the removal of domestic livestock.

In past years, this area has been moderately to heavily grazed by a herd of registered cows. The existing vegetation reflects this use through the abnormal high percentage of lower value species (Invaders) such as mat muhly (Muhlenbergia richardsonis) and shrubby cinquefoil (Potentilla fruticosa). At this time the vegetation is reflecting the beneficial aspects of rest as a result of the livestock being removed 4 years ago. Basically, this change has been in the form of increased vigor of the existing plant species and the accumulation of plant litter causing minor changes to begin occurring in the microclimate. The dramatic changes in vegetation that have occurred are a result of livestock removal. Future changes toward a more balanced composition will not be so noticeable and will progress slower.

B. Geology

There are no known direct geological values on the proposed research natural area.

C. Fauna

Wildlife activity on the area is very minor and insignificant, there being only two species of game animals observed, white-tailed deer and Javelina. There are numberous species of song birds and small game animals. These will need to be inventoried.

D. Minerals

There are no known minerals or mineral activity in the area.

E. Recreation

Due to access and associated vegetation types, the area receives only light use by recreationists.

F. Water Use

Water production on this area is negligible with any excess being committed to downstream use.

G. Other Uses

The Research Range is an outdoor laboratory for environmental studies dedicated to the improvement of man's threatened environment. The Research Ranch has been inventoried by students from Colorado State University in cooperation with IBP using computer data processing techniques. In addition, ecological studies were conducted. As a result of a grant from the Atomic Energy Commission, intensive studies on 1,000 acres were conducted. Present research and evaluation has resulted in classification of soils, vegetation, geology, and fauna.

The continually updating of changes in flora and fauna occurring on the Ranch and the continuity of programs are valuable assets. This project will compliment the proposed Research Natural Area as well as add to its overall value.

H. Recommendation

The Elgin Research Natural Area provides an opportunity to integrate the research natural area program with the programs that are in the process of being developed on the Research Ranch, Inc., and establishment is recommended.

DATE _____ _____
R-3 Research Natural Area Committee

DATE 10-3-73 Charles R. Ames
Forest Supervisor

DATE 10/24/73 W. D. Hurst
Regional Forester

DATE 11/21/73 Paul J. Wenger
Director - Rocky Mountain Forest & Range Exp. Station

DATE _____ _____
Director, Recreation & Lands

DATE _____ _____
Deputy Chief - Research

DATE _____ _____
Chief

ORDER

By virtue of the authority vested in me by the Regulations posted in 36 CFR 251.23, I hereby designate as the Elgin Research Natural Area the lands described in the preceding report by the Region 3 Research Natural Area Committee dated November 5, 1973; said lands shall hereafter be administered as a Research Natural Area, subject to the said regulations and instructions thereunder.

1-25-74
Date

John R. McGuire by R. Burgess
Chief, Forest Service

MEMORANDUM OF UNDERSTANDING AMONG THE RESEARCH RANCH, INCORPORATED, THE REGIONAL FORESTER, SOUTHWESTERN REGION, AND THE DIRECTOR, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

The Research Ranch, a non-profit, tax-exempt, charitable and scientific organization established as an Arizona corporation for ecological and environmental research, education and conservation.

And the Forest Service, United States Department of Agriculture, composed of the Rocky Mountain Forest and Range Experiment Station and the Southwestern Region, which includes the Coronado National Forest, acting under the authority established by the Agricultural Organic Act of May 15, 1862, and the McSweeney-McNary Forest Research Act of May 22, 1928

Hereby understand and agree to the following:

A. As part of The Research Ranch, an area of approximately 8,000 acres located near Elgin, Santa Cruz County, Arizona, there will be included a portion of the Patagonia Ranger District, Coronado National Forest, known as the Chuney grazing allotment consisting of 2,275 acres. Inclusion of the National Forest acreage will be subject to these provisions:

1. National Forest status and public use of the Federal land will not be affected or altered by participation in the programs of The Research Ranch. The Forest Service will retain authority and responsibility for protection and management of the National Forest area involved.

2. This area will be designated by the Patagonia Ranger District Multiple Use Plan as a management unit wherein management emphasis will be placed on the overall research program of The Research Ranch.

3. Project proposals and study plans affecting the National Forest portion of The Research Ranch must be approved by the Forest Service.

4. Project proposals involving wildlife or introduction of wildlife species not now present will be coordinated with and approved by the Forest Service and the Arizona Department of Game and Fish. Introduction of exotic wild animal species will not be undertaken or authorized on National Forest lands without the approval of the Fish and Wildlife Service, United States Department of the Interior.

5. Publications resulting from studies conducted on The Research Ranch will acknowledge use of locations on the Coronado National Forest.

6. In addition to appropriate cooperative signing that may be done by mutual agreement, the Forest Service reserves the right to place public informational signs on the National Forest land involved and to do whatever else may be deemed appropriate for interpretation of the area and its purposes to the public.

7. Grazing of domestic livestock in connection with research projects on the National Forest portion of The Research Ranch may be authorized by the Forest Supervisor in accordance with applic ble Forest Service regulations and policies.

8. The Forest Service will have complete responsibility for fire prevention and suppression of fires on or threatening the National Forest.

B. The Rocky Mountain Forest and Range Experiment Station is authorized to conduct research on the National Forest portion of The Research Ranch. Research by the Experiment Station on the private and State portions of The Research Ranch will be subject to the review and approval of the Board of Trustees.

C. The Forest Service will be represented on the Board of Trustees by the Forest Supervisor, Coronado National Forest, and the Range Project Leader, Rocky Mountain Forest and Range Experiment Station, Tucson. Through its trusteeship, the Forest Service will approve or disapprove all projects involving use of any National Forest lands by The Research Ranch.

D. A map (2" = 1 mile scale) showing location and lands status of The Research Ranch is attached and made part of this agreement.

E. No Member of, or Delegate to, Congress or Resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

F. This agreement may be terminated at any time by mutual consent of all parties involved or within 90 days following written notice from either The Research Ranch Board of Trustees or the Forest Service.

The parties named above hereby execute this agreement as of the final date of signature.

The Research Ranch

By _____ Date 3 DECEMBER

_____

Regional Forester, Southwestern Region

_____ Date 12/16/70

Director, Rocky Mountain Forest & Range Experiment Station

_____ Date 12/10/70

SUPPLEMENT NUMBER 1

TO

MEMORANDUM OF UNDERSTANDING (December 16, 1970) AMONG
THE RESEARCH RANCH, INCORPORATED,
THE REGIONAL FORESTER, SOUTHWESTERN REGION,
AND THE
DIRECTOR, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

This amendment provides for the establishment, protection, and use of a Research Natural Area in T. 22 S., R. 18 E., Santa Cruz County, Arizona. The Elgin Research Natural Area, as proposed, includes: about 140 acres of land belonging to the State of Arizona ($NE\frac{1}{4}$ Section 23), about 180 acres of land belonging to the Research Ranch ($SE\frac{1}{4}$ Section 23) and about 280 acres of National Forest Land (mainly in $E\frac{1}{2}$ Section 26). The area is bounded on the north by the north line of Section 23; on the south by the south line of Section 26; on the west by an undeveloped road; and on the east by: (1) the east line of Section 23 and (2) the existing allotment boundary fence in Section 26, as outlined on the attached map.

The Research Ranch agrees that land belonging to the Research Ranch that lies within the Elgin Research Natural Area shall be so recognized and used during the corporate life of the Research Ranch Inc. as limited by Arizona Statutes. Also, any land belonging to the State of Arizona that is dedicated by the state to be included in the Elgin Research Natural Area will be administered in the same manner as Research Ranch lands within the Elgin Research Natural Area so long as the State lands are controlled by or leased to the Research Ranch.

The Forest Service agrees that National Forest land within the Elgin Research Natural Area will be so designated indefinitely and will take action to withdraw the affected lands from mineral entry.

It is mutually agreed that public access to and use of the National Forest land within the Elgin Research Natural Area shall not be more restrictive than set forth in guidelines contained in the Forest Service manual (copies of pertinent sections attached) and that legitimate users will not be denied access to the area by agents of either the U. S. Forest Service or the Research Ranch Incorporated.

No experiments or demonstrations that involve grazing of adjacent lands will be initiated unless the Research Natural Area is fenced to protect it against grazing before grazing begins. The expense of such fencing will be bourne by the organization or individual responsible for the experiment.

This provision of the amendment is binding on all parties and is subject to revision or cancellation only by mutual agreement among all the parties concerned.

The parties named above hereby execute this agreement as of the final date of signature.

THE RESEARCH RANCH

Reid B. Appleton Date Oct. 12, 197

V. Bruce Cobb Date Oct 16, 197

REGIONAL FORESTER, SOUTHWESTERN REGION

Lyle D. Hurst Date 10/24/73

DIRECTOR, ROCKY MTN. FOREST & RANGE EXP. STATION

Karl T. Arnold Date 11/21/73

4063.3 - Size. Research natural areas should be large enough to provide essentially unmodified conditions in their interior portions--usually over 300 acres. Exceptions to the usual minimum of 300 acres should be limited to truly outstanding cases. Seldom can tracts smaller than 300 acres be expected to maintain essentially unmodified conditions unless they are buffered by scenic or other areas that are maintained in relatively unmodified conditions.

4063.4 - Protection and Management. A research natural area must be protected against activities which directly or indirectly modify ecological processes if the area is to be of value for observation and research on plant and animal succession, habitat requirements of species, insect and fungus depredations, soil microbiology, phenology, and related phenomena. Logging activities and uncontrolled grazing by domestic livestock are not permitted. The criterion for management of research natural areas is for protection against unnatural encroachments.

4063.41 - Identification. Research natural areas should be identified in the administrative records as to location, purpose, and objectives, and the boundary marked in the field. Signs which would tend to attract sightseers, recreationists, and casual visitors should be avoided. However, if roads or trails pass along the boundary or through the research natural area, limited posting may be needed to protect the area.

4063.42 - Fences. Research natural area boundaries need not be fenced unless necessary for protection against livestock or excessive human use.

4063.43 - Publicity. Publicity is generally limited to professional groups at either national, State, or university levels and mainly to inform scientists and educators of the location, vegetation types, and administering agency in order to make the fullest proper use of the research natural areas. Other publicity should be avoided.

4063.44 - Physical Improvements. Generally speaking, no physical improvements such as roads, trails, fences, or buildings should be permitted within a research natural area. Temporary facilities needed for research, such as instrument shelters, may be installed with the approval of the Station Director. Except as essential to fire protection of adjoining lands, no buildings, roads, or trails should be permitted at or on the boundaries of a research natural area.

4063.45 - Protection. Fires within a research natural area should be extinguished as quickly as possible, but no cleanup, fire hazard reduction, or reforestation should be undertaken.

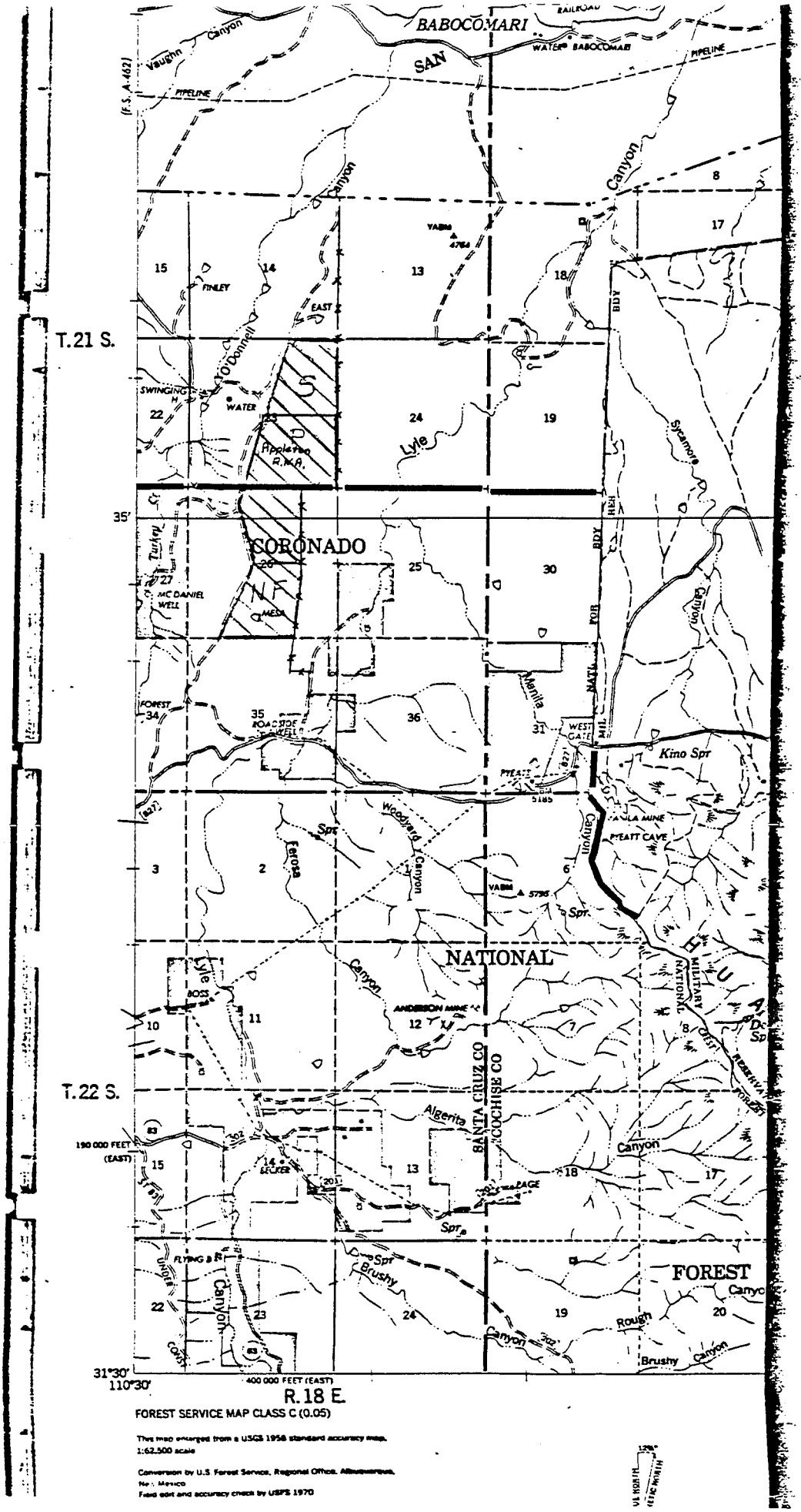
No control of insects or disease should be instituted unless the infestation or infection threatens adjacent forests or will drastically alter the natural ecological processes within; for example, white pine blister rust. Insect- or disease-killed trees are a part of the natural forest and should not be felled or removed.

4063.46 - Public Use. Picnicking, camping, collecting plants, gathering nuts and herbs, picking berries, and other public uses which contribute to modification of a research natural area should be discouraged or expressly prohibited if such uses threaten serious impairment of research or educational value. Hunting, fishing, and trapping should be prohibited only if the removal of game, fish, and furbearers is likely to be on a scale sufficient to affect the biotic communities

4063.47 - Scientific and Educational Use. The Forest Service encourages use of research natural areas by responsible scientists and educators. Generally the educational use should be at the upperclassman or graduate college level. Research on natural areas will be essentially nondestructive in nature. Studies that require timber felling, seedbed modification, or extensive soil excavation should be done on the experimental forests and ranges, or similar areas.

Because of the fragile character of most research natural areas, cooperative agreements will normally be prepared between the Forest Service and non-Forest Service scientists outlining briefly the mechanics of field research and the limitations thereto. Forest Service scientists should cooperate in the research whenever possible in order to derive the greater benefit from the work.

4063.48 - Vegetation Management. Station Directors may authorize such management practices as are necessary to preserve some representation of the vegetation for which the natural area was created originally, including Ribes eradication in white pine types, control of excessive animal populations, or prescribed burning or grazing to maintain a grass community. Only tried and reliable techniques will be used, and then only where the vegetative type would otherwise be lost without management. The criterion here is that the management must provide a closer approximation of the vegetation and the processes governing the vegetation than would be possible without management. If doubt exists about the need for vegetation management or the reliability of the techniques, then nothing should be done. Where management practices are necessary, a portion of natural areas should be kept untreated as a "green check."

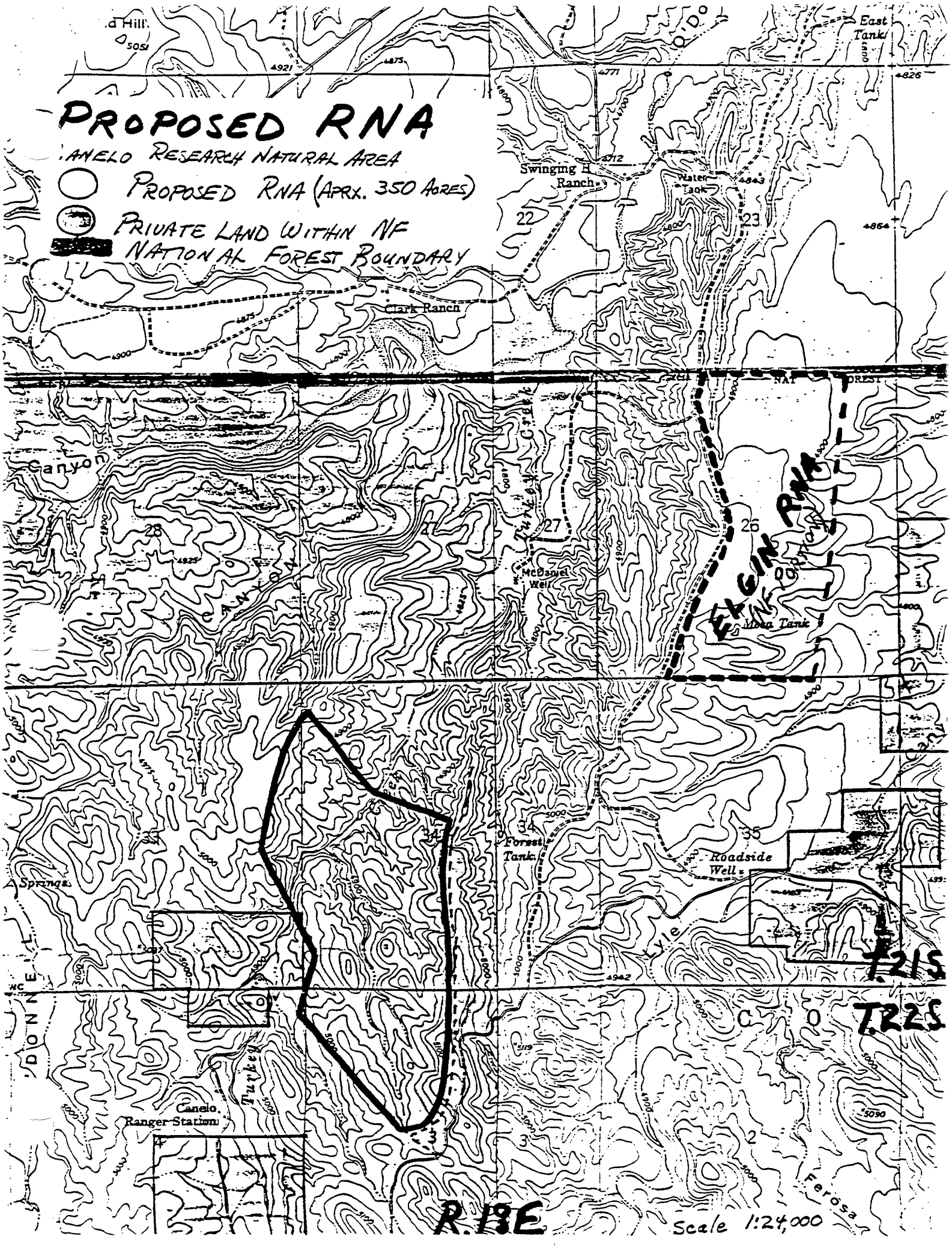


FOREST SERVICE MAP CLASS C (0.05)

This map enlarged from a USGS 1958 standard accuracy map, 1:62,500 scale

Conversion by U.S. Forest Service, Regional Office, Albuquerque, New Mexico

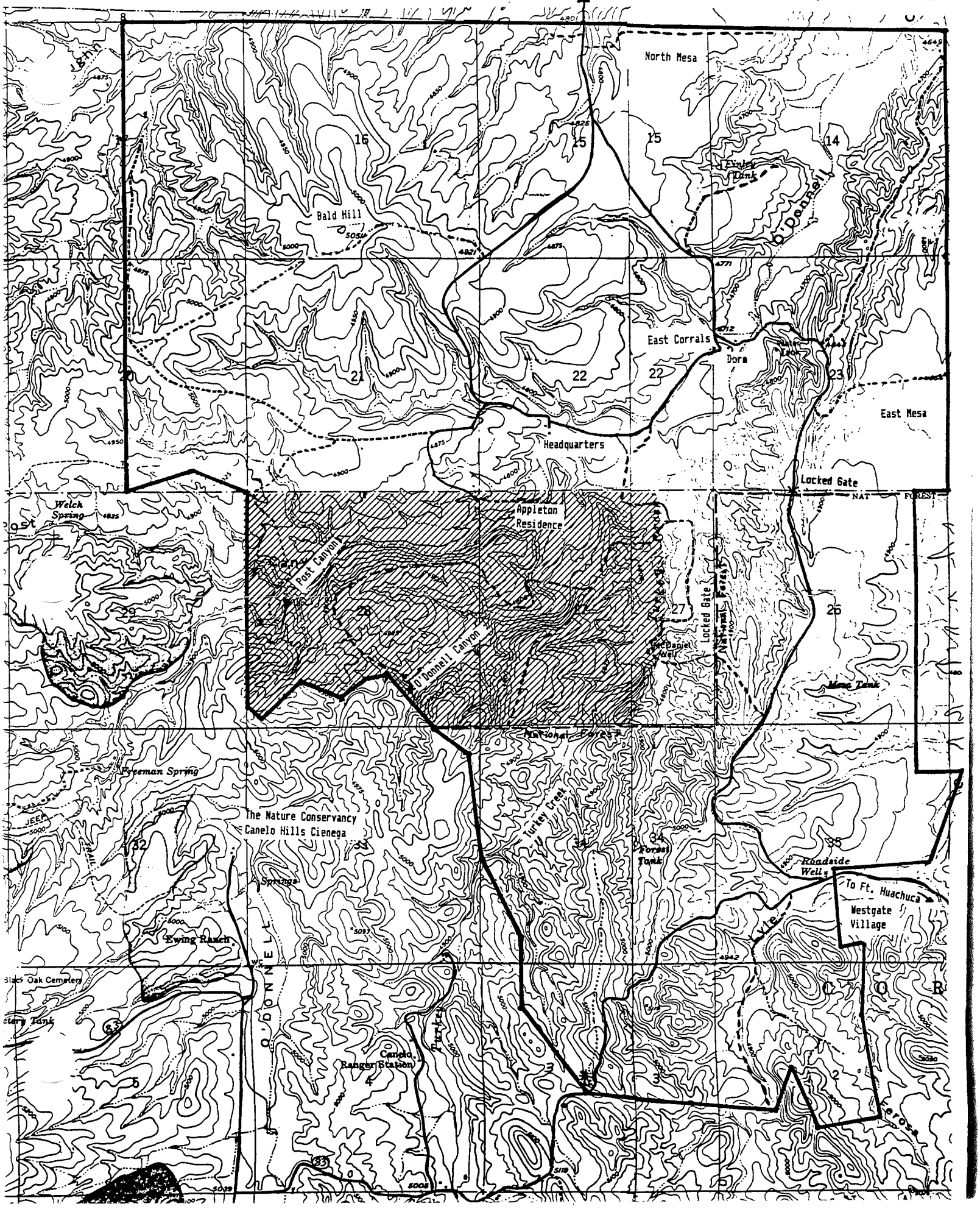
Field edit and accuracy check by USFS 1970

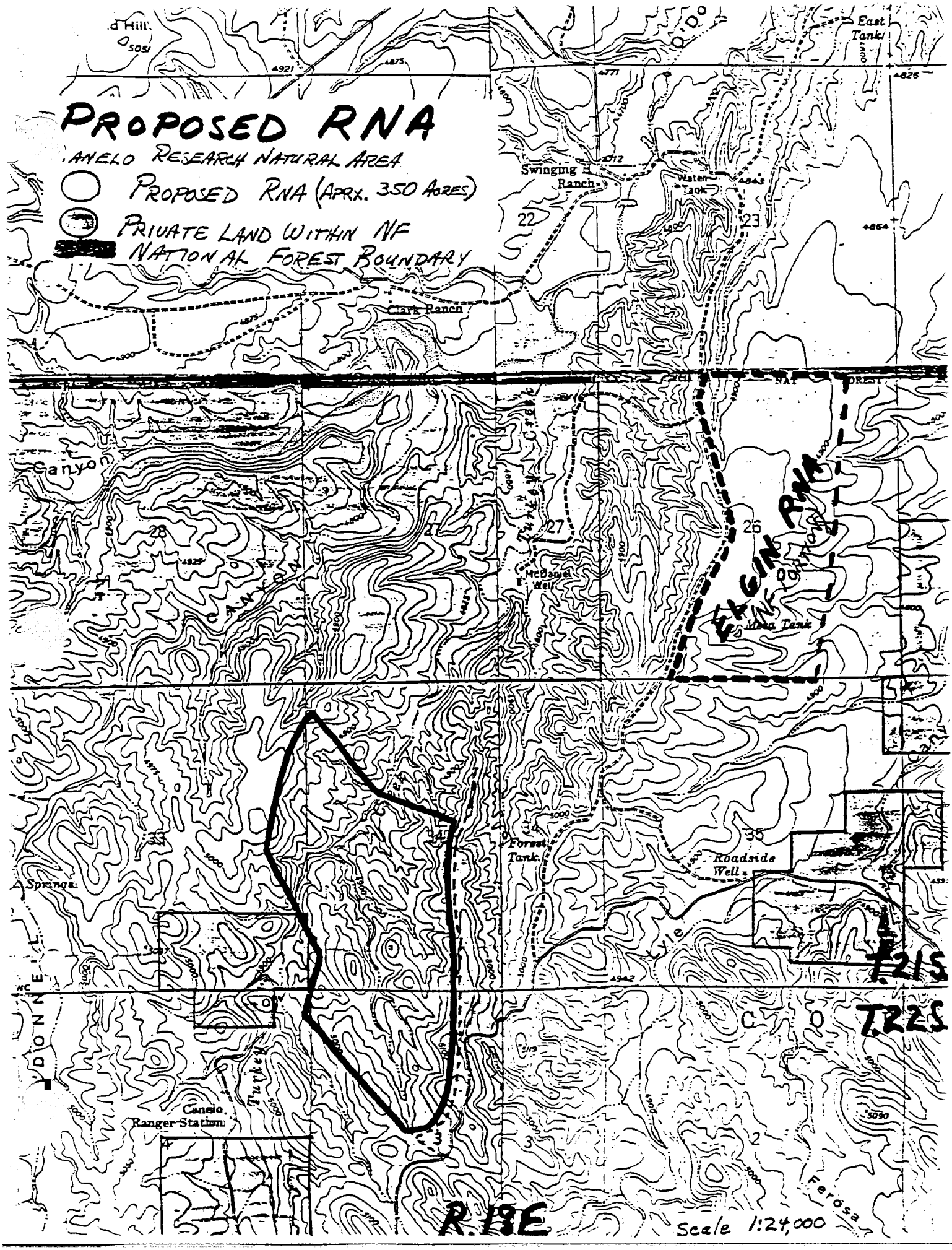

PROPOSED RNA
CANELO RESEARCH NATURAL AREA
PROPOSED RNA (APRX. 350 ACRES)
PRIVATE LAND WITHIN NF
NATIONAL FOREST BOUNDARY
Clark Ranch
Swinging H Ranch
Water Tank
East Tank
Canyon
Turkey Cr.
McDaniel Well
Mesa Tank
ELGIN RNA
Forest Tank
Roadside Well
Springs
Tyle
Canelo Ranger Station
Turkey
DONNELLY
T.21S
T.22S
R.18E
Scale 1:24,000

Areas marked in cross hatching (shaded) are private property closed to the public.

A toilet is available in the small garage adjacent to the dorm (see map).

2. No picnics or camping. 4. No firearms.
5. Vehicles stay on roads
(solid lines= 2-wheel drive, dashed= 4-wheel drive)




PROPOSED RNA
CANELO RESEARCH NATURAL AREA
PROPOSED RNA (APPX. 350 ACRES)
PRIVATE LAND WITHIN NF
NATIONAL FOREST BOUNDARY
Clark Ranch
Swinging H Ranch
Water Tank
East Tank
Canyon
Turkey Creek
McDaniel Well
Mesa Tank
Forest Tank
Roadside Well
Springs
Canelo Ranger Station
Turkey
DONNELL
Vie
Ferosa
T.21S
T.22S
R.18E
Scale 1:24,000

United States Department of Agriculture
Forest Service
Region 3
Range Management
517 Gold Avenue SW
Albuquerque, NM 87102

JUL 30 1982

Reply to 4060

Date JUL 2[illegible]

Mr. & Mrs. Carl E. Bock
Co-Directors Audubon Society Research Ranch
Box 44
Elgin, AZ 85611

Dear Mr. & Mrs. Bock:

Enclosed is a signed copy of the Memorandum of Understanding covering Coronado National Forest lands managed as a part of the Audubon Research Ranch Facility. We believe that through these cooperative efforts, better information on grassland management will be developed. Application of this new technology will provide a basis for improving productivity through management.

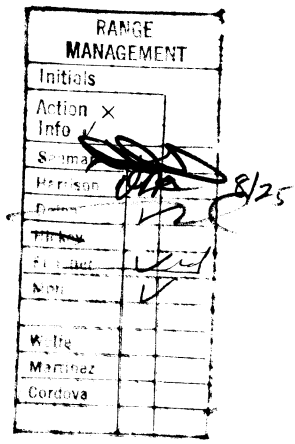
In addition, I'm certain that you are aware how important it is to recognize in any research reports, the contributions made by the Arizona State lands and Coronado National Forest System lands. The public needs an awareness of the values being obtained through this cooperative program. This awareness provides the best assurance of continued support for allocating Arizona State and National Forest System lands to this effort.

The final agreement includes the corrected citation for PL--307, and on page 3 item C. number 2, the word "resource" was changed to ranch.

Sincerely,

M.J. HASSELL
Regional Forester

Enclosure



The Research Ranch
602-455-5731

FS-6200-11 (8-80)

IN WITNESS WHEREOF, the parties hereto have executed this Memorandum of Understanding as of the last date written below.

The Audubon Society Research Ranch

By Carl E. Bock Date June 14, 1982

Regional Forester, Southwestern Region

W J Hansen Date 7/28/82

Director, Rocky Mountain Forest and Range Experiment Station

for J Stanmore Date 7/13/82

CHARLES M. LOVELESS
Director

MEMORANDUM OF UNDERSTANDING AMONG THE NATIONAL AUDUBON SOCIETY, THE REGIONAL FORESTER: SOUTHWESTERN REGION, AND THE DIRECTOR, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

This Memorandum of Understanding, made and entered into by and among the National Audubon Society Research Ranch, a nonprofit, tax-exempt, charitable and scientific organization established as an Arizona corporation for ecological and environmental research, education and conservation, hereafter referred to as the SOCIETY; acting in behalf of and by agreement with the Research Ranch Foundation, hereafter referred to as the FOUNDATION: and the Forest Service, United States Department of Agriculture, through the Director of the Rocky Mountain Forest and Range Experiment Station, hereafter referred to as the STATION, and the Southwestern Region, which includes the Coronado National Forest, hereafter referred to as the REGION, acting under the authority established by the Agricultural Organic Act of May 15, 1862, and the Forest and Rangeland Resources Research Act of 1978, PL 95-307, 16 USC 1643.

The parties hereto are mutually interested and desire to cooperate in studies to encourage research on factors related to maintaining and improving management of Southwestern desert grasslands and to maintain the established Elgin Research Natural Area. This agreement supersedes the previous agreement with Research Ranch of December 16, 1970, covering management of National Forest System lands by the parties involved. In accordance with this Memorandum of Understanding, the parties hereto agree as follows:

A. That the SOCIETY SHALL:

1. Submit project proposals and study plans affecting National Forest System (NFS) lands included in The Research Ranch for review and approval of the Forest Supervisor, Coronado National Forest.

2. Acknowledge use of locations on the Coronado National Forest in publications resulting from studies conducted on The Research Ranch, and provide copies of studies/research and resulting publications to REGION and STATION.

3. Provide for the protection, and use of an established Research Natural Area in T. 21 S., R. 18 E., Santa Cruz County, Arizona. The Elgin Research Natural Area includes: about 140 acres of land belonging to the State of Arizona (NE¼, Section 23), about 180 acres of land belonging to the Research Ranch (SE¼, Section 23) and about 280 acres of NFS land (mainly in E½, Section 26). The area is bounded on the north by the north line of Section 23; on the south by the south line of Section 26; on the west by an undeveloped road; and on the east by: (1) the east line of Section 23 and (2) the existing allotment boundary fence in Section 26, as outlined on the attached map. Exhibit A.

4. Recognize and use in accord with Research Natural Area purposes land belonging to the SOCIETY that lies within the Elgin Research Natural Area during the corporate life of the Audubon Society Research Ranch, Inc., as limited by Arizona Statutes. Also, any land belonging to the State of Arizona that is dedicated by the state to be included in the Elgin Research Natural Area will be administered in the same manner as SOCIETY lands within the Elgin Research Natural Area so long as the State lands are controlled by or leased to the SOCIETY.

5. Initiate no experiments or demonstrations that involve grazing of adjacent lands unless the Elgin Research Natural Area is fenced to protect it from grazing. The expense of such fencing will be borne by the organization or individual responsible for the experiment.

6. Assure that all research cooperators are provided with a copy of this agreement and that they comply with all provisions that apply to their activities.

7. Maintain range improvements specified in map Exhibit D and identified on the following inventory:

Range Improvement Inventory and Maintenance Responsibility
Research Ranch
Coronado National Forest

NAME	KIND	IMP. NO.	UNITS	ASSIGNMENT
MESA TANK	DAM &/OR RESVOR	000001	12	Research Ranch
CANELO CHUNEY FEN	ALOT.BDRY.FENCE	R00001	1.0	Canelo Permittee
FOREST TANK	DAM &/OR RESVOR	000002	13	Research Ranch
CHUNEY SPR	DELVELOPED SPRING	000015		Research Ranch
ROADSIDE WELL	WELL, WINDMILL	000003	17	Research Ranch
SOUTH WELL	WELL, WINDMILL	000004	21	Research Ranch
BOUNDARY FEN	N.F. BDRY FENCE	000005	1.0	Research Ranch
WEST BDRY	ALOT.BDRY.FENCE	000006	2.0	Research Ranch
DIV FEN	ALOT.ENTR.FENCE	000007	1.7	Research Ranch
DIV FEN	ALOT.INTR.FENCE	000008	1.0	Research Ranch
CHUNEY MANILA	ALOT.BDRY.FENCE	000010	2.0	Manila Permittee
Z TRIANGLE CHUNEY	ALOT.BDRY.FENCE	000011	1.5	O'Donnell Permittee
MESA TANK FEN	WATER LOT FENCE	000012	.0	Research Ranch
FOREST TANK FEN	WATER LOT FENCE	000013	.0	Research Ranch
CHUNEY-Z TRIANGLE	ALOT.BDRY.FENCE	000014	.5	Research Ranch
HARREY CHUNEY	ALOT.BDRY.FENCE	R00033	.8	Sawtelle Permittee

B. That the REGION shall:

1. Include a portion of the Sierra Vista Ranger District, Coronado National Forest, known as the Chuney grazing allotment consisting of 2,275 acres. Inclusion of NFS lands will be subject to all provisions of this agreement.

2. Designate indefinitely the NFS land within the Elgin Research Natural Area and maintain the withdrawal of the affected lands from mineral entry.

3. With delegated authority, assume responsibility for protection and management of the NFS lands involved.

4. Review and take approval action as merited on project proposals and study plans affecting the NFS portion of The Research Ranch.

5. Identify The Research Ranch and Elgin Research Natural Area as management units in the Coronado National Forest Land Management Plan and provide management emphasis on the overall research program of the SOCIETY.

6. Place public information signs on NFS land involved and do whatever else may be deemed appropriate for interpretation of the area and its purposes to the public.

7. Authorize grazing of domestic livestock in connection with research projects on the NFS portion of The Research Ranch exclusive of the Elgin Research Natural Area in accordance with applicable Forest Service regulations and policies.

8. Have complete responsibility for fire prevention and suppression of fires on or threatening NFS lands.

C. That the STATION shall:

1. Submit Research proposals affecting the private and State portions of The Research Ranch for review and approval of the Board of Trustees. Retain authority to conduct research on the NFS portion of The Research Ranch.

2. Provide copies of study plans and resulting publications from research activities on the Research Ranch to the SOCIETY and the REGION.

3. Lead the effort to provide a basic ecological characterization of the Elgin Research Natural Area.

D. The REGION, STATION, and SOCIETY, acting on behalf of the FOUNDATION, mutually agree to the following:

1. National Forest System status and public use of the Federal land will not be affected or altered by participation in the programs of the SOCIETY Research Ranch. The Forest Service will retain authority and responsibility for protection and management of the National Forest area involved.

2. The agreement between The Research Ranch Foundation and the National Audubon Society executed on February 2, 1980, which authorizes the SOCIETY to act on behalf of the FOUNDATION, is attached hereto and hereby made a part of this agreement as Exhibit B.

3. A map (1½" = 1 mile scale) showing location and lands status of The Research Ranch and the Elgin Research Natural Area is attached and made part of this agreement. See Exhibit A.

4. The REGION and STATION will be represented on the FOUNDATION Board of Trustees by the Forest Supervisor, Coronado National Forest, and the STATION. Through its trusteeship, the REGION and STATION will approve or disapprove all projects and studies involving use of any NFS lands by The SOCIETY Research Ranch.

5. Public access to and use of the NFS lands within the Elgin Research Natural Area shall not be more restrictive than set forth in guidelines contained in the Forest Service Manual (copies of pertinent sections attached as Exhibit C), and that legitimate users will not be denied access to the area by agents of either the REGION or the SOCIETY.

6. Project proposals involving wildlife or introduction of wildlife species not now present will be coordinated with and approved by the REGION and the Arizona Department of Game and Fish. Introduction of exotic wild animal species will not be undertaken or authorized on NFS lands without the approval of the Fish and Wildlife Service, United States Department of the Interior.

7. No Member of, or Delegate to, Congress or Resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

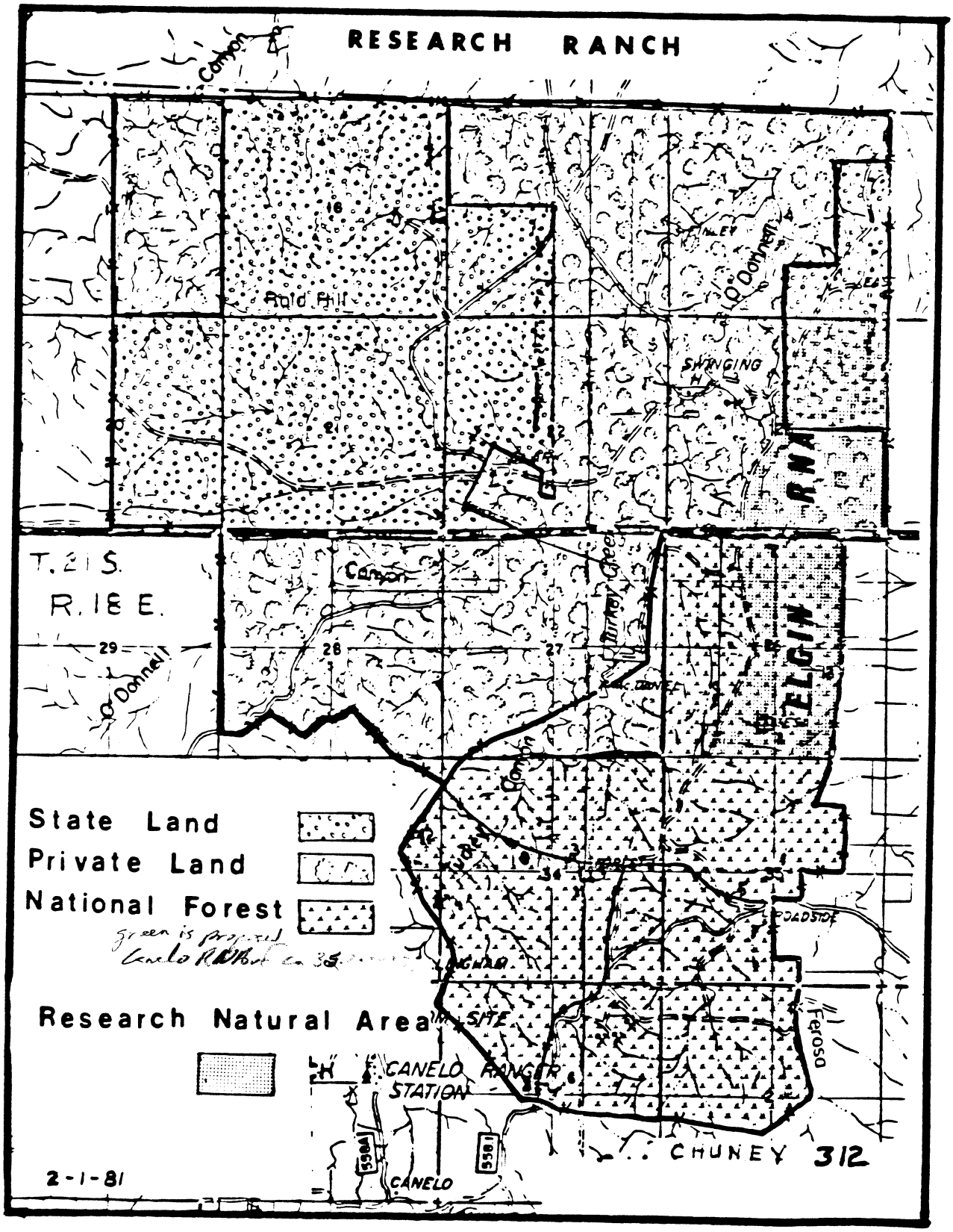
8. Nothing in this agreement shall be construed as obligating the STATION or REGION in any contract or other obligation for the future payment of money in excess of appropriation authorized by law and administratively allocated for this work.

9. No agreements herein provided for shall entitle the SOCIETY to any share or interest in the land other than the right to use the same under the regulations of the Forest Service.

10. The extension of benefits under the provisions of the Memorandum of Understanding shall be without discrimination as to race, color, creed, sex, or national origin.

11. This Memorandum of Understanding may be terminated at any time by mutual consent of all parties involved or within 90 days following written notice from either the SOCIETY, the STATION, or the REGION. Unless so terminated, this Memorandum of Understanding shall remain in force indefinitely.

EXHIBIT A


RESEARCH RANCH
Comon
Bald Hill
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O'Donnell
SWINGING H
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Murray Creek
O'Donnell
ELGIN
State Land
Private Land
National Forest
green is proposed
Canelo
Research Natural Area
SITE
CANELO RANGER STATION
550
CANELO
CHUNEY
312
Feroso
2-1-81

EXHIBIT B

AGREEMENT BETWEEN
THE RESEARCH RANCH FOUNDATION
AND
THE NATIONAL AUDUBON SOCIETY

This Memorandum of Agreement sets forth in general terms the key elements of the transfer of title to and of responsibility for the funding, management and operation of The Research Ranch from The Research Ranch Foundation, hereafter referred to as THE FOUNDATION, to the National Audubon Society, hereafter referred to as THE SOCIETY. Basic to this memorandum is an understanding on the part of both organizations that the purpose of non-disruptive habitat research and conservation, for which the Ranch has been set aside by the Appleton family, will be supported and continued.

The purposes of THE FOUNDATION are:

1) To protect and maintain approximately 7,543.09 acres of grassland and oak savannah preserve where scientists may conduct research and studies on facets of biology and ecology in specified areas, and where such research and studies will not be disturbed or interrupted by any other use of the land. These studies shall be consistent with the goal of preserving the natural condition of the land.

2) To provide an undisturbed control area against which man-induced and natural changes in grazing lands, such as contour plowing, seeding of non-native grasses, and the effects of range fires, can be evaluated with regard to their long-range impact on the environmental health and ecological stability of the land.

3) To compile an inventory of past land use patterns as well as to update continuously a computerized inventory of physical and biological characteristics.

4) To maintain a gene bank for native plants and animals, and, when appropriate, to reintroduce those species that have been regionally eliminated.

5) To provide limited areas for breeding selected endangered species whose native habitat is similar to that found on The Research Ranch.

In consideration of their mutual agreements, THE FOUNDATION and THE SOCIETY agree as follows:

1 THE RESEARCH RANCH: THE FOUNDATION will transfer title to approximately 919.07 acres owned by it to THE SOCIETY. THE FOUNDATION further agrees to relinquish its interest in existing leases and/or agreements with Federal and State agencies involving 2,375 acres on lands of the United States Forest Service, U.S. Department of Agriculture and 2,342 acres on lands owned by the State of Arizona. THE SOCIETY agrees to enter into such leases and/or agreements in accordance with procedures as required by the Federal and State agencies involved. THE FOUNDATION further will transfer title to and relinquish its interest in existing leases and/or agreements in any additional land acquired by THE FOUNDATION which is proximate to and should reasonably be a part of The Research Ranch. It is understood by THE FOUNDATION and THE SOCIETY that members of the Appleton Family will continue to support the purposes of The Research Ranch by leasing, transferring, or otherwise making available to THE FOUNDATION approximately 1,900.00 acres owned by them. These properties and leases are depicted on a map attached hereto and made a part hereof, and marked Exhibit "A".

These properties and leases, including all building, structures, roadways, fences, wells, windmills, storage tanks, dams and other man-made facilities thereon, and totalling approximately 7,543.09 acres collectively, shall be owned, leased, held, and managed by THE SOCIETY as the Appleton-Whittell Research Ranch of the National Audubon Society.

THE SOCIETY will create a fund of not less than $1,000,000 as an endowment fund for The Research Ranch. Income from this fund shall be used to the fullest extent by THE SOCIETY to fund the management and operation of The Research Ranch, including, but not limited to, preservation and conservation of the land, protection and maintenance of the land and properties, staffing and administration and research and education. An audited statement of investment return on the fund and use of these proceeds for funding The Research Ranch shall be made available each year by THE SOCIETY to THE FOUNDATION within four months of the close of THE SOCIETY'S fiscal year.

Should the funding needs of The Research Ranch for management, supervision, and operation fall below the level of endowment income in any fiscal year, July 1 to June 30, as specified herein, any excess endowment income in said fiscal year may be applied to the cost of any projects then being undertaken on The Research Ranch, provided, however, that in no event shall said income be applied for any purpose other than management, supervision and operation of The Research Ranch. Should the funding needs of The Research Ranch exceed the level of endowment income in any fiscal year, THE SOCIETY will, provided its Board of Directors shall approve, endeavor to provide funds in addition to endowment income to meet such needs. THE SOCIETY shall be responsible for any operating deficit.

II. RELATIONSHIP OF THE FOUNDATION AND THE SOCIETY: THE FOUNDATION shall continue to encourage, advocate, and promote the purposes of The Research Ranch. THE FOUNDATION may assist THE SOCIETY in the management and operation of The Research Ranch as an advisory entity. THE SOCIETY shall fund, manage, and operate The Research Ranch. The funding, management and operation of The Research Ranch shall be according to the sanctuary management goals, policies, practices and standards of the National Audubon Society and in accord with the purposes and standards adhered to by THE FOUNDATION during its management of The Research Ranch. THE SOCIETY shall set fourth more specific policies regarding research projects and other initiatives, access to and visitation on The Research Ranch, maintenance of facilities, and the criteria for the selection of the Director of The Research Ranch

THE SOCIETY will request THE FOUNDATION to provide advice in the selection of any Director of The Research Ranch, the determination of research projects to be undertaken on The Research Ranch, and the establishment of the budget for management and operation of The Research Ranch for each ensuing year. The Director of The Research Ranch shall meet at least annually with THE FOUNDATION and present to THE FOUNDATION a report on the status of management operation, and finances of The Research Ranch and current projects on The Research Ranch. THE FOUNDATION shall submit its advice and recommendations on the foregoing matters to such person or persons designated by THE SOCIETY and may also direct such advice and recommendations to the Scientific Activities Committee of THE SOCIETY.

III. SUPERVISION OF RESEARCH PROJECTS: The Director of The Research Ranch shall oversee all research projects to assure that all standards, as expressed in the conditions and terms of the respective contracts, are honored. THE SOCIETY shall take action to correct any documented breach

in conditions or terms of any research contract, or to cancel said contract if, in the judgment of THE SOCIETY terms and conditions of the contract are violated to the detriment of The Research Ranch.

IV. FUNDING FOR RESEARCH INITIATIVES: Research initiatives at The Research Ranch shall be self-supporting, exclusive of endowment income. THE SOCIETY reserves the right to designate appropriate charges as a part of the requirements for self-supported research projects. Such charges shall be used to support the supervision, management, and operation of The Research Ranch. They may be used to meet necessary travel, per diem, and administrative expenses of the Board of Directors of THE FOUNDATION as well as for other expenses directly related to The Research Ranch and its operation. Authority for accounting, management and disbursement of such funds shall be vested in THE SOCIETY.

V. TIMING OF TRANSFER OF TITLE: Every effort will be made to complete transfer of title to and of responsibility for the funding, management, and operation of The Research Ranch from THE FOUNDATION to THE SOCIETY as soon after the signing of this memorandum as possible.

VI. APPLETON PROPERTIES: At the discretion of members of the Appleton Family, their heirs and assigns, properties held by them may be leased, transferred or otherwise made available to THE FOUNDATION or THE SOCIETY in support of the overall purposes of The Research Ranch.

VII. ACCESS TO THE RESEARCH RANCH: Access to The Research Ranch shall be controlled in such a manner as to perpetuate the conservation and research purposes of the Ranch and to protect the integrity of on-going research projects. Visitation to The Research Ranch shall be with advance approval and under restrictions that assure the continuing vitality, scientific value, and natural beauty of The Research Ranch. The Director of The

Research Ranch shall have final authority on all questions of access to the Ranch.

VIII. MAINTENANCE AND DEVELOPMENT OF FACILITIES: THE SOCIETY shall manage The Research Ranch in a manner that will hold human impact and disruption of natural processes to a minimum. Maintenance of facilities and any development of new facilities shall be attuned to the aesthetic and environmental qualities of The Research Ranch.

IX. RELATIONSHIP WITH STATE AND FEDERAL AGENCIES: To the greatest possible extent, THE SOCIETY shall coordinate its management role with the State of Arizona and the United States Forest Service. This coordination shall include advocacy for the purposes of The Research Ranch and continuation, as long as possible, of the leases and/or agreements with the State and Federal agencies under terms that complement the purposes of The Research Ranch.

X. LIMITATIONS: THE SOCIETY obligates itself to hold title and leases to The Research Ranch for a minimum of 25 years from the date of title transfer, and thereafter, unless circumstances cause THE SOCIETY, in the judgment of THE SOCIETY'S Board of Directors, to divest itself of the Ranch holdings. In the highly unlikely event that THE SOCIETY so judges, title for all The Research Ranch, at the option of THE FOUNDATION, shall pass at no cost, and free and clear of all liens or other obligations, back to THE FOUNDATION and THE SOCIETY shall relinquish its interest in existing leases and/or agreements with Federal and State agencies to THE FOUNDATION. In such case, THE SOCIETY shall be released from its obligations to fund, manage and operate those lands covered by those titles and leases and/or agreements that may pass back to THE FOUNDATION. The refusal to renew or the cancellation of any lease and/or agreement by the Federal or State agencies shall not be deemed a divestiture of Ranch holdings by THE SOCIETY. Should

THE FOUNDATION, at that time choose not to accept title and/or leases and/or agreements of The Research Ranch, it shall be the obligation of THE SOCIETY to seek, favor and vest title and leases and/or agreements in an organization capable of perpetuating the purposes of The Research Ranch as herein expressed. Only if a diligent search fails to assure transfer of title and leases and/or agreements to a suitable organization would THE SOCIETY be free to vest title and leases and/or agreements in any other organization or individual. Before any such transfer is concluded, THE SOCIETY will consult with and seek the advice of THE FOUNDATION, or, if THE FOUNDATION shall cease to exist, members of the Appleton Family, their heirs and assigns.

XI. In the event THE SOCIETY shall divest itself of title in accordance with the terms of Paragraph X, then and in that event the principal of the endowment fund together with any accruals and any unexpended income shall remain with THE SOCIETY.

XII. CONCLUSION: The forthcoming addition of The Research Ranch to THE SOCIETY'S Sanctuary System surely will be counted as a major milestone in strengthening private conservation initiatives in this country. This memorandum of agreement shall remain a permanent part of the record of transfer of title, and as a general guide to the funding, management, and operation of The Research Ranch.

Glenn Paulson 1/16/80
Vice President for Science, National Audubon Society
Date

Jane N Berk 2-2-80
Chairperson, The Research Ranch Foundation
Date

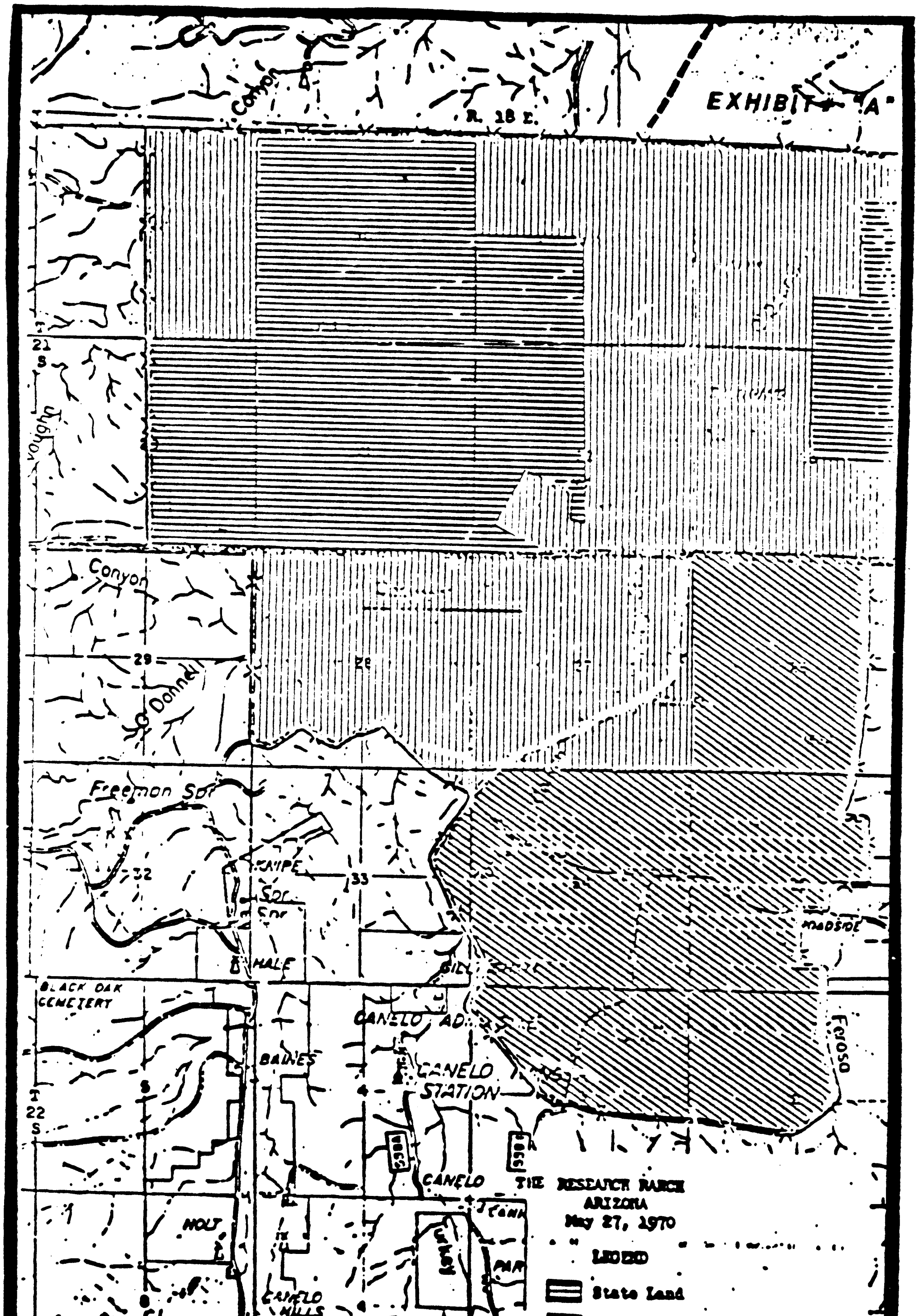
EXHIBIT "A"
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Freeman Spr
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HALF
BLACK OAK
CEMETERY
CANELO
BAINES
CANELO
STATION
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HOLT
CANELO
HILLS
Feroso
R. 18 E.
THE RESEARCH RANCH
ARIZONA
May 27, 1970
LEGEND
State Land
Private Land
Cor.nado National Forest

EXHIBIT C

4063.3

SERIES 4000 - RESEARCH

4063.3 - Protection and Management. A research natural area must be protected against activities which directly or indirectly modify ecological processes if the area is to be of value for observation and research on plant and animal succession, habitat requirements of species, insect and fungus depredations, soil microbiology, phenology and related phenomena. Logging activities are not permitted, and grazing by livestock is restricted to those areas where their use is essential for the maintenance of a specific vegetative type. Discourage recreational uses. The criterion for management of research natural areas is for protection against inappropriate encroachments on existing conditions.

Special closures of research natural areas may be necessary to protect such areas from actural or potential harm resulting from public use. Closures must be done by an order issued under the provisions of 36 CFR 261.50. Such orders incorporate the special closure provisions of 36 CFR 261.53 which allow for criminal citations to be issued whenever one or more of the listed resources are endangered (FSM 5353).

4063.31 - Identification. Identify research natural areas in the administrative records as to location, purpose, and objectives. Mark their boundaries in the field, when appropriate, to ensure integrity of the area. As a minimum, all corners or turning points should be monumented and the monumentation documented and recorded in the establishment report. Avoid signs that tend to attract sightseers, recreationists, and casual visitors. However, if roads or trails pass along the boundary or through a research natural area, limited posting may be needed to protect the area (FSM 5351). An area may be closed pursuant to 36 CFR 261.50 and criminal action taken for violation of 36 CFR 261.53 (FSM 5353).

4063.32 - Fences. Research natural area boundaries should not be fenced unless necessary for protection against livestock or excessive human use. When fencing is necessary to protect an area, however, it should be budgeted and constructed in management of the area.

4063.33 - Publicity. Publicity, generally to professional groups at either National, State, or university levels, is mainly to inform scientists and educators of the location, natural features, and administering agency in order to make the fullest proper use of research natural areas. A news release upon initial designation of an area may be appropriate. Publication of research natural area directories, including detailed descriptions of features within each area, is encouraged.

4063.34 - Physical Improvements. As a general guide, physical improvements such as roads, fences, or buildings should not be permitted within a research natural area. However, in many instances, limited temporary improvements may be needed if these tracts are to fulfill their scientific potential.

*- Trails frequently are needed for access to conduct research and for educational purposes. They actually may protect an area by concentrating impacts of human use. Roads often form good boundaries and may not be detrimental even if they go through a proposed area. Once an area is established, construction of roads should not be permitted unless they contribute to the research natural area objectives. In rare instances, it may be desirable to establish temporary gaging stations and instrument shelters. Submit plans for improvements and/or temporary facilities the Station Director for approval and to the Forest Supervisor for concurrence. These plans will specifically fix the tenure of the improvement or facility and list actions to be taken, time limits for completion, and parties responsible for returning disturbed areas to a natural condition.

4063.35 - Protection. Specific management direction for each natural area will include protection from fires, insects, diseases, and animals. Maintenance of the natural processes within each area will be the prime consideration. Where cultural resources on, or eligible for, the National Register are likely to be involved, a memorandum of understanding or an interagency agreement with the Advisory Committee on Historic Preservation should be prepared (FSM 2360, FSH 1509.11). As a general guide, fires endangering research natural areas should be extinguished as quickly as possible. Fires within the area will be allowed to burn undisturbed, unless they threaten persons or property outside of the area, or the uniqueness of the RNA. Debris resulting from fires should not be cleaned up nor should any fire hazard reduction or reforestation be undertaken. Generally, no action should be taken against endemic insects, diseases, or wild animals. However, protection measures for research natural areas within Congressionally-designated areas must be in accord with the management plan for that designated area.

4063.36 - Public Use. Picnicking, camping, collecting plants, gathering nuts and herbs, picking berries, hunting, fishing, trapping, and other public uses which contribute to modification of a research natural area should be discouraged or expressly prohibited if such uses threaten serious impairment of research or educational values. Public use or access may be limited or prohibited under 36 CFR 261.53 (FSM 5353).

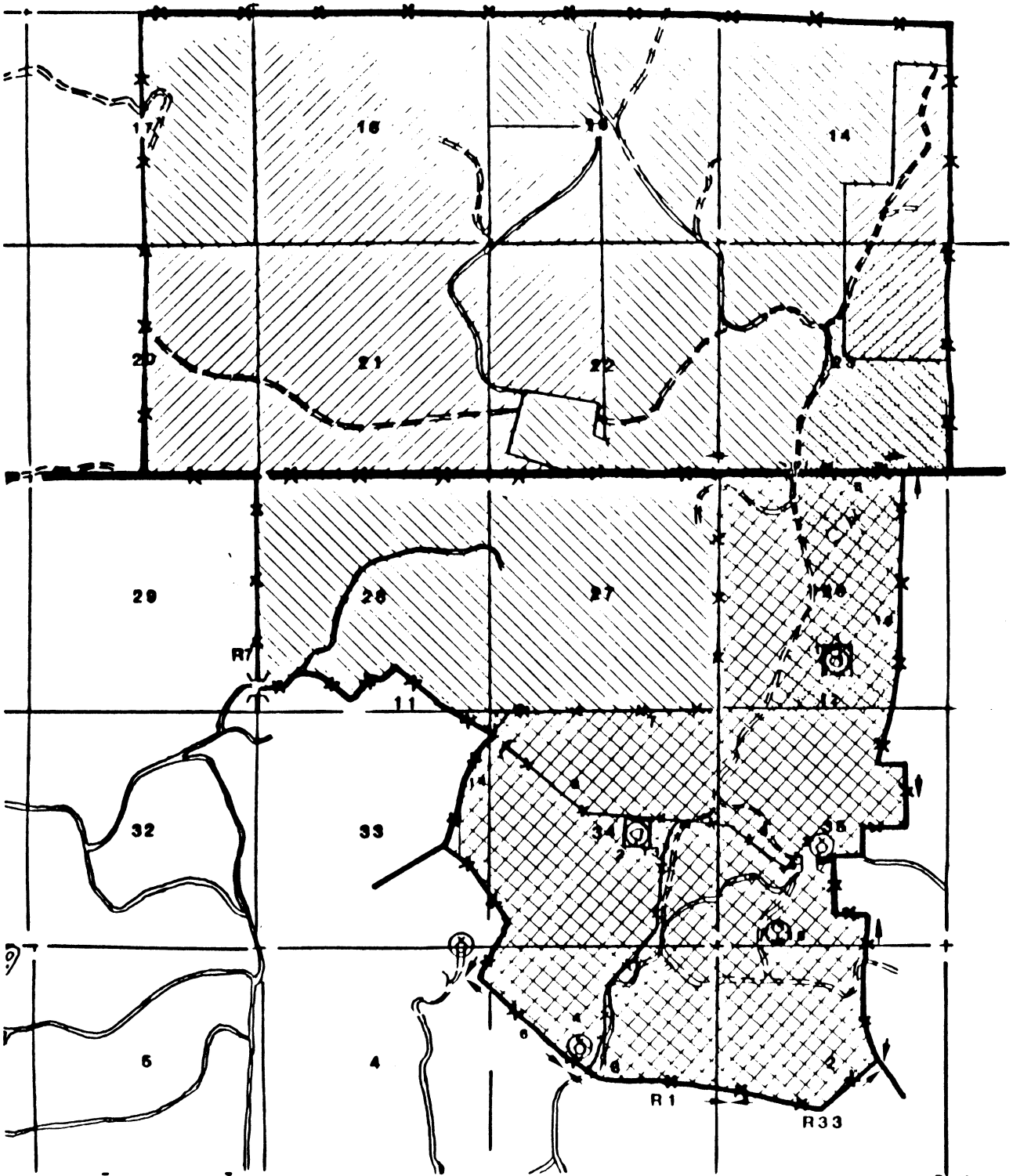
4063.37 - Scientific and Educational Use. The Forest Service encourages use of natural areas by responsible scientists and educators. Generally, educational use should be at the college upper classman or graduate level. However, lower levels of educational institutions are not excluded. Any scientist interested in using a research natural area should contact the appropriate Station Director and outline the activity planned. In some instances, -*

*- a special use permit will be adequate to cover the planned activity. Normally, however, a cooperative agreement will be prepared that outlines the planned research, mechanics of field work, and the limitations thereto. This will be executed between the scientist and the Station Director with the review and approval of the Forest Supervisor and District Ranger. Research projects inservice and outservice within wildernesses must be submitted to the Regional Forester for approval (FSM 2323.04c). Forest Service scientists should cooperate in the research whenever possible to derive the greatest benefit from the work. Copies of all data, reports, etc., resulting from research on an RNA shall be filed with the Station, Region, Forest, and Washington Office.

Collection of endangered, threatened, or rare plants must be carefully controlled. Permits must be issued by the U.S. Fish and Wildlife Service (50 CFR 17.22). If permits are issued, a voucher sample should be deposited in the Forest Service Herbarium at Fort Collins, Colorado. Collection of duplicate material of rare, endangered, or threatened species should be prevented once adequate material have been deposited in appropriate herbaria.

4063.38 - Vegetation Management. The Station Director, with the approval of the Forest Supervisor, may authorize management practices, except within wildernesses, necessary to preserve the vegetation for which the research natural areas was created. These practices may include grazing, control of excessive animal populations, or prescribed burning. Only tried and reliable techniques will be used, and then only where the vegetative type would otherwise be lost without management. The criterion here is that the management practice must provide a closer approximation of the vegetation and the processes governing the vegetation than would be possible without management. If doubt exists about the need for vegetation management or the reliability of the techniques, then nothing should be done. Generally, planned practices for vegetation management should be suggested in the establishment report and documented in the management plan after establishment.

4063.39 - Mineral Entry. Research natural areas should be withdrawn from mineral entry after establishment in conformance to Section 204 of the Federal Land Policy and Management Act of 1976 (PL 94-579). However, the difficulty or resistance to withdrawal to mineral entry should not be a deterrent to selection and establishment of desirable areas. It is better to develop a network of research natural areas and lose a few to mineral development than not establish sufficient areas because of resistance to withdrawals. -*



RESEARCH RANCH

CHUNEY ALLOTMENT 312

0 1/2 1 MILE
scale

State Land

Private Land

National Forest

Research Natural Area

ALLOTMENT BOUNDARY

FENCE

IMPROVEMENT NUMBER 01138

SPRING, DEVELOPED

TANK

WATER TROUGH

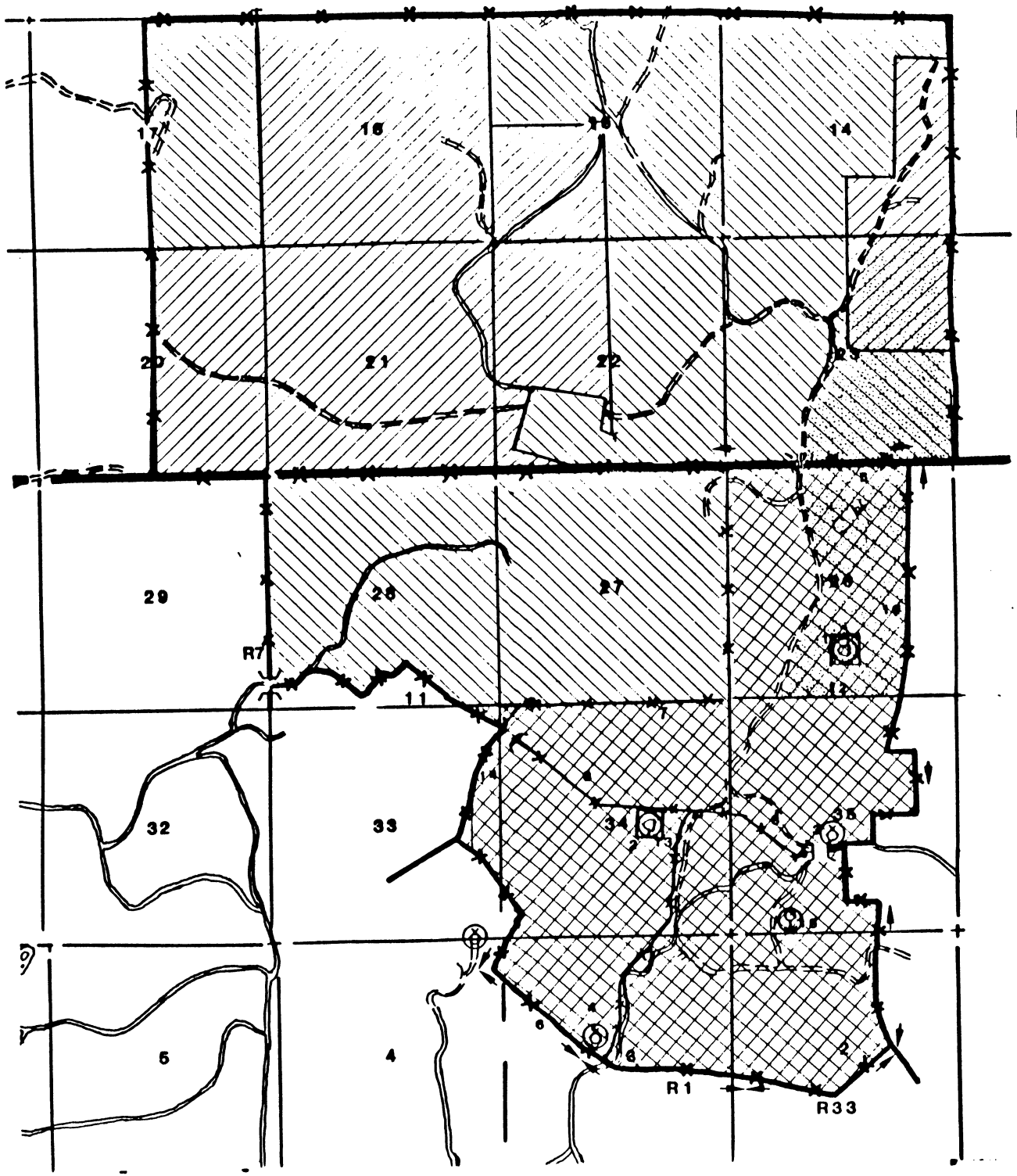
WINDMILL

WELL

CORRAL

N

EXHIBIT D



RESEARCH RANCH

CHUNEY ALLOTMENT 312

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State Land

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Research Natural Area

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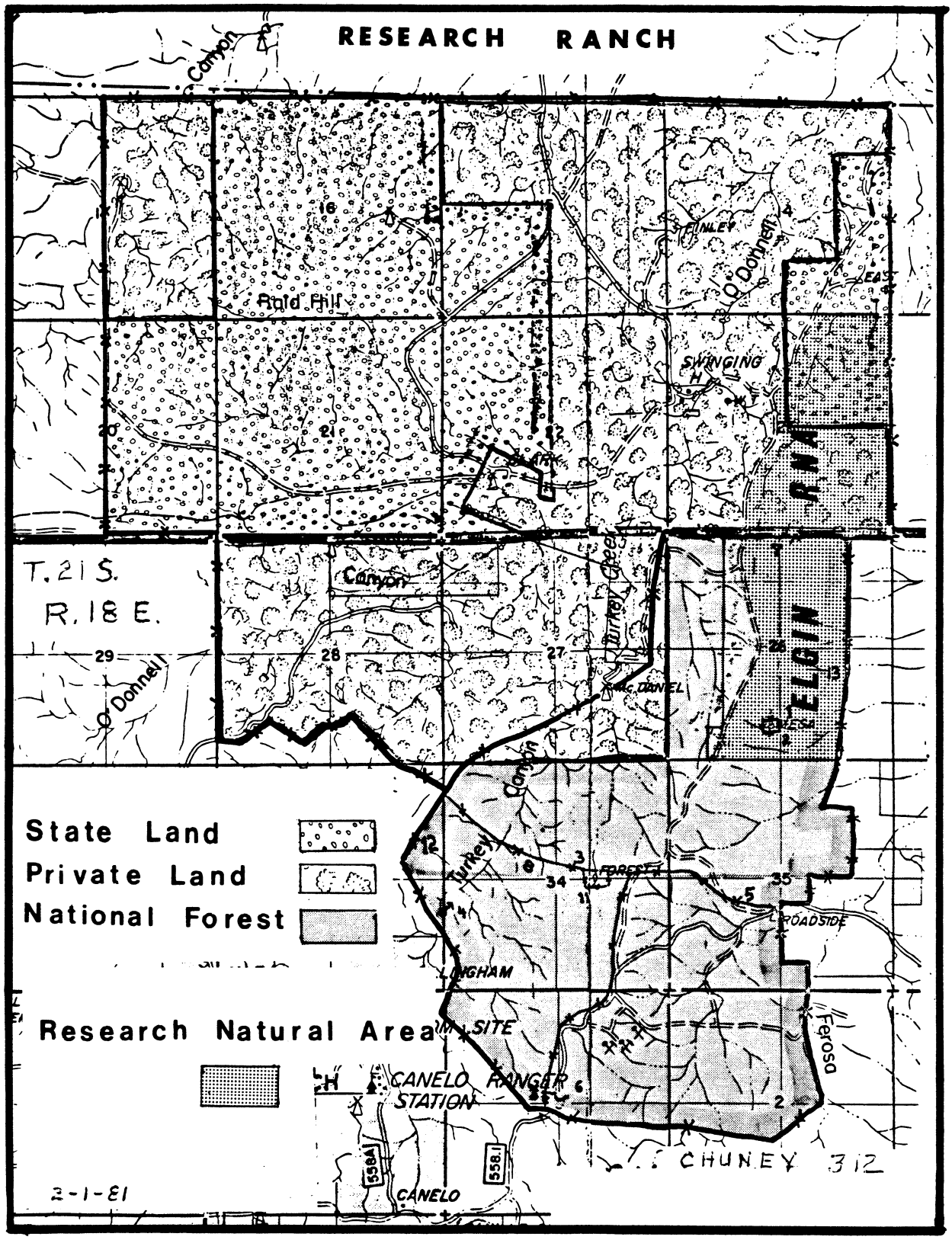
EXHIBIT A


RESEARCH RANCH
Canyon
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T. 21 S.
R. 18 E.
Canyon
Turkey Creek
O'Donnell
DANIEL
Turkey Canyon
FOREST
BROADSIDE
LINGHAM
SITE
Feroso
CANELO RANGER STATION
CHUNEY
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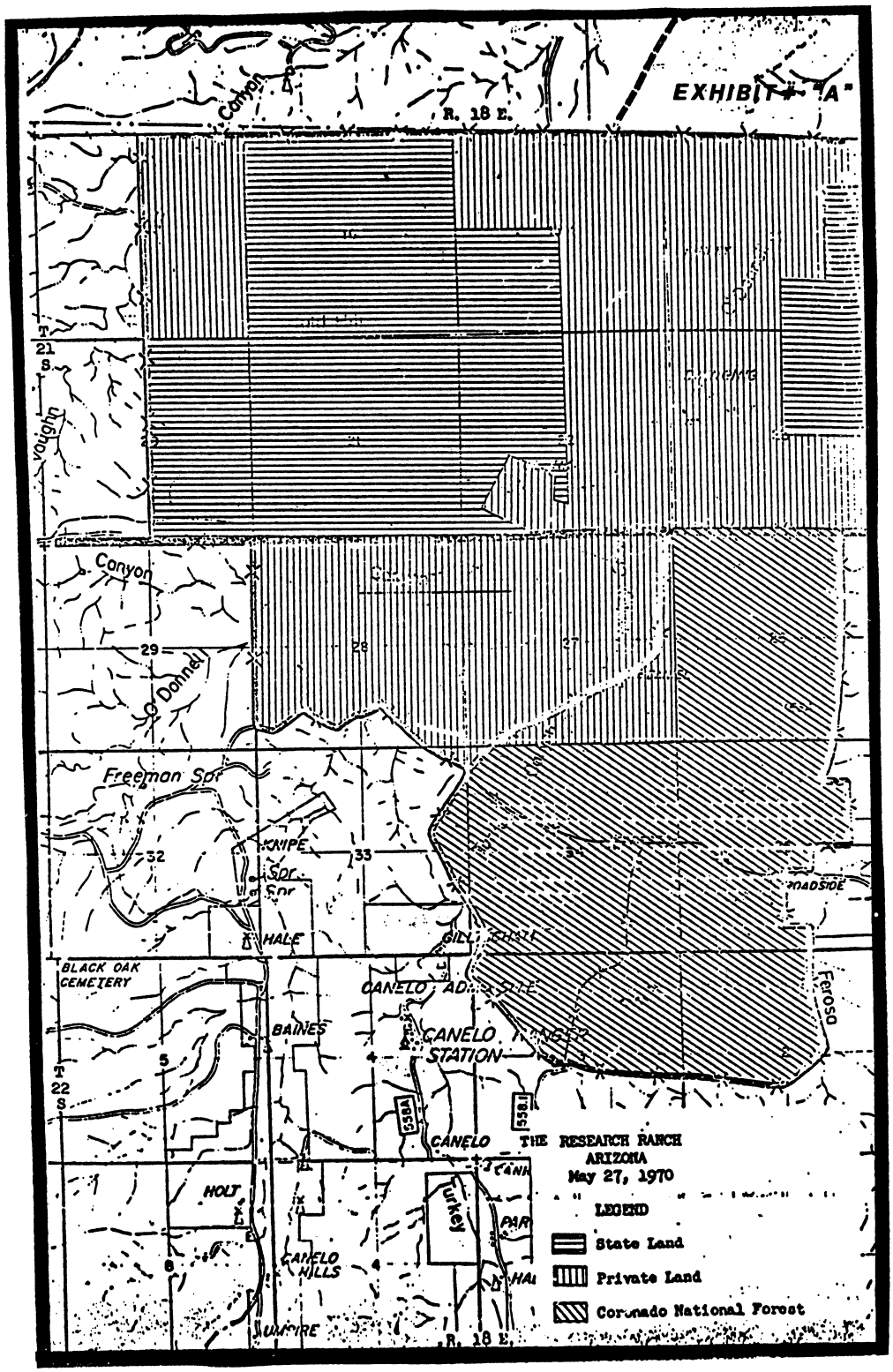
State Land
Private Land
National Forest
Research Natural Area
2-1-81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R. 18 E.
Canyon
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BLACK OAK CEMETERY
BAINES
CANELO
STATION
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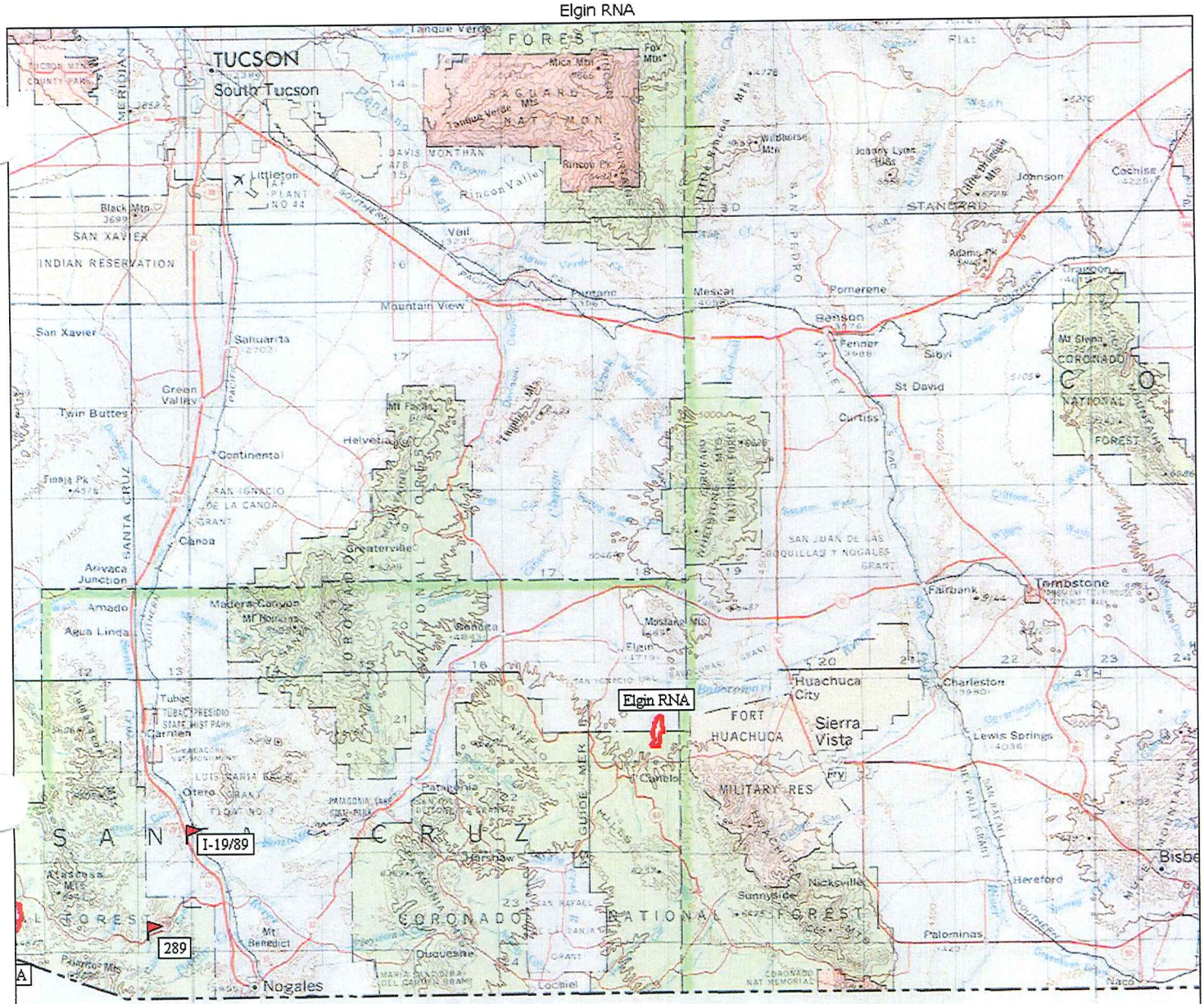
HOLT
CANELO HILLS
6
Turkey
R. 18 E.
THE RESEARCH RANCH
ARIZONA
May 27, 1970
LEGEND
State Land
Private Land
Coronado National Forest

Elgin RNA



TN 11° MN

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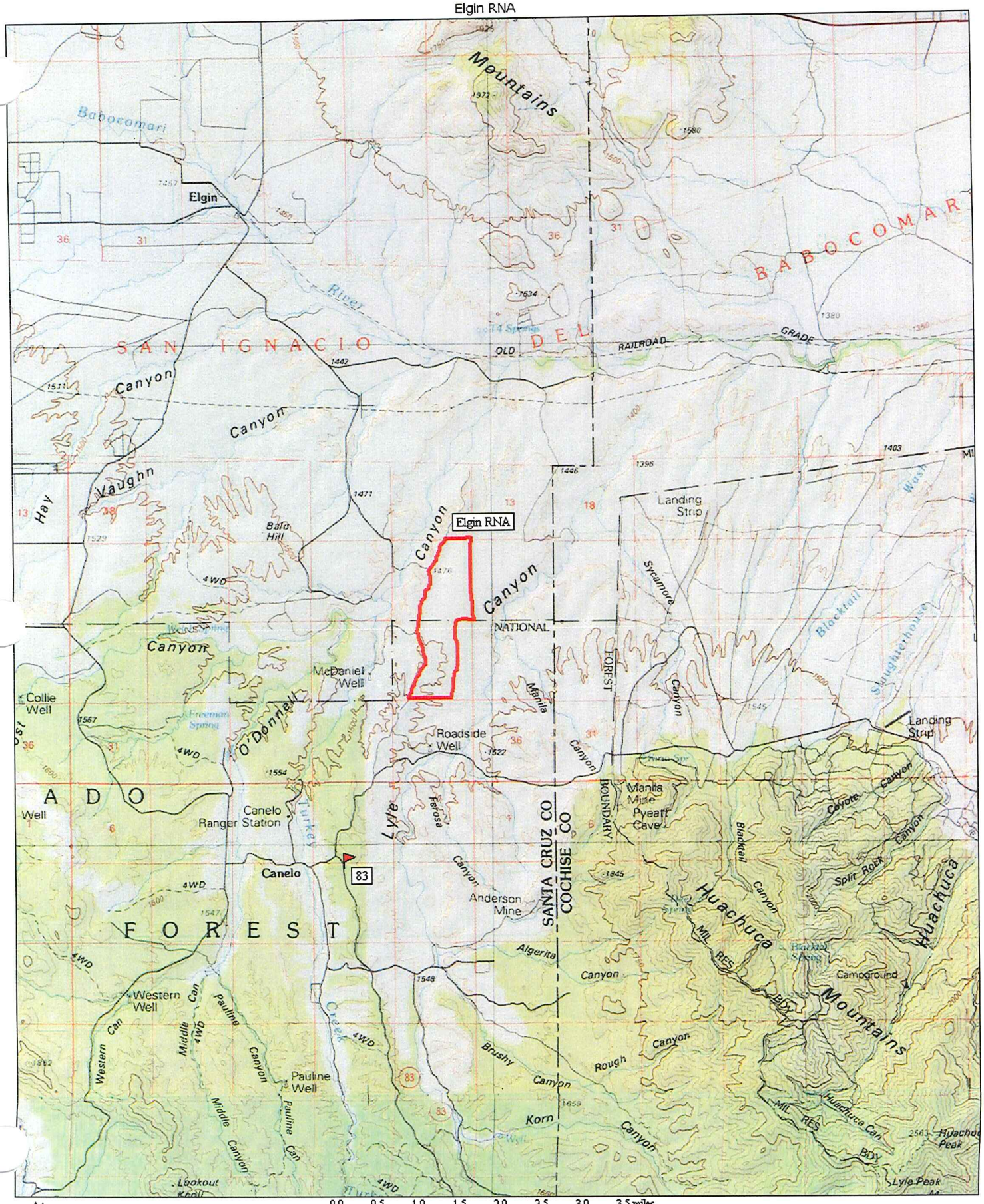
Elgin RNA



TN 11° MN

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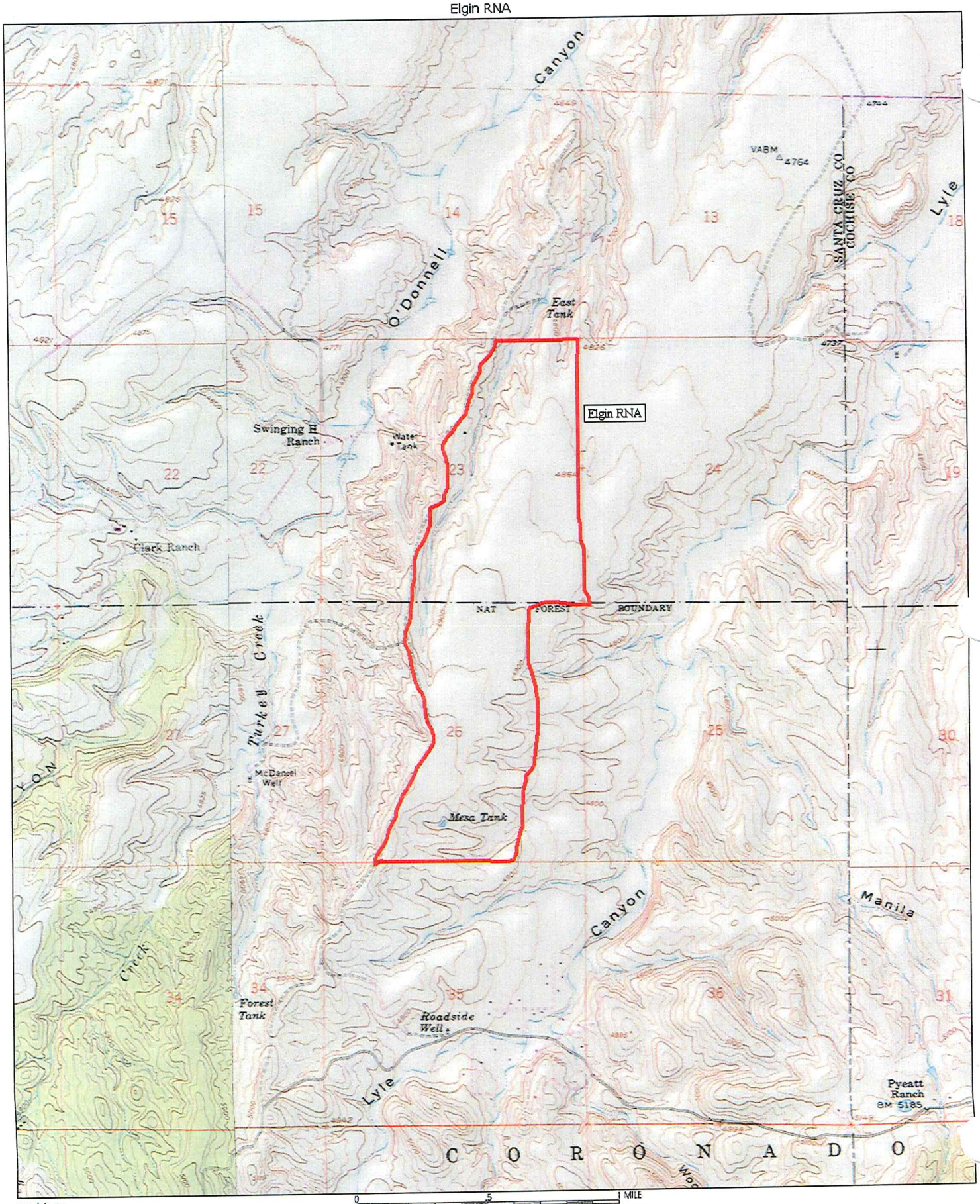

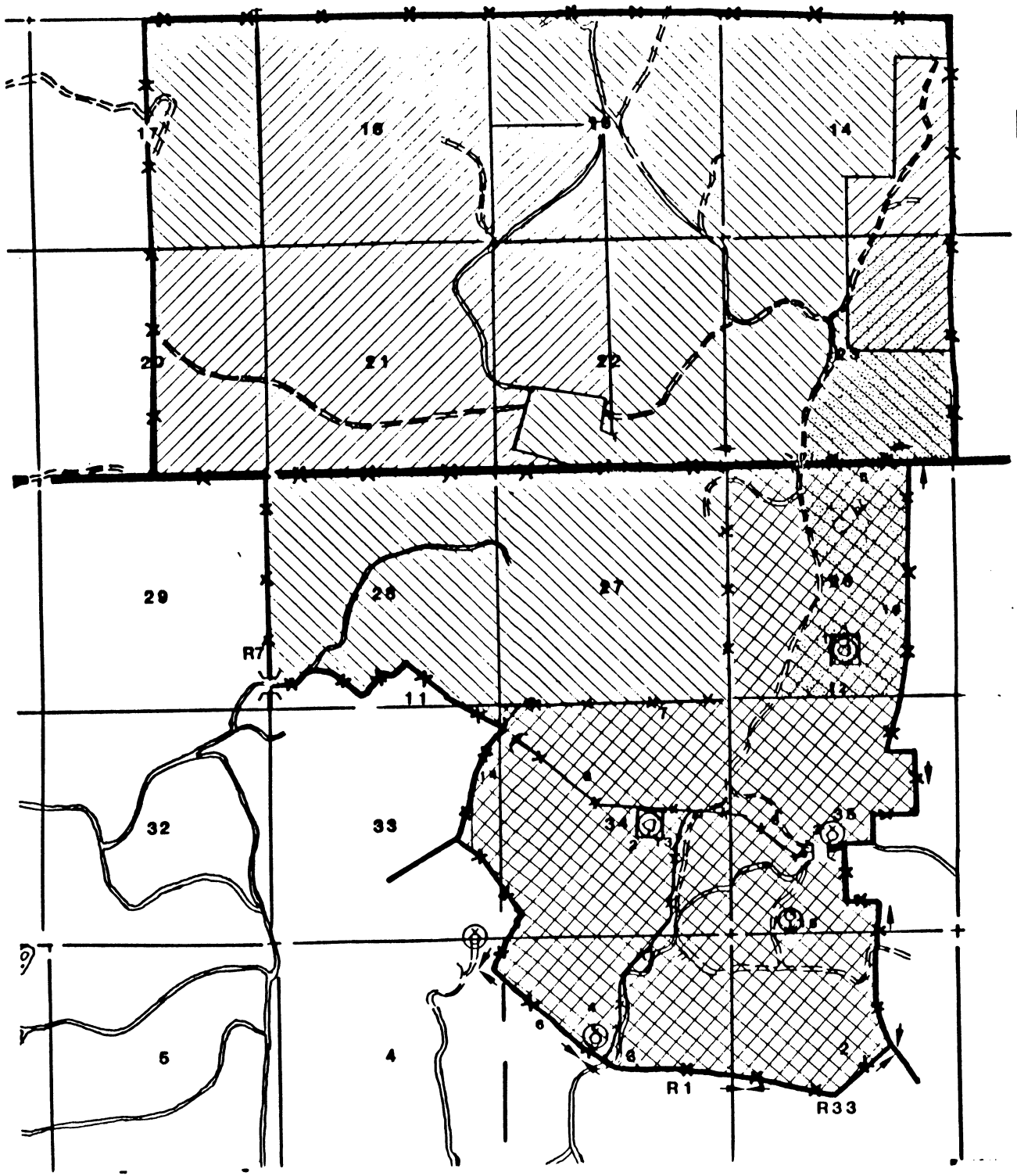

RESEARCH RANCH

CHUNEY ALLOTMENT 312

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scale

State Land

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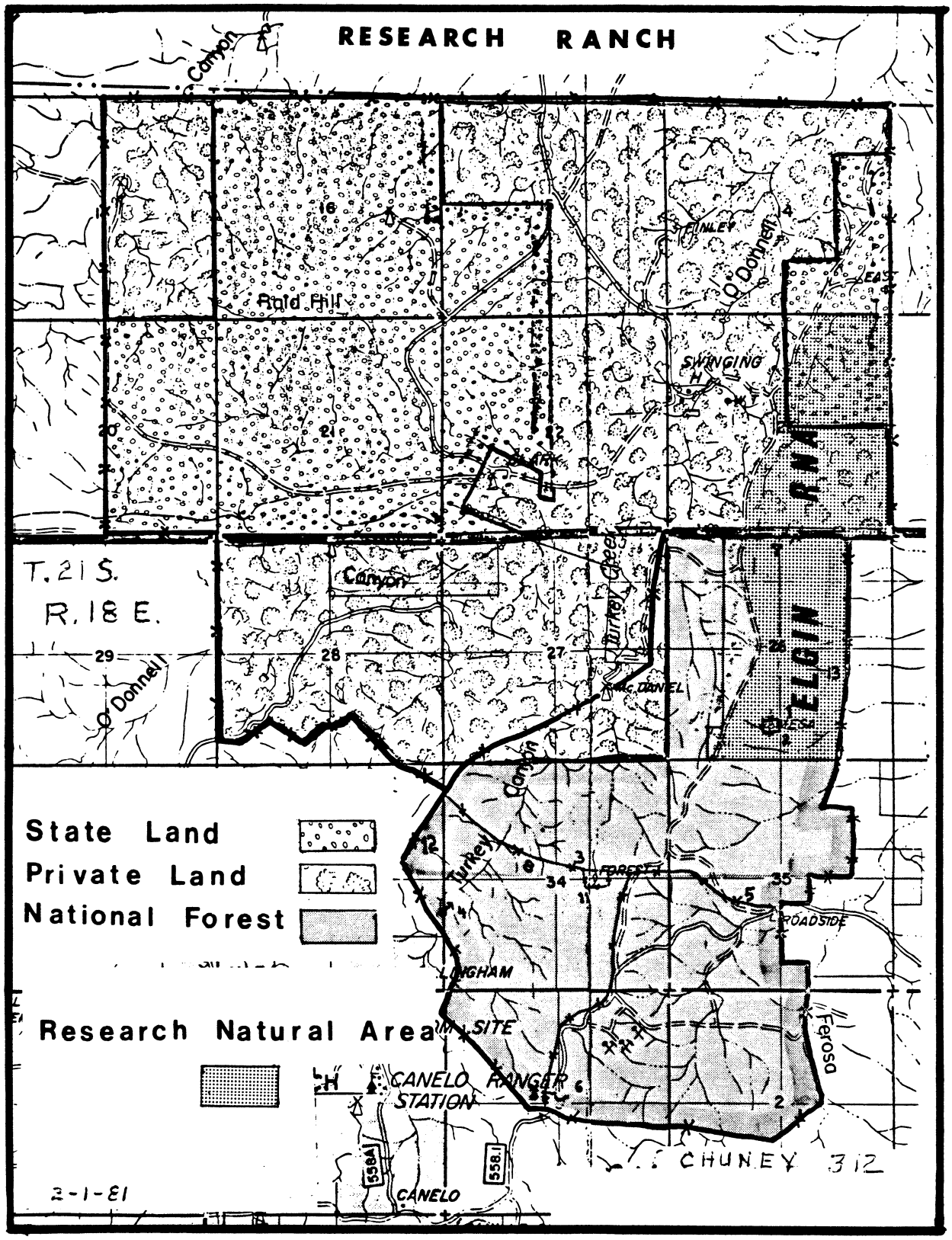
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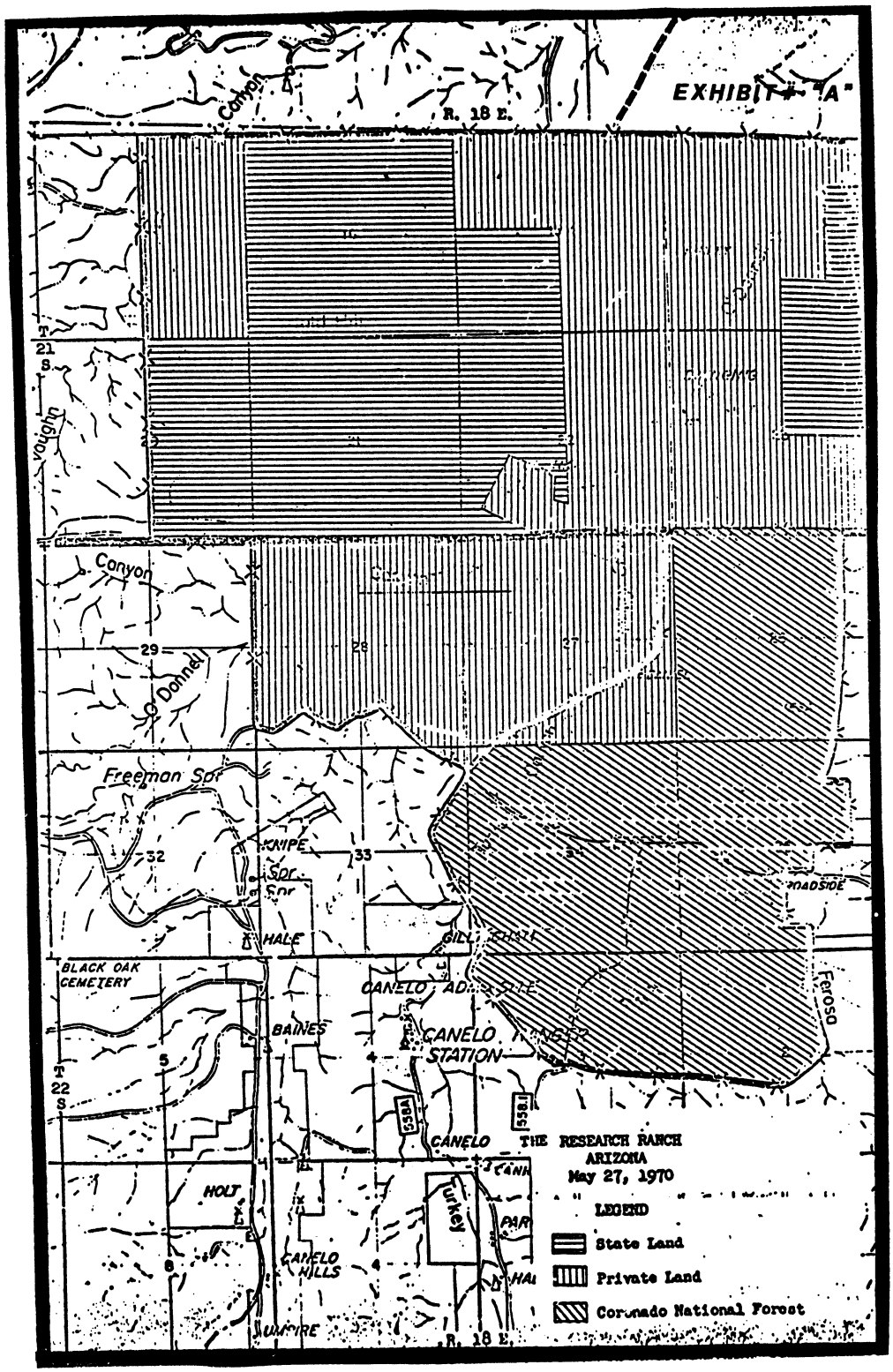
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BAINES
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CANELO
HOLT
CANELO HILLS
6
Turkey
R. 18 E.
THE RESEARCH RANCH
ARIZONA
May 27, 1970
LEGEND
State Land
Private Land
Coronado National Forest

Elgin

DATE May 23, 1984

CROSS REFERENCE (1) Outservice Groups...

CROSS REFERENCE (2) Elgin RNA 1/

CROSS REFERENCE (3) Apache-Sitgreaves NF 1/

CROSS REFERENCE (4) Kaibab NF 1/

TO T. Johnson, AZ. Game & Fish Dept.

FROM M. Hughes (for J. Overbay, Reg'l Forester)

SUMMARY Reply to 4/26/84 letter with information on the current state of RNA program. Includes Rocky Gulch & Elgin RNA's, and Coconino, Coronado, Apache-Sitgreaves, & Kaibab NF's. (Johnson's request is attached to it)

FILED

REMARKS

1/ These files contain this form only.

Other x-refs include Rocky Gulch RNA and Coconino & Coronado NFs

AD-170-4 CROSS REFERENCE
(4-58)

this pg not in S.O. #2

Elgin

United States Department of Agriculture
Forest Service
Region 3
517 Gold Avenue SW
Albuquerque, NM 87102

Reply to 4060

Date JUL 2 8 198

Mr. & Mrs. Carl E. Bock
Co-Directors Audubon Society Research Ranch
Box 44
Elgin, AZ 85611

Dear Mr. & Mrs. Bock:

see file "Coronado NF"

Enclosed is a signed copy of the Memorandum of Understanding covering Coronado National Forest lands managed as a part of the Audubon Research Ranch Facility. We believe that through these cooperative efforts, better information on grassland management will be developed. Application of this new technology will provide a basis for improving productivity through management.

In addition, I'm certain that you are aware how important it is to recognize in any research reports, the contributions made by the Arizona State lands and Coronado National Forest System lands. The public needs an awareness of the values being obtained through this cooperative program. This awareness provides the best assurance of continued support for allocating Arizona State and National Forest System lands to this effort.

The final agreement includes the corrected citation for PL--307, and on page 3 item C. number 2, the word "resource" was changed to ranch.

Sincerely,

M.J. HASSELL
Regional Forester

Enclosure

United States Department of Agriculture

Forest Service

R-3

Elgin

Copy for committee file

Reply to: ~~2820~~ 1350 Leases and Permits

Date: August 25, 1981

Subject: Oil and Gas Leases Proposed
Coronado-Elgin Ranch Research Natural Area

To: Research Natural Area Committee

Oil and gas leasing proposals have been received which involve land in the Elgin Research Natural Area. At this point it will be necessary for the Coronado to prepare an EA addressing the proposal (for all the National Forest in Elgin), for review and recommendation of the Regional Forester and decision by the Chief. Please consider the proposal and provide such comment and information as you believe will aid the Coronado in preparation of the EA and the Chief in reaching an appropriate decision.

RICHARD L. HARRIS
Director of Lands and Minerals

Return to Larry Schmidt 3401

ECOLOGICAL INVENTORY INFORMATION STORAGE - RETRIEVAL SYSTEM FOR THE RESEARCH RANCH, ELGIN, ARIZONA

Range Science Department
Science Series No. 14
Colorado State University

ECOLOGICAL INVENTORY AND DATA STORAGE-RETRIEVAL SYSTEM FOR THE RESEARCH RANCH

FINAL REPORT

Charles D. Bonham

Principle Investigator

November, 1972

PREFACE

This publication was made possible by a grant from The Research Ranch, Elgin, Arizona. Many individuals contributed to the successful completion of the project, but I wish to especially acknowledge Ariel and Frank Appleton, owners of The Research Ranch, who made it all possible. Their preservation of this 7800-acre ranch for the sole sake of ecological observation and research was a landmark contribution by the Appleton family to the citizens of the Earth.

This ranch was set aside in 1968 by the Appleton family as an area on which plant and animal ecological studies in a natural setting could be conducted in perpetuity. The area has not been grazed by livestock since late 1967 and is presently governed by a board of trustees.

Several authors contributed to this report and they are listed with the section of the report contributed especially by them. Otherwise, thanks are due to Ward and Jan Brady, Kellie and William Beavers, and Marabeth White for the many hours of labor on detailed data analysis and report compilation. Appreciation is also due Dennis Child who produced the section on INFOL. Professor C. H. Wasser of the Range Science Department at Colorado State University is particularly acknowledged for his critical review of the manuscript.

The compilation of the report was carried out with a selected audience in mind, those interested in knowing the vegetation-soil characteristics of The Research Ranch. The computer phase is, therefore, minimized and can be studied further as directed in the report.

Charles D. Bonham
Fort Collins, Colorado
November, 1972

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INTRODUCTION

The Research Ranch of Elgin, Arizona, has been of interest to applied and basic ecologists for the past few years. Ecological interest centers in the area because of the unusual opportunities that exist for ecological studies and the wide variation of vegetation combinations available for study. In fact, the grassland type on the ranch was primarily responsible for bringing plant ecological studies to the area in 1968.

The Research Ranch is ideal for initiation of basic studies of ecological variations because relatively few dominant plants occur in the area. Also, the area is protected from domestic livestock grazing and offers a number of opportunities to study ecological habitats by way of manipulation or in a natural state. In addition to plant species occurring in the area, numerous other species of ecological importance also occur.

Until initiation of this project, studies dealing with plant ecological variations had been made only on a 1,000-acre portion of the ranch. Moreover, other ongoing research on the ranch has been restricted to a few localized studies. These studies, which began in 1968, have developed plant species lists and associated plant groupings on localized grassland portions of the ranch. Bonham (1969) presents a comprehensive review of studies conducted in this grassland segment. Additional research has also been conducted on the grassland portion with emphasis on range plant responses to fertilization (Ogden, 1969).

Inasmuch as The Research Ranch has been permanently established to engage in ecological research, a basic inventory needed to be made of the vegetation and soils of the area. This inventory was important before other zoological and botanical projects, including those concerning domestic

and wildlife species, could be initiated in the area. Further studies of other environmental variables would also depend rather heavily upon the availability of inventory data. Although several institutions, both local and national, are participating in research at the ranch, these studies will be restricted to localized conditions and cannot be collated across the geographical area covered by the ranch.

The principal investigator has studied the ecology of a grassland site at the ranch for the past four years. As a result of a study sponsored by the Atomic Energy Commission (Bonham, 1969, 1970, 1971), it was recognized that a study covering the entire ranch would add significant information to that already available. Therefore, a soil and vegetation inventory of a statistical nature was carried out to obtain a better understanding of the vegetation and soil characteristics over the entire ranch.

A thorough understanding of the variation that exists in various ecosystems represented by differing vegetation types was needed to facilitate formulation of basic ecological principles as well as relating the results of future research from one time and place to another. These relationships could not be made with any measure of reliance unless the inventory was conducted on a statistical basis. Such ecological variations have not been studied extensively in the southwestern U.S. nor on the ranch. Only in the past few years has there been any discernible interest exhibited in describing any ecological phenomena over geographical spaces. Studies of plant associations in the area have been carried out on the site set aside for the AEC study (Bonham, 1969, 1970). It was soon evident that The Research Ranch needed to have available a complete inventory of its vegetation and habitat characteristics covering the entire

8,000 acres. Therefore, a study was initiated in August, 1970, for the purpose of obtaining bench-mark data on vegetation and soils of the ranch.

Objectives

The objectives of this study were:

1. To obtain inventory data for a vegetation description of The Research Ranch.
2. To design and implement a computerized data information system for all data at The Research Ranch.
3. To reference all data by a coordinate system for use in research or demonstration alternatives.

The completion of this project provides a base for the ranch to seek almost infinite opportunities for ecological studies using this inventory information, such as: secondary succession studies, oak-woodland complex ecological analyses, plant-soil nutirent cycling, and environmental analyses for wild animal preservation.

The secondary succession studies in the grassland areas could be conducted using the inventory information as a base reference. The rate of succession in vegetation types of the area would be useful information since it is not known for this grassland type in southern Arizona. Any natural occurrence of fire in the area would also allow succession studies to be made in this regard.

The oak-woodland complex of the ranch offers an opportunity to make an ecological analysis without interference of the usual ranching operation procedures. An evaluation needs to be made of the oak-tree status in the ecological complex of the area. Furthermore, the inventory information could be used in an evaluation of the area for endangered wild animal preservation programs. Determination of optimum environmental conditions for some of these animals will be enhanced by basic inventory

information obtained from this project.

Southwestern Vegetation History

Most of the early vegetation history of the Southwest comes from three sorts of visitors that traveled in the region: prospectors, surveyors, and soldiers (Humphrey, 1958). Many of these early travelers kept diaries and only occasionally mentioned the vegetation. This was usually in relation to their needs for fuel (wood for campfires) and forage for livestock. However, some of the information comes from fairly competent naturalists that accompanied many of the early military and survey operations.

Bartlett (1854) explored the San Rafael Valley west of the Huachuca Mountain Range and reported it as "a smooth gravelly plain, without a tree or brush." This area appears to be essentially the same today as in the 1850's. The ranch is approximately 15 km north of the valley.

The International Boundary Commission (1899) photographed all the boundary monuments from El Paso to San Diego from 1892 to 1896. Humphrey (1958) re-photographed the markers in the Nogales area in 1956 and noted few observable changes in the vegetation. Slight increases in brushy species and some replacement of grasses by brush were some of the mentioned changes.

Thompson (1942) dated the inception of livestock grazing in the southwestern United States at about 1500. Columbus and Cortez both brought sheep, cattle and horses from Spain and these formed the parent populations of large wild herds that later spread over the Southwest. From 1540 to 1542, Coronado traveled in the Southwest with large herds of livestock. Animals strayed and formed large herds that were reported later by other travelers in the region. In 1891, cattle numbers were estimated to be

approximately 1,500,000 head on Arizona ranges, a most probable all-time high. This gives testament to likely overgrazing in many areas of the desert grassland (Haskell, 1935).

Since the United States Department of Agriculture began establishment of range experiment stations around 1900, vegetation records have been available for those areas. The Santa Rita Experimental Range is located closest to the ranch. Toumey (1891) reported that many of the ranges of the West, including Arizona, were being deteriorated by overstocking. Griffiths (1901, 1904, 1910), also an employee of the Department of Agriculture, documented conditions of southern Arizona ranges early in this century. He noted at the time that most of the ranges were in great need of rest time to recover from a deteriorated condition.

Ellison (1960), in an excellent and extensive review of literature concerning the effects of grazing on grasslands, also found that most studies in the desert grasslands showed increases in shrubs along with decreases in desirable species of perennial grasses with grazing.

Ecology and Succession

Early researchers refer to the region of southwestern Arizona as "desert grassland" (Shantz and Zon, 1924; Shreve, 1917). Clements (1920) regarded the area as in the "desert plains". Whitfield and Anderson (1938) refer to the "Desert Plains Grassland" when describing grasslands of the Southwest.

Weaver and Clements (1938) noted that the desert grassland resembled the shortgrass regions of the Great Plains, and under some circumstances the two would be difficult to differentiate.

Whitfield and Beutner (1938) considered the desert grassland to be the true shortgrass association of the grassland formation. The particular

region of the study area is considered to be in the upper blue grama-curly mesquite (*Eouteloua gracilis, Hilaria Belangeri*) faciation which is predominantly composed of those two species. Overall, the Desert Plains Grassland was thought to be in a disclimax subsere as a result of overstocking and consequently returning towards a climax state (Whitfield and Anderson, 1938).

Humphrey (1949, 1953, 1960) reported that the shortgrasses of the area are not climax, but rather a product of a fire-controlled climax. Subsequently, he believed the desert grasslands of today would not appear greatly different than those present prior to the settlement of white men, but for the absence of fires. This would be identical to the Clementsian proclimax.

Nichol (1952), in a study of the natural vegetation of Arizona also described vegetation in a southeastern Arizona grassland. He referred to this region of the state as "some of the best cattle range country in the United States." The region was also characterized as having an abundance of *Bouteloua* and *Hilaria* species. *Quercus* and *Prosopis* species along with a few less abundant species were considered the most valuable browse plants occurring in the area. This area of the desert grasslands generally supports a wide variety of wildlife in abundance.

Observations by Bray (1901) indicated that the desert grassland was undergoing changes in species composition from predominantly grasses to shrubs and brush. This of course was not entirely true for all desert grasslands of the Southwest, since certain local regions such as those near the study area are now and undoubtedly were pure grasslands.

According to Whitfield and Beutner (1938), many areas of the southwestern grasslands have suffered from relatively heavy invasions of brush

and shrubs since use by white man commenced. Glendening (1952) produced quantitative data to affirm this indictment of excessive grazing and intimated that mesquite and cactus have increased significantly over a number of years in some desert grassland areas. Parker and Martin (1952) cite 12 references attributing the invasion of mesquite to overgrazing. Humphrey (1958) states that mesquite invasion provides an adequate index for the whole brush invasion picture. The most probable reasons given for the shrub invasion were overgrazing and absence of fires, the latter being primarily a consequence of the former (Humphrey and Mehroff, 1958).

In a more recent study very near the present study site, Wallmo (1955) made observations about the grassland region juxtaposing the Huachuca Mountains. He noted that slight changes in elevation coincide with pronounced changes in the predominant grass species. At elevations below 1200 m he noted black grama (*Bouteloua eriopoda*) was predominant, while above that elevation, blue grama was the predominant grass with up to 50 percent relative cover. At about 1500 m elevation plains lovegrass (*Eragrostis intermedia*) becomes the most important grass.

Bonham (1969, 1970, 1971) described basic ecological variations and associated phytosociological relationships on a 35-hectare site located within the present study site.

ENVIRONMENTAL AND PHYSICAL DESCRIPTION OF THE RESEARCH RANCH

All vegetation and soil samples were taken within the boundaries of The Research Ranch, Inc., located 9.6 km south of the town of Elgin, Santa Cruz County, Arizona (Figure 1). The total area of the ranch consists of approximately 30 km^2.

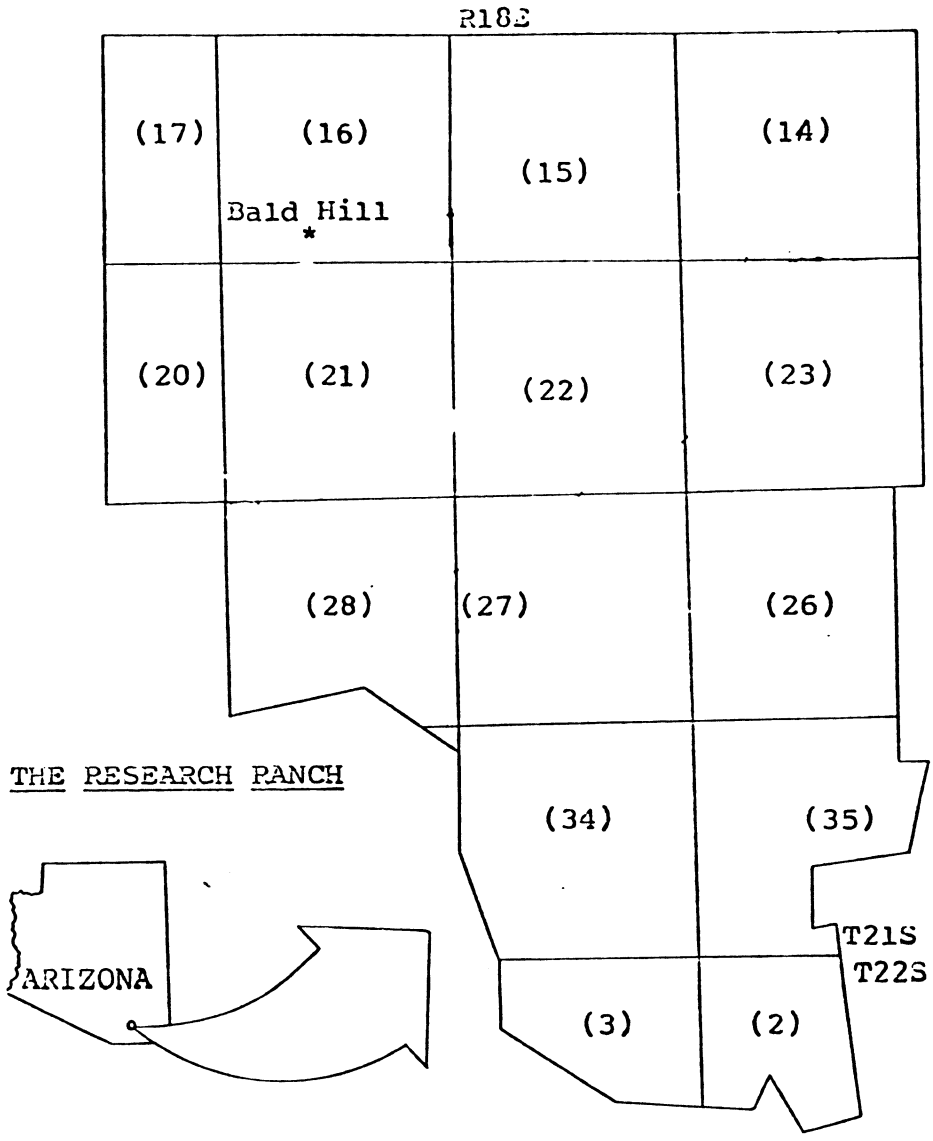


Figure 1. Map of The Research Ranch showing section numbers in parentheses. Bald Hill is designated by *.

Physiography

The elevation of the ranch ranges from 1417 m at the northeastern corner to 1560 m at the southern boundary. A large portion of the north end of the ranch is dominated topographically by Bald Hill, which is a very broad and relatively high area. The hill is gently sloping and is slightly dissected in all directions. This particular hill, because of its size, has a profound influence upon the ecology of the ranch. It expresses a dominating influence upon the vegetation and its distribution, and is undoubtedly one of the most influential pieces of the landscape of the ranch. The remainder of the northern half of the ranch to the east of Bald Hill is characterized by mostly narrow ridges and steeply-sloping canyons. The relief in this portion may be as much as 35 m with slopes as steep as 35 degrees. The southern half of the ranch consists of small plateaus which are deeply dissected into narrow, steep-walled canyons. Relief in this area ranges up to 70 m with slopes as steep as 35 degrees. The remainder of the landscape relief is characterized by rolling hills with intermittant level areas. Drainage is to the northwest.

Vegetation

The vegetation is predominantly perennial grasses. The *Bouteloua* species and *Aristida* species along with *Lycurus phleoides* (wolftail grass) are the most important species. Solid stands of alkali sacaton (*Sporobolus airoides*) are found on most of the flood plain areas. In the northern part of the study area, live oak (*Quercus* spp.) are common on north-facing slopes, while in the southern portion at higher elevations, oaks are important on all slopes. Oaks also form some savannah-like areas as well. Detailed descriptions of the vegetation

will be presented in later sections of this paper since they were a primary objective of the study.

In the United States Soil Conservation Service classification of major land resource areas, the Southeastern Arizona Basin and Range (41) includes roughly an area south and east from the city of Tucson. The major land resource areas are subdivided into environmental zones, two of which are represented on the ranch. Environmental zone 41C, the Coronado Chaparral, is somewhat represented by the vegetation occurring on the southern portion of the ranch. However, this area of the ranch is more like a transition between zones 41C and 41D, the Sonoita Desert Grassland. This latter zone is represented by the vegetation of the northern portion of the ranch. Each of these zones is characterized by the Soil Conservation Service with respect to representative common species of vegetation, representative soils and topography, all of which are described in more detail in other sections of this paper.

Soils

Wilson, Moore, and O'Haire (1960) date the formation of most of the region around the study area to the early portion of the Quaternary period, 15 to 20 million years ago. Parent materials of existing soils are primarily mixed alluvia and conglomerates which have been classified by the United States Department of Agriculture, Soil Conservation Service, into four series: Bernardino, Hathaway, Pima, and White House (Bonham, 1969).

Bernardino Series: The Bernardino series belongs to the family of fine, mixed, thermic Mollic Haplargids. The soils are characteristically mildly alkaline in the surface layer, contain fine-textured red-brown B

horizons, and show distinct accumulation of calcium carbonate at depths of 50 cm or less. The pH range is generally from 7.5 in the surface layers to 8.0 in the lower soils. The soils typically occur as level to rolling alluvial fans and are derived from andesite, basalt, chert, limestone, quartzite, and rhyolitic tuff rocks. The slopes on which these soils are found range between one and 13 degrees. These soils are typically well drained, have a medium runoff class, and a slow permeability rating.

Hathaway Series: The Hathaway series belongs in the family of Typic Calciustolls and usually has dark-colored A horizons over gravelly, coarse-textured C horizons. The pH typically ranges from 8.0 in the upper layers to 8.2 in the lower soils. These soils occur on nearly level (one degree) to steep slopes (30 degrees) of alluvial fans or plains and are derived from andesite, dacite, granite, limestone, quartzite, rhyolite, sandstone, shale and tuff. They are generally well drained, moderately permeable, and have a medium surface runoff rating.

Pima Series: The Pima series belongs to the Fluventic Haplustolls family and characteristically has dark-brown clay loam A and C horizons. The soils are usually calcareous throughout and contain more than one percent organic matter. The upper layers generally have a pH of about 7.5, while the lower layers have a pH of 8.0. The soils occur on level to gently sloping low terraces and flood plains (slopes from 0 to 13 degrees) and are derived from acid and basic igneous rocks, limestone, quartzite, and shale. The Pima soils are generally well drained and have moderately slow to slow permeabilities with a surface runoff class of slow to medium.

White House Series: The White House series, like the Bernardino series, belongs to the Mollic Haplargids family. These soils have well-developed, red-brown B horizons with some concentrations of calcium carbonate in the lower horizons. The series typically contains at least one percent organic matter and a range in pH of 5.5 to 8.0 in upper and lower layers, respectively. The White House soils are primarily found as alluvial fans or plains and are derived from andesite, dacite, granite, quartzite, and rhyolite with basalt and limestone influences. The permeability of the White House series generally ranges between moderately slow to slow and these soils are considered to be well drained with a medium surface runoff rating.

Climate

No permanent official weather records are available for The Research Ranch; therefore, two nearby United States Weather Service recording stations were used: Canelo and Fort Huachuca, Arizona. The Elgin station data were eliminated from consideration due to the lack of temperature records.

The Canelo weather station, located on the eastern slope of the Canelo Hills, is only 2 km from the southwestern boundary of the study area. But, Canelo was considered unlikely to provide the most accurate record for the study area because it is higher in altitude and located closer to mountains. This latter factor is a very critical climatological factor in this area as will be explained later in this section. Fort Huachuca, located on the northeast slopes of the Huachuca Mountains, is slightly lower in elevation at 1421.58 m and somewhat farther away (11.26 km). For similar reasons, Fort Huachuca alone may not accurately

represent the weather at the study area. Therefore, it was apparent that the best representative of available meterological records for the study area would be an average of the U.S. Weather Service records for the Canelo and Fort Huachuca Stations (Table 1).

Temperature and precipitation records are the only weather records available within a geographical vicinity worthy of the efforts of interpolation. Other factors such as wind are discussed generally for the region.

Approximately one-third to three-fourths of the total annual precipitation in the southwestern United States falls only during late summer (Shreve, 1944; Dorroh, 1946; Sellers, 1964). More specifically, southeastern Arizona receives about one-half of its total annual precipitation during the months of July and August (Figure 2). Most of the remainder falls from December through mid-March, although precipitation of seasons other than late summer is much less predictable (Huntington, 1914; Sellers, 1964). Mean monthly precipitation calculated for the ranch for July and August was 21.38 cm, very nearly 50 percent of the yearly average of 43.01 cm (Table 1). The total for December through March averages 11.17 cm, which is approximately 25 percent of the total annual average. It is notable that over 75 percent of the yearly precipitation usually falls during only about one-half of the year.

Sellers (1964) believes the two-season precipitation pattern is better described by referring to the "two seasons of the year when drought conditions are less noticeable than usual." Drought conditions are more noticeable, however, during the months of May and June. In southwestern Arizona, for example, measurable precipitation occurs on the average of only one out of every three years during these months. The month of May

Table 1. Mean monthly minimum and maximum temperatures (C) and mean monthly precipitation (cm) are expressed as an average of records from the Canelo and Fort Huachuca weather stations.

	Means 1910 - 1970		
Month	Minimum	Maximum	Precipitation
January	-1.70	14.30	3.02
February	-0.60	16.10	2.99
March	1.90	19.40	1.87
April	4.60	25.20	0.86
May	9.00	27.50	0.60
June	13.83	32.38	2.00
July	16.40	23.20	10.99
August	16.20	29.77	10.38
September	12.94	28.90	5.13
October	7.60	25.21	1.87
November	1.90	18.40	2.18
December	-1.30	14.80	3.27
Mean	6.73	22.76	3.59
Total			43.10

is commonly the mid-point of the first yearly drought in the region of the ranch, averaging less than 0.7 cm per year. October is the mid-point of the other dry season with approximately 1.9 cm of precipitation falling in an average year (Table 1).

Sellers (1964) describes the meterological conditions necessary for the bi-seasonal precipitation pattern which occurs in southeastern Arizona. The summer precipitation is mostly of convective origin and results from the influx of moist tropical air masses. The movement of these moist air masses is contingent upon the presence of a high pressure cell situated over the Atlantic Ocean and projecting into the central portion of the United States. As a result, winds originating in the Gulf of Mexico gently flow around the high cell from the southeast into Arizona. Huntington (1914) describes the late summer rainy season as a monsoon, a term that is often heard locally. The storms resulting from the tropical air movements are generally quite intense with abundant thunder and lightning. The higher elevations receive the most precipitation from the storms, while the lower elevations usually only receive gusty winds and a light shower.

Usually, the ranch receives a thunderstorm every day during July and August. This pronounced regularity is almost always accompanied by predictable circudian periodicity with most of the storms occurring in late afternoon and the fewest during the morning. Intense heating of the ground surface during the day produces strong vertical wind currents (orthographic uplifts), bringing about condensation of warmer, moist air upon contact with cooler air above. Other factors contributing to the regular precipitation pattern are also important locally, such as drainage winds that blow upslope during the day, reaching a maximum in the

Figure 2. Annual variations of the mean monthly precipitation (cm) for the southeastern section of Arizona. The horizontal dash line is the average of 12 monthly values (Institute of Atmospheric Physics, University of Arizona, and the U.S. Weather Bureau, 1964).

afternoon, and downslope winds at night that reach their maximum during morning hours.

The distribution and intensity of summer precipitation, as Sellers (1964) has pointed out, is a function not only of the location of the source of moisture, but also of local surface elevation. Since the ranch is located in the southeastern part of Arizona, it is closer to the source of the precipitation than most of the remainder of the state. In addition, the general area is approximately 1800 m in elevation, and therefore is in a favorable precipitation pattern.

Occassionally tropical hurricanes off the west coast of Mexico move across Arizona causing severe storms with intense precipitation. This system has historically produced nearly all of the record rains in Arizona, yet their causes have not definitely been established. Precipitation occurring during late August and September normally averages over 3.81 cm (Table 1). Since these are long-term averages, much of this amount probably resulted from storms originating over the Pacific Ocean. Wide variations in the amount of precipitation occurring during September from year to year testify to this hypothesis.

Sellers (1964) also describes storm conditions necessary for winter precipitation in Arizona. The prevailing westerly winds carry periodic cyclonic storms from the Pacific Northwest through the center of the United States then back up again to the Hudson Bay region. In most instances these storms are reported to cause only wind and a few clouds in Arizona, but when precipitation does occur, it is usually from this type of system. The Canelo station averages 25.40 cm of snow per winter, yet most of this amount melts as soon as it strikes the ground. Fort Huachuca also receives approximately ten percent of its yearly precipitation as

snow, but only when it is exceptionally cold does it remain on the ground surface past a day or so.

Large daily temperature variations among various geographical locations in Arizona are largely a function of altitude due to local drainage winds as mentioned earlier. This is easily observed from the individual weather station records, where Fort Huachuca had a 5.28°C warmer average minimum than Canelo. Daily maximums between the two stations, however, varied only 0.48°C in an average year. The study area, located at an intermediate altitude, would probably have intermediate values (Table 1). Latitude is also important, particularly in the winter when southern Arizona is 12.5°C warmer than northern Arizona. Most other Arizona locations also experience large diurnal variations with ranges of 20 to 25°C. The greatest daily temperature range calculated for the ranch area was 18.5°C for each of the months of April, May, and June.

Sellers (1964) comments that there are very few locations in Arizona that are genuinely comfortable year round. "Probably the most comfortable part of Arizona is the ... hill country of the southeast section ... Fort Huachuca ... and Canelo have especially mild temperature climates, although there it may be a bit too wet for most people in mid-summer." He gives three reasons for the mild climate in this area: the southern latitude, intermediate altitudes and topographically located on gentle slopes near mountains.

METHODS AND PROCEDURES

Methods were chosen which would obtain the necessary data in the most economical way. Therefore, a departure was made from the original field sampling design. Instead of locating sampling points on a

symmetrical grid, photographic techniques were used to identify basic vegetation units on the ground. These units were then used as keys to locating field sampling points.

A total of 16 vegetation types were identified. Each of these types were characterized by information on plant species composition, species cover, biomass by plant life form, energy content, nitrogen content, and associated soil characteristics. Procedures for each of these data are described.

VEGETATION MAPPING BY PHOTOGRAPHIC INTERPRETATION

by

Gary Gnauck and Terry McLendon

The purpose of this section is to document the procedures employed during the compilation of an accurate vegetation map of The Research Ranch from aerial photography. The objective of this portion of the program was to stratify the ranch into basic vegetation types based on intensive field observations in combination with interpretation of specific aerial photographs. It is convenient to present the work in chronological order.

Phase I (Initial Field Work)

A search of existing aerial photographic data banks revealed that coverage of the ranch at a scale of 1:15,840 was obtained by the U.S. Forest Service in June of 1969 using Kodak Aero negative color film. Contact prints were obtained of the imagery in both color and black and white. It was determined that the black and white photographs were not suitable for detailed vegetation analyses. Therefore, they were not used extensively in this effort.

Preliminary field work indicated that several general vegetative characteristics of the ranch could be delineated. The color photographs were then used in the field for a three-day period in August, 1971, and studied in detail as each basic vegetation type was visited. For each vegetation type, one or more 35 mm ground photographs were taken along with pertinent notes on topography and important plant species occurring in the type.

After this phase of work was completed, two parallel efforts were made to prepare a vegetation map. A field crew remained on site at the ranch and, using existing U.S. Geological Survey topographic maps at a scale of 1:24,000, prepared a tracing overlay of the vegetation as determined from field observations. Concurrently and independently, a preliminary interpretation of the 1:15,840 scale color photographs was made by a professional photo-interpreter.

Phase II (Photo-interpretation)

The areas for which ground visits had been made were located on the aerial photographs. The tone, texture and pattern of these areas as portrayed in the photographs were studied in detail along with field notes and available topographic maps. In this way, a characteristic signature of each vegetation type was developed. It was found that stereoscopic analysis of the photographs was essential to accurately delineate various categories of vegetation due to the importance of topography. Each stereo pair of photographs was examined and the extent of each vegetation type was carefully delineated within an accuracy area of five acres. (To preserve the color photographs for later use, the type delineations were marked on a sheet of matte acetate taped to each photograph.)

Two problems were encountered. The first concerned the dates of the photographs which represented the vegetative condition as it was three growing seasons prior to the August, 1971, field trip. The wooded areas were virtually unchanged; however, some of the grass types did show changes in pattern and distribution. This was thought to be the result of the grassland recovering from prior grazing by cattle. The second problem concerned the scale of the photographs which caused difficulty in identifying some of the types due to the insufficient photographic detail. It was also very difficult to draft many of the bottomland grass types because they occur in very long, narrow strips.

Phase III (Field Check of Initial Interpretation)

After all of the photographs had been interpreted, an uncontrolled composite overlay was prepared. This photo-produced overlay was then compared with the field-produced overlay in order to work out differences and discrepancies between the two. Field checks were again conducted.

The field-produced overlay was more accurate with respect to correctly identifying some of the vegetative types, particularly when based upon the presence of certain grass species. However, the photo-produced overlay was more accurate with respect to the overall pattern and distribution of each type. This is typically the case since it is impractical to visit each acre during the field efforts.

Phase IV (Final Map Compilation and Interpretation)

New photographs (black and white panchromatic) were obtained of the ranch at a scale of 1:10,000 and with a 60 percent overlap between frames and a 30 percent sidelap between runs. Cooper Aerial Survey of Tucson, Arizona, flew the photography, using an RC 10 mapping camera. The resulting imagery was of excellent quality.

The final map of the ranch was to provide accurate measurements of the various vegetative types within the ranch, but it was not essential to prepare a controlled map with respect to latitude and longitude. There were no known bench marks or ground controlled points within the area photographed. Thus, the construction of a complete radial line plot was not possible. However, a partial radial line plot was constructed in the area. The procedure followed, however, has resulted in a map that has good accuracy relative to the ranch itself. That is, the map is accurate within the ranch between vegetation types, but is not accurate with respect to a formal coordinate system, although it could easily be tied to such a system at a later date.

It is important to point out that greater error exists in the delineation of many of the vegetation type boundaries than is due to the distortions of the photographs since personal judgement determines where a given type ends and the adjacent vegetation type begins.

After template lay-down was completed, a large sheet of mylar was layed over the template composite. The center of each triangle was selected as the actual location of each pass point and this was pricked with a sharp needle in the large mylar overlay and labeled.

The final interpretation was then performed using both the color and larger scale panchromatic photographs along with all available auxiliary information. The actual delineations down to the five-acre area were marked on the 1:10,000 scale photographs in ink and labeled by type number. As with the initial analysis, stereoscopic analysis was used. After all the photographs were interpreted, each was placed under the large mylar overlay, matching pass point of the photograph with those that had been transferred to the mylar sheet.

Detail in the photograph (type boundaries) was then transferred to the mylar overlay and inked. The photographs were adjusted in position as the boundaries were transferred around each point. The final map was then colored and identified, a legend prepared, and sprayed with a plastic preservative.

Two maps were prepared (cartographically, the second map was a simple copy placed over the first large mylar overlay). One map portrays 16 vegetation types and is more detailed than the other which portrays only 12 categories of vegetation. The latter map is very similar to the final field map with respect to the categories portrayed. Both are accurate, the difference being one of criteria used to define a vegetation type. The detailed map is illustrated in Figure 3.

Field Sampling Procedures

Each of the 16 vegetation associations were sampled to determine plant species composition, plant species cover, biomass of plant species according to life form categories, energy content, and nitrogen content. Samples were obtained from each of the vegetation associations by the use of line transects in conjunction with sampling plot units. Line transects were placed according to cardinal directions and were 20 m in length. Sampling units, 40 cm^2 plots, were located systematically along each of these transects. The total of 12 quadrats was used to obtain the vegetation information from each point. Vegetation species cover values were obtained by estimating the projected ground covered by foliage for each species occurring within each of the sampling units. These were recorded for each sample plot placed along the transect. Standing crop biomass was determined by life forms which consisted of perennial grasses and forbs, annual grasses and forbs, and shrubs. Each

of these life forms was clipped and weighed as it occurred within a sample plot. The energy content of vegetation was determined also by the major life forms indicated for standing crop. Samples were obtained for each of these life forms, oven-dried, ground, and returned to Colorado State University for chemical determinations.

All values obtained from the sampling units concerning vegetation characteristics were then averaged to obtain an estimate of these characteristics for the vegetation association. At least three sampling points consisting of the two line transects were located within each vegetation association. More than three sampling points were obtained when the vegetation association was considerably variable over the ranch.

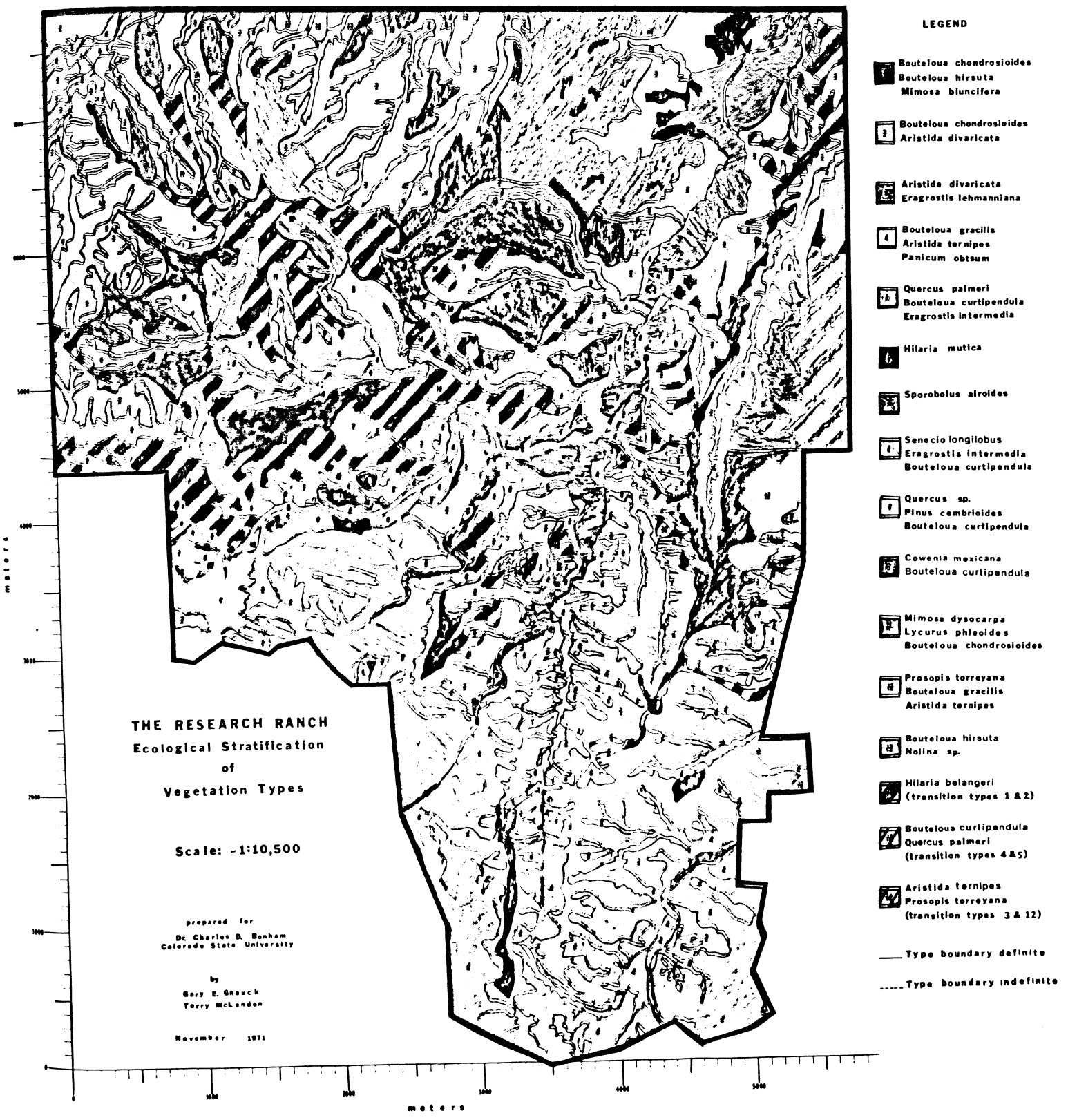
The determination of gross energy content, kilocalories per gram, was made using the PARR peroxide bomb calorimeter. Percent nitrogen content of the air-dried vegetative material was determined by the micro-kjeldal digestion method.

Each of the vegetation types was also sampled with respect to soil. Soil samples were obtained from each sampling point in a random fashion. A sample of the first six inches of soil only were characterized. These samples were taken to Colorado State University where laboratory analyses were conducted to determine mechanical and chemical characteristics.

All of the data concerning vegetation and soil characteristics were averaged over all plots and sample points within an association. This information was then used to describe the 16 vegetation associations which occur on the ranch. This information will undoubtedly change to some degree as the effects of past livestock grazing are masked by time.

A computer storage-retrieval system was built to accommodate the information obtained with respect to The Research Ranch environment. A

Figure 3. Vegetation map of The Research Ranch.



number of systems are available which are useful for this purpose. However, after an extensive study was made of various systems, it was decided that the most efficient system was INFOL, which is a Control Data Corporation system. Therefore, INFOL was modified to accommodate The Research Ranch information. The system is easily used and is available at most CDC computer installations. A complete description of INFOL is available in a manual from Control Data Corporation. A copy of this manual is on file at The Research Ranch library. Only a brief description will be given in this report to indicate some of the important features of the system and its basic operating characteristics. Refer to Appendix A for details of INFOL.

The vegetation map displayed in Figure 3 was used to obtain a grid system which would allow the storage of environmental information on a computer system. This system was a special design for The Research Ranch data. The map was divided into approximately 12,000 grid points. Each of the grid points was sampled to determine the vegetation type at that particular x-y coordinate. After determination of the vegetation type, each of the vegetation and soil characteristics was identified with a grid point and prepared for computer input. Since a number of data points is involved in such a technique, an efficient method was found by creating two major steps for the storage-retrieval system. By identifying only the vegetation type associated with the 12,000 grid points, only 361,750 characters of information are used. If all of the associated information had been stored on one tape, it would have required 110,400,000 characters of information. Therefore, it is easily seen that an extremely large amount of space would have been required to store the information.

Therefore, a second tape was generated which contained information specific to the 16 vegetation associations.

The two-tape system is easily used by, first of all, inquiring as to what vegetation occurs at a particular grid point. After this information is obtained, the second tape is searched for the specific information concerning vegetation or soil characteristics. All future updating of information will be made using this approach.

The beginning of the grid system in terms of the x-y coordinate begins at the northwest corner of the ranch. This point is indicated as $y = 0$, $x = 0$. The y increases along the direction of north to south, and x increases along the direction of west to east. Therefore, if interest should center on a particular point on the ranch, this grid system should be applied. The particular point should be obtained from the original map of Figure 3, which will be in the library of The Research Ranch. The accuracy of the grid system is within a five- to seven-acre range.

Figure 4 shows detailed lists of information stored on these two tapes and the way in which it was stored. The basic units used in INFOL are referred to as files. The tape containing specific information has a file for each of the 16 vegetation types. Each file contains the detailed vegetation and soil data appropriate to it. The vegetation grid tape contains 12,544 files which store the x, y coordinate system with the vegetation type code and associated general information.

INFOL has two basic operations:

1. Storing (and later modifying) quantities of data.
2. Selecting and retrieving data in its original form which meets specified requirements.

FILE ---> VEGETATION TYPE

Number of Elements in File. 16

Maximum Sizes of All Variable Length Information

Item Description	Item No.	Category	Type	Field Length	Number of Sub-Items
Vegetation Type	1	Unary	Numeric	2	
Sand	2	Unary	Numeric	5	
Silt	3	Unary	Numeric	5	
Clay	4	Unary	Numeric	5	
Soil Nitrogen	5	Unary	Numeric	6	
Soil pH	6	Unary	Numeric	6	
Soil Salt	7	Unary	Numeric	6	
Soil Organic Matter	8	Unary	Numeric	6	
Soil Phosphorus	9	Unary	Numeric	6	
Soil Potassium	10	Unary	Numeric	6	
Soil Zinc	11	Unary	Numeric	6	
Soil Iron	12	Unary	Numeric	6	
Gross Energy	13	Multiple 1	Numeric	6	8
Vegetation Nitrogen	14	Multiple 1	Numeric	5	8
Biomass	15	Multiple 1	Numeric	5	8
Vegetation Class	16	Multiple 1	Alphanum	3	8
Cover	17	Multiple 2	Numeric	5	100
Frequency	18	Multiple 2	Numeric	6	100
Spp. ID	19	Multiple 2	Alphanum	6	100
Scientific Name	20	Multiple 2	Alphanum	26	100
Common Name	21	Multiple 2	Alphanum	25	100

FILE ---> GRID

Number of Elements in File. 16668

Maximum Sizes of All Variable Length Information

Item Description	Item No.	Category	Type	Field Length	Number of Sub-Items
Grid Point	1	Unary	Numeric	5	
X Coordinate	2	Unary	Numeric	3	
Y Coordinate	3	Unary	Numeric	3	
Vegetation Type*	4	Multiple	Alphanumeric	14	4

*Has type number and three major species.

Figure 4. Data description for INFOL.

VEGETATION DESCRIPTIONS

The vegetation description process consisted of two parts. The first part dealt with determining major vegetation types and their distribution over the ranch. This part of the work was accomplished by using remote sensing techniques, namely aerial photography, and was accomplished by a professional photo-interpreter. The vegetation map was generated after a series of interpretation-field examinations were made as previously described.

Part Two of the vegetation description consisted of extensive field sampling to determine vegetation characteristics. These characteristics included species cover, species frequencies, standing crop by vegetation life forms, gross energy by life form, and percent nitrogen of air-dry weight by life form. These data were used to form a vegetation association description in conjunction with the vegetation map generated by photo-interpretation process.

A combination of these two approaches to a vegetation description of The Research Ranch gave a satisfactory description with regard to vegetative properties found on the ranch. The vegetation associations were named according to the major species found to form an association. The association names found on the map (Figure 3) were derived by visual examinations of these associations in the field. There is some disparity between these association names and those derived by quantitative sampling within a vegetation type. The quantitative sampling process yielded cover values of species which are indicative of their relative dominance in a community or association. However, this disparity occurs only occassionally and does not affect the overall vegetation description by associations.

Figure 5. The Research Ranch vegetation associations identified and described.

Association #1	*Bouteloua chondrosioides / Bouteloua hirsuta / Mimosa biuncifera*
Association #2	*Bouteloua chondrosioides / Hilaria belangeri / Aristida divaricata*
Association #3	*Eragrostis lehmanniana - Aristida divaricata / Bouteloua chondrosioides / Aristida ternipes*
Association #4	*Bouteloua gracilis / Aristida ternipes*
Association #5	*Bouteloua curtipendula / Eragrostis intermedia / Quercus emoryi*
Association #6	*Hilaria mutica / Eriochloa lemmoni*
Association #7	*Sporobolus airoides / Hilaria mutica*
Association #8	*Senecio longilobus / Eragrostis intermedia / Platanus wrightii*
Association #9	*Bouteloua curtipendula - Hilaria belangeri - Bouteloua chondrosioides / Mimosa dysocarpa*
Association #10	*Bouteloua curtipendula / Cercocarpus breviflorus*
Association #11	*Mimosa dysocarpa - Lycurus phleoides - Cassia leptadenia / Bouteloua hirsuta*
Association #12	*Bouteloua gracilis / Aristida divaricata / Eragrostis intermedia*
Association #13	*Bouteloua hirsuta - Bouteloua gracilis / Nolina texana*
Association #14	*Hilaria belangeri / Aristida divaricata / Nolina texana*
Association #15	*Bouteloua curtipendula / Hilaria belangeri - Panicum obtusum*
Association #16	*Aristida ternipes - Bouteloua gracilis / Eragrostis intermedia*

Each association is defined by having the most frequently occurring species, in terms of cover, being placed first and separated by a hyphen (-) from another species if this second species is a co-dominant. The separation of species by a slash (/) indicates that the species following the slash is an important associate found in this vegetation association. Therefore, by reviewing the name of the association in Figure 5, it is possible to have a concise summary of the major species relationships found in that particular association.

Each association is described briefly and the discussion was derived from the information reported in Tables 2 through 11.

ASSOCIATION #1

Bouteloua chondrosioides / Bouteloua hirsuta / Mimosa biuncifera

This association occurs in the north central part of the ranch and is characterized by the presence of *Bouteloua chondrosioides* as the major species (20.3 percent cover). *Bouteloua hirsuta* and *Aristida ternipes* are the most common associates in this association, and are found occassionally as dominants in small, localized areas. Five of the six *Bouteloua* species found on the ranch occur in this vegetation association. However, these species occur much less abundantly (< 1.0 percent) than the two major *Boutelouas* already mentioned. *Lycurus phleoides* occurs infrequently (1.6 percent cover), while *Aristida divaricata* occurs much more frequently (4.5 percent cover).

This association is easily observed in the field. The primary identification feature aside from the vegetation is that it occurs on flat topography. A major criteria for further delineation of this vegetation association is a slope of less than five percent. However, this association does not include large areas in the northeast portion of the ranch

classified as Association #2 (reseeded area), although these areas are also relatively flat.

The most abundant forbs are *Croton corymbulosus*, *Brayulinea densa*, *Evolvulus sericeus*, and *Sida procumbens*. However, none of these forbs exceed 1.5 percent cover values in this association. Annual forbs are quite abundant here as well as in other associations on the ranch. These forbs are often easily identified but are also extremely variable in their occurrence from one year to the next. Therefore, individual information concerning these annuals is not used in the vegetation description.

The most abundant shrub is *Mimosa biuncifera* with a cover value of only 1.8 percent. *Acacia angustissima* along with *Haplopappus tenuisectus* also occur in this vegetation association. Small amounts of *Desmanthus cooleyi* and *Haplopappus spinulosus* are observed in this vegetation association.

The standing crop values for Association #1, as expressed by the five life form classes of vegetation, reveal that the perennial forbs obtain their greatest production in this particular association. Perennial forbs are noted to have 33 g/m^2, while the perennial grass component produces 151 g/m^2. Annual forbs and annual grasses have values of 13 and 8 g/m^2, respectively. Shrubs are noted to produce 5 g/m^2 on the average for this association.

Association #1 is noted to have the highest gross energy value for shrubs, 4.72 Kc/gm (kilocalories/gm), which is not unusual (Table 6.). The lowest gross energy value is found to be in perennial grasses, with a value of 4.26 Kc/gm.

Association #1 has the highest value (of all associations) for percent nitrogen occurring in the annual forbs with a value of 3.61 percent.

The perennial forbs for this association have a percent nitrogen content of 2.21, while the annual and perennial grasses are rather low in percent nitrogen (Table 7).

Soils for this association are low in nitrates and have a 51.6 percent sand content. Iron content is rather high at 22.9 ppm. Phosphorus values are intermediate for this type. The pH of these soils averages 5.5.

ASSOCIATION #2

Bouteloua chondrosioides / Hilaria belangeri / Aristida divaricata

This association is the most ubiquitous vegetation association found on the ranch. It is characterized by the occurrence of *Bouteloua chondrosioides* with an average cover value of 10.5 percent. *Hilaria belangeri* with a cover value of 6.5 percent and *Aristida divaricata* (average cover value of 5.1 percent) are the common associates in this vegetation type. *Bouteloua gracilis* is absent in this association or is found only in local depressions. This is in contrast to Association #1 where this species occurrs with a cover value of approximately one percent. Another important distinction of this vegetation association is the occurrence of *Andropogon barbinodis* with a cover value of 2.1 percent. Overall, the *Bouteloua* genus occurs less frequently in this association than in Association #1. However, these species are, nonetheless, the characteristic genus for distinguishing this association.

The primary identification feature for this association is very steep slopes and the absence of woody vegetation. With stereoscopic analysis of aerial photography, this association is easily delineated. (Without stereoscopic analysis it is very difficult to determine the exact limits.) In the northwest corner of the ranch, this association

grades into Association #11 (*Mimosa dysocarpa / Lycurus phleoides - Bouteloua chondrosioides*).

The most commonly occurring forbs are *Croton corymbulosus*, *Evolvulus sericeus*, and *Sida procumbens*. An abundance of annual forbs occurs in this association. The most common shrubs are *Desmanthus cooleyi* (1.4 percent cover), *Haplopappus spinulosus* (0.1 percent), and *Mimosa dysocarpa* (0.1 percent).

Standing crop estimates for Association #2 indicate that perennial grasses are the highest with a value of 137 g/m^2, while annual grasses produce only 8 g/m^2 for the lowest standing crop contribution. Forbs are approximately equally divided with 20 and 18 g/m^2 being produced for annual and perennial forbs, respectively. Shrubs produce 13 g/m^2 on the average for this association.

Association #2 has a gross energy value of 4.31 Kc/gm for annual forbs, which is the highest for this association. The annual grasses are second with 4.23 Kc/gm.

Association #2 also has a high value for shrubs with a 2.18 percent value, while the other life forms have less than 2.0 percent nitrogen content based on dry weight. The perennial grasses are the lowest in nitrogen content for this particular association with 1.26 percent occurring.

Soils of this association are high in nitrate (17 ppm) and are a sandy loam. Fe and P both are intermediate in this association. K is relatively high at 222 ppm and the pH of these soils averages 6.3.

ASSOCIATION #3

Eragrostis lehmanniana - Aristida divaricata / Bouteloua chondrosioides / Aristida ternipes

This association is characterized by the occurrence of *Eragrostis lehmanniana* with an average cover value of 16.1 percent. This particular association has a co-dominant of *Aristida divaricata* with a cover value of 12.5 percent. Common grass associates include *Aristida ternipes*, *Bouteloua chondrosioides*, *Bouteloua gracilis*, and *Bouteloua hirsuta*. *Lycurus phleoides* occurs as a minor species.

This association can be easily identified by the striation pattern in the aerial photographs and exists because of reseeding of areas in the northern and eastern portions of the ranch. *Eragrostis lehmanniana* was planted during the 1950's and the vegetation is slowly returning to its former state, that of Association #1.

Common forbs for this association include *Brayulinea densa* and *Sida procumbens*, while *Convolvulus incanus* and *Evolvulus sericeus* are present in small amounts. The only shrub-like species occurring in a significant amount is *Haplopappus spinulosus* with an average cover value of approximately one percent.

Standing crop estimates obtained for Association #3 indicate that the annual grasses produce the lowest with 5 g/m^2. Other associations such as #11, #12, #13, and #15 also produce only 5 g/m^2. Perennial grasses are noted to produce an abundance of biomass with a value of 197 g/m^2 on the average. Forbs are significantly lower in their contribution to the total biomass with values for annual and perennial forbs being 11 and 14 g/m^2, respectively. Shrubs produce only 5 g/m^2 on the average for this association.

Association #3 has a gross energy value for annual grasses of 4.07 Kc/gm which is the lowest caloric content for the annual grasses of any association. The other life forms of plants in this association are

similar for caloric content. The highest caloric value for vegetation in this association is that of shrubs with 4.57 Kc/gm.

This association has the highest value of percent nitrogen for annual grasses with a value of 2.10 percent. Perennial grasses is rather low along with annual forbs with values of 1.66 and 1.56 percent, respectively.

Soils of this association are sandy with low nitrate values (0.80 ppm) and have a pH of 5.0. P, K, and Fe are found to be 9.1, 205.0, and 21.2 ppm, respectively. Organic matter is low in all soils and is only 1.0 percent in soils of this association.

ASSOCIATION #4

Bouteloua gracilis / Aristida ternipes

This association is characterized by the occurrence of *Bouteloua gracilis* with an average cover value of 21.2 percent. The most common associate in this vegetation type is *Aristida ternipes* with a cover value of 9.8 percent. The other species of *Bouteloua* occur in small amounts.

An abundance of annual grasses are observed to occur in particular years. The most abundant forb found in this association, aside from annuals, is *Brayulinea densa*. The only shrub or shrub-like plants found in this association includes *Apodanthera undulata* and *Cassia leptadenia*. The total cover of all species is the third greatest cover of all associations (81.9 percent).

This association grades into Association #5 (grassland-oak woods) creating a distinct transition or intermediate community which was designated as Association #15. Dominant species also change as indicated by cover values of species.

Standing crop estimates for Association #4 reveal that the annual grasses produce the highest values in this particular association with a value of 61 g/m^2. Perennial grasses produce 199 g/m^2 on the average, while annual forbs are noted to have 49 g/m^2 followed by perennial forbs with 20 g/m^2 on the average. Shrubs produce only 3 g/m^2.

This association has caloric values which are about equal for all classes of vegetation. Shrubs are the highest with 4.62 Kc/gm.

The vegetation of Association #4 is intermediate in nitrogen content for all life forms. Perennial forbs are the highest with a value of 2.05 percent. With the exception of shrubs, other values are much less than 2.0 percent.

The soils of this association are sandy (59 percent sand) and low in nitrates (1.53 ppm). P, K, and Fe are relatively high with 26, 423, and 24 ppm, respectively, occurring in this vegetation association. The pH is 5.9 and organic matter is 1.3 percent. The highest P for any soil occurs in this association.

ASSOCIATION #5

Bouteloua curtipendula / Eragrostis intermedia / Quercus emoryi

This association is very easily identified by the presence of oak trees, although they are not the dominant species throughout. Tree densities in this association range from sparse in the northern portion of the ranch to moderately dense in the southern portion of the ranch. This association is easily separated from Association #9 by the presence of *Pinus cembroides* which occurs in Association #9. Association #15 is an intermediate type representing a transition between Association #4 and #5.

This association is further characterized by the major grass, *Bouteloua curtipendula*, which has an average cover value of 11.7 percent. Its

most common associate is *Eragrostis intermedia* and other associates include the other *Bouteloua*s in addition to the *Aristida* spp. The most common forbs occurring in this particular vegetation association include *Bahia absinthifolia* and *Dyschoriste decumbens*. An abundance of annual forbs is found to occur in this vegetation association. In fact, the largest cover value for annual forbs, with an average value of 18.3 percent, occurs in this association. An average cover value of 2.5 percent is observed for oak trees, and *Cassia leptadenia* is the most common shrub associate.

Association #5 has a standing crop value of 156 g/m^2 for perennial grasses followed by annual forbs of 59 g/m^2. Shrubs, annual grasses and perennial forbs have values of 3, 9, and 27 g/m^2, respectively.

This association also has the highest value for the energy value of annual grasses and perennial grasses with 4.43 Kc/gm and 4.65 Kc/gm, respectively. Shrubs are noted to be 4.57 Kc/gm.

Association #5 has the lowest percent nitrogen content for annual grasses with a value of 1.05 percent. Perennial forbs and shrubs exceed 2.0 percent nitrogen based on dry weight of material.

Soils in this association are relatively high in nitrates (7.93 ppm) and are sandy loam. The pH is 6.3 and organic matter content is second highest at 2.0 percent for this association. Nitrates occur in intermediate amounts at 7.9 ppm. Zn is higher in soils of this association than others, 2.1 ppm.

ASSOCIATION #6

Hilaria mutica / Eriochloa lemmoni

This is a very distinctive association found in the northeastern portion of the ranch. The criteria for this type is the occurrence of *Hilaria*

mutica in almost pure stands. It is readily identified on the ground due to the light coloration of the species foliage.

Although this association is made up almost entirely of pure stands of *Hilaria mutica*, *Eriochloa lemmoni* and *Bouteloua curtipendula* are fairly common associates with cover values of 6.1 and 3.1 percent, respectively. Some annual grasses are also present along with *Sporobolus airoides* and *Panicum obtusum* in very small amounts. This association has the greatest amount of ground cover, 88.9 percent, of all associations described, although there are only eight species found in significant quantities.

Association #6 has standing crop values for perennial grasses of 240 g/m^2. The annual grasses, annual and perennial forbs are very close in their contribution to standing crop by having values of 11, 10, and 12 g/m^2, respectively. Shrubs are noted to contribute 3 g/m^2 on the average to the total standing crop values for this association. The total standing crop of 276 g/m^2 is the third largest for all associations.

This association has the highest gross energy content for perennial forbs with a value of 4.80 Kc/gm being observed. Shrubs and annual grasses are noted to occur in this association, although no caloric content was measurable. Perennial grasses and annual forbs, however, have values of 4.44 and 4.33 Kc/gm, respectively.

Association #6 has rather low values of nitrogen content for the vegetative life forms. Perennial forbs and perennial grasses have values of 1.94 and 1.27 percent, respectively. Annual forb nitrogen content is the highest at 2.94 percent.

Soils occurring in this association are clay and are high in K (534 ppm) and have a pH value of 7.6. Other nutrients are relatively low in this type.

ASSOCIATION #7

Sporobolus airoides / Hilaria mutica

This vegetation association results from the drainage patterns of the canyons: Post, Turkey, and O'Donnel. The vegetation occurs in seasonally-flooded areas and has been mowed for hay over a long period. This type occurs from the south-central to the northeastern portion of the ranch.

This association has the second greatest total cover value for species. A large amount of *Hilaria mutica* is observed (22.2 percent), but the dominant species is *Sporobolus airoides* with a cover value of 41.3 percent. *Bouteloua curtipendula* and *Bouteloua gracilis* as well as other grasses are found in small amounts in this association.

The most abundant forbs in this association are annuals. The only perennial forb found in any significant amount is *Convolvulus incanus* with a cover value of only 0.1 percent. There are no particular trees or shrubs identified with this association.

Association #7 has the highest annual forb biomass standing crop with a value of 64 g/m^2. This association also has the lowest perennial standing crop value of all the associations with a value of 9 g/m^2. The perennial grass standing crop for this association is by far the largest of all associations with a value of 600 g/m^2. Annual grasses are noted to have 17 g/m^2, while shrubs have 3 g/m^2 on the average for this association.

Association #7 is observed to have a caloric content value for annual grasses and annual forbs of 4.12 Kc/gm. The highest caloric value observed for the life forms of this type is that of shrubs with a value of 4.94 Kc/gm.

Association #7 has the highest nitrogen content in perennial forbs with a value of 2.89 percent, while perennial grasses have 1.50 percent. Shrubs are observed to have 3.74 percent nitrogen content, which is the highest value for shrubs considering all types.

Soils of this association are a clay loam and have a pH value of 7.7 and have the highest K content (668 ppm) found in any soil. Nitrates are also high in these soils (16.3 ppm), which is second highest.

ASSOCIATION #8

Senecio longilobus / Eragrostis intermedia / Platanus wrightii

This association is a shrub (*Senecio longilobus*) - grass (*Eragrostis intermedia*) association with occurrences of Arizona sycamore (*Platanus wrightii*). The latter species is common in this association with an average cover value of 5.5 percent, while the shrub has a cover value of 7.5 percent and the grass a value of 7.0 percent. This is one of two vegetation associations on the ranch that has a shrub as a dominant species. Other grasses, in addition to *Eragrostis intermedia*, included *Bouteloua curtipendula* with a cover value of 2.9 percent. *Aristida ternipes* has a cover value of only 0.1 percent, while *Oryzopsis* spp. has a value of 0.6 percent. *Paspalum* spp. has a cover value of 1.1 percent, while that of *Sporobolus airoides* is 0.1 percent. This particular association is not extensive, but rather is restricted to the dry washes such as Post Canyon. No perennial forbs are observed in quantity.

This association has the lowest total vegetation cover which averages approximately 28 percent.

Association #8 has a standing crop value for perennial grasses of 94 g/m^2 and a value of 6 g/m^2 for annual grasses. Shrubs contribute 14 g/m^2 of standing crop, while the perennial and annual forbs contribute 14 and 10 g/m^2, respectively.

Gross energy values are lowest for the perennial forbs (4.02 Kc/gm) and highest for shrubs (4.67 Kc/gm). Annual forbs are not abundant; therefore, no determinations were made during the 1971-72 period.

Association #8 has the lowest value for perennial grasses with respect to percent nitrogen content (1.04 percent). Annual and perennial forbs are about equal at 1.91 and 1.81 percent, respectively. Shrubs contain an average of 2.23 percent nitrogen on an air-dry weight basis.

Soils for this association are sandy loam and have a pH value of 7.7 and are very low in nitrate nitrogen (0.73 ppm). Very low organic matter content (0.10 percent) is also observed in the soils in this vegetation type.

ASSOCIATION #9

Bouteloua curtipendula - Hilaria belangeri - Bouteloua chondrosioides / Mimosa dysocarpa

This association occurs in the central and southwestern portion of the ranch and is characterized by a co-dominance of *Bouteloua curtipendula* (4.6 percent cover), *Hilaria belangeri* (3.0 percent), and *Bouteloua chondrosioides* (2.7 percent). The most common forb is *Dyschoriste decumbens* (0.5 percent), while the other forbs have cover values of less than 0.5 percent.

The most common shrub is *Mimosa dysocarpa* with a cover value of 2.2 percent. *Pinus cembroides* and *Quercus* spp. are the most abundant trees in the association. This particular vegetation association has a richer mixture of shrubs and trees than any of the other 15 associations occurring on the ranch.

Association #9 has a standing crop value for perennial grasses of 79 g/m^2 followed by 34 g/m^2 for annual forbs. Perennial forbs

contributes the lowest to standing crop of all life forms with a value of 15 g/m^2.

This association has a caloric content for annual forbs of 4.22 Kc/gm. Shrubs which have 4.85 Kc/gm contained the highest energy value in this particular association. Perennial grasses, perennial forbs, and annual grasses have values of 4.41, 4.37, and 4.29 Kc/gm on the average in this association.

Association #9 has only one value for nitrogen content which exceeds 2.0 percent. Perennial forbs contain an average of 2.07 percent while annual forbs are second with a value of 1.84 percent.

Soils are a sandy clay loam and are moderately low in nitrate nitrogen. Organic matter averages 1.27 percent and Fe content averages 14.17 ppm. Soil K is 158.00 ppm and pH is 6.37 on the average.

ASSOCIATION #10

Bouteloua curtipendula / Cercocarpus breviflorus

This is a unique vegetation association found on the very steep slopes of the ranch. It occurs in only the central and southwestern portion of the ranch and in all but one case this type is devoid of vegetation. The only exception is a very steep, but vegetated slope, adjacent to Post Canyon.

This association is characterized by the dominance of *Bouteloua curtipendula* (6.4 percent cover). Common grass associates include *Bouteloua radicosa* and *Muhlenbergia rigida*. Several other grasses occur in very small amounts. The most common forb is *Convolvulus incanus* with a cover value of 2.3 percent. Annual forbs are also very abundant in this particular association.

Cercocarpus breviflorus, the main associate in this type, has an average cover of 3.3 percent and is followed closely by *Cowania mexicana* with a cover value of 2.2 percent. These two shrubs are the only ones noted to occur in significant quantities in the association.

Association #10 has standing crop values for perennial grasses of 85 g/m^2 and annual forbs contributes 44 g/m^2. Annual grasses have only 8 g/m^2 in this association, while perennial forbs contribute 15 g/m^2. Shrubs are noted to have 3 g/m^2 on the average for this association.

Association #10 has a high caloric content for shrubs with a value of 4.98 Kc/gm. This is not the highest value observed considering all the associations, but is the third highest. Annual forbs are not sufficiently abundant for measuring caloric content for this particular association. All caloric values for the life forms exceed 4.0 Kc/gm on the average, but perennial grasses have the lowest caloric value in this association.

Vegetation in this association has values for nitrogen content less than 2.0 percent with the exception of perennial forbs which have a value of 2.14 percent. Shrubs are noted to have 1.65 percent, while perennial grasses are the lowest with 1.34 percent nitrogen content. Annual grasses are not sufficiently abundant in the association to evaluate them.

Soils are a sandy clay loam with a pH value of 7.8 and contain 1.00 percent nitrogen on the average. The Fe content for these soils is relatively low with 3.40 ppm.

ASSOCIATION #11

Mimosa dysocarpa - Lycurus phleoides - Cassia leptadenia / Bouteloua hirsuta

This association replaces Association #2 in the northwestern portion of the ranch and also occurs in the southeast region of the ranch in localized areas. *Mimosa dysocarpa* is estimated to have 9.3 percent cover. This shrub is the dominant shrub and co-dominates along with another shrub and a grass.

Cassia leptadenia and *Lycurus phleoides* have values of 6.0 and 7.2 percent cover, respectively, compared to *Bouteloua hirsuta* which has a cover of 5.5 percent. This is the only association on the ranch in which *Lycurus phleoides* is considered a dominant or co-dominant. Other common grass associates found in this association include *Bouteloua chondrosioides* and *Aristida ternipes*.

Forbs occurring in this particular association include *Evolvulus sericeus*, *Sida procumbens*, and *Brayulinea densa*. Other shrubs occurring include *Acacia angustissima*, *Desmanthus cooleyi*, and *Mimosa biuncifera*.

Association #11 is one of the associations which has the lowest production for annual grasses (with a value of 5 g/m^2). Perennial grasses for this association produce 90 g/m^2, while annual forbs and shrubs are approximately even in their contribution with 41 and 35 g/m^2, respectively. The total standing crop for the association is 89 g/m^2 on the average.

Caloric values for the vegetation life forms are 4.43, 4.57, 4.22, and 4.30 for shrubs, perennial grasses, annual grasses, and perennial forbs, respectively. No annual forbs were collected for analyses.

Association #11 has very low values for nitrogen for three of the five life forms. These values are less than 2.0 percent with the exception of perennial forbs which have a value of 2.17 percent and shrubs which contain 2.51 percent.

Soils of this association are a sandy clay loam with a pH of 5.2. Organic matter content is 1.5 percent and nitrates are 2.37 ppm. Both Fe and K are relatively high at 19.77 and 182.0 ppm, respectively.

ASSOCIATION #12

Bouteloua gracilis / Aristida divaricata / Eragrostis intermedia

This is a very poorly defined association on the ranch proper. Interpretation of aerial photographs suggests that this type occurs just north and east of the ranch and occupies a larger area. A few areas of this association contain *Prosopis torreyana*. These areas are not well delineated on the photographs or from ground level and therefore the boundary limits for this association are approximate. It may be that *Prosopis torreyana* is encroaching upon the ranch and will in time control more areas of this association.

This association is characterized by blue grama (*Bouteloua gracilis*) and is one of two associations on the ranch which is dominated by blue grama. The other association is Association #4. The most common associate is *Aristida divaricata* with a cover value of 5.0 percent. *Eragrostis intermedia* occurs quite frequently in the association followed closely by *Bouteloua chondrosioides* with cover values of 3.0 and 2.7 percent, respectively. This association differs primarily from Association #4 in the abundance of *Aristida ternipes*. This species occurs with a cover value of 10 percent in Association #4, whereas in this association the cover value is only 1.9 percent. *Aristida divaricata* occurs in approximately equal amounts in the two associations. Other differences include a greater abundance of *Eragrostis intermedia* in Association #12 compared to Association #4.

Association #12 is noted to have the lowest shrub standing crop with a value of only 1 g/m^2 on an average. This association also has a small amount of annual grasses being produced, 5 g/m^2. Perennial grasses are somewhat lower than some of the other associations with a value of 77 g/m^2, while annual forbs have 24 g/m^2 on the average. Perennial forbs contribute 17 g/m^2 standing crop.

Association #12 has relatively high energy values for all life forms of vegetation. The shrub energy content for this association is quite high with a value of 4.96 Kc/gm, while perennial forbs have an average of 4.76 Kc/gm. Other values exceed 4.20 Kc/gm.

Association #12 has the lowest percent nitrogen content of all associations for annual forbs with a value of 1.02 percent. Perennial grasses are quite low in nitrogen content compared to the remaining life forms, with a value of 1.49 percent. Shrubs, annual grasses, and perennial forbs exceed 2.0 percent with values of 2.05, 2.07, and 2.02 percent nitrogen content, respectively.

The soils of this association are sandy clay with a pH of 5.0 and an organic matter content of 1.0 percent. Values for Fe and K are 16.07 and 217.50 ppm, respectively. Soil P values average 9.93 ppm.

ASSOCIATION #13

Bouteloua hirsuta - Bouteloua gracilis / Nolina spp.

This is a distinct grassland type with dense *Nolina* occurring in the north-central portion of the ranch.

This association is characterized by the co-dominance of *Bouteloua hirsuta* and *Bouteloua gracilis* with cover values of 10.5 and 8.8 percent respectively. The most common associates include *Bouteloua chondrosioides* and *Aristida divaricata* with cover values of 4.0 and 3.7 percent,

respectively. Other grasses contribute small amounts to this association.

The most common forb found in this vegetation is *Croton corymbulosus* with a cover value of 3.5 percent. Other forbs, such as *Psoralea tenuiflora* and *Sida procumbens* are common associates with average cover values of 1.3 and 2.7 percent. These species are locally more abundant within the association.

Desmanthus cooleyi and *Mimosa biuncifera* have cover values of 3.5 and 0.9 percent, respectively, and the only other significant shrub noted in this association is *Cassia leptadenia* with a cover value of 0.1 percent.

Association #13 has the lowest annual forb production of all associations with 8 g/m^2. This association has the lowest perennial grass production with a value of 49 g/m^2 and has one of the lowest values for annual grass production with 5 g/m^2. In contrast, this association has the highest shrub production with a value of 72 g/m^2 being produced on the average.

The life forms of vegetation collected for caloric determinations did not include annuals. These data were collected in 1971 which was not a particularly good year for annuals. Perennial forbs have a value of 4.78 Kc/gm. This latter value is the second highest caloric content observed for perennial forbs over all the associations.

Values of nitrogen content for all life forms are less than 1.60 percent. A value of 1.59 percent is observed for perennial forbs which is considerably lower than most of the other associations. However, this is not the lowest value observed.

The soils of this association are clay with an average pH of 7.1. Organic matter content averages 1.8 percent and K occurs at an average

of 254 ppm. Other nutrients are low in their occurrence in the soils in this association.

ASSOCIATION #14

Hilaria belangeri / Aristida divaricata / Nolina texana

This association is a transition between flat areas of Association #1 and very steep slopes of Association #2. Thus, this is the vegetation of intermediate slopes and exact boundaries between this association and Association #1 are not always definite.

This association is dominated by *Hilaria belangeri* with a cover value of 28.8 percent. This particular association has the highest cover value for any grass species outside the pure stand of *Hilaria mutica* of Association #6 and *Sporobolus airoides* of Association #7. The most common grass associates found in this association are *Bouteloua hirsuta* and *Aristida divaricata* with cover values of 5.0 and 5.8 percent, respectively. Lesser amounts of *Bouteloua curtipendula* and *Aristida ternipes* occur in this association (2.6 percent cover values for both species). The most common forb occurring in this association is *Nolina texana* with a cover value of 5.1 percent. Forbs include *Croton corymbulosus*, *Evolvulus sericeus*, *Psoralea tenuiflora* and *Sida procumbens*.

The most common shrubs in this association include *Desmanthus cooleyi* and *Mimosa dysocarpa*.

Association #14 has standing crop values of 70, 32, and 10 g/m^2 for perennial grasses, perennial forbs, and shrubs, respectively. The annual grasses and annual forbs produce 19 g/m^2 each in this association.

Caloric values are lowest for annual forbs in this association, 4.09 Kc/gm. Other values are relatively high at 4.52, 4.33, 4.52, and 4.77 Kc/gm, respectively, for perennial forbs, annual grasses, perennial grasses, and shrubs.

Nitrogen content for perennial grasses is lowest in this association (1.66 percent). The other life forms of vegetation are close in their nitrogen content with a range in values of 1.53 to 1.91 percent.

Soils of this association are sandy clay loam and have an average pH value of 5.2 Fe and K are high at 25.50 and 227.67 ppm, respectively. Organic matter content averages 1.60 percent while nitrates average 3.40 ppm.

ASSOCIATION #15

Bouteloua curtipendula / Hilaria belangeri - Panicum obtusum

This is a transitional type between the Association #4 grassland and the wooded Association #5. Species composition is a combination of both, while overall biomass is more similar to Association #5.

This association is dominated by *Bouteloua curtipendula* with a cover value of 21.1 percent. Two species of grasses, *Hilaria belangeri* and *Panicum obtusum*, are strong associates in this grassland association. Lesser associates include *Bouteloua hirsuta* and *Aristida divaricata* with cover values of 5.6 and 2.5 percent, respectively. *Andropogon barbinodis* occurs with a cover value of 3.5 percent in this association. While this latter value indicates a low association value, this species dominates in very small, localized areas. This is true not only for this association, but for some of the other associations in which it occurs. This species is among the few tallgrasses that occur on the ranch in significant amounts and is expected to increase as grazing by livestock is prohibited from the ranch.

The only forb found to occur in any significant amount in this association is that of *Brayulinea densa* with a cover value of only 0.1 percent. There are very few shrubs or trees found to occur in this

association. It is significant to point out that this particular association in addition to that of Association #14 has no annual forbs occurring during the 1971-72 period. Furthermore, annual grasses are not significant in either of the associations.

Association #15 is one of the associations having a low value for standing crop of annual grasses with 5 g/m^2 on the average. This association is fairly productive in perennial grasses with a value of 101 g/m^2, while annual and perennial forbs are low in standing crop with values of 10 and 14 g/m^2, respectively. Shrubs produce only 3 g/m^2.

Gross energy values for annual forbs are 4.40 Kc/gm, which is the highest value for this life form. Perennial forbs and grasses have caloric values of 4.51 and 4.63 Kc/gm, while shrubs contain 4.98 Kc/gm.

Nitrogen values for the vegetation classes range from 1.20 percent for perennial grasses to 1.54 percent for perennial forbs. Shrubs are low in nitrogen, 0.96 percent.

The soils in this association are clay with a pH value of 7.2. Nitrates are very low with only 0.10 ppm recorded on the average. Organic matter averages 1.97 percent and 228.33 ppm of K are observed.

ASSOCIATION #16

Aristida ternipes - Bouteloua gracilis / Eragrostis intermedia

This transitional type occurs where *Prosopis torreyana* is encroaching upon Association #3 (reseeded) and is also similar to Association #12.

This association is characterized by the co-dominance of *Aristida ternipes* and *Bouteloua gracilis* with cover values of 11.6 and 9.9 percent, respectively. A strong grass associate is *Eragrostis intermedia* with a cover value of 6.4 percent. Other grasses occur in smaller amounts and include *Aristida divaricata, Andropogon barbinodis* and *Lycurus phleoides.*

The most common forb in this association is *Ambrosia confertiflora* with a cover value of 1.0 percent. Annual forbs make up 2.4 percent of the total cover value. The only other forb found to occur in this association is of the family *Cactaceae* with a cover value of only 0.1 percent. One shrub is found to contribute significantly to the total cover and that is *Haplopappus tenuisectus* with a cover value of 0.2 percent.

Association #16 has quite high values of standing crop for perennial grasses with 120 g/m^2. Annual grasses are quite low with 6 g/m^2 being produced on the average for this association. Annual and perennial forbs produce 16 and 24 g/m^2 on the average, while shrubs are noted to produce 4 g/m^2 over the association.

Association #16 has high values of energy content for shrubs and perennial grasses with 5.02 and 4.51 Kc/gm, respectively. Perennial forbs for this association have a value of 4.44 Kc/gm, while annual forbs and annual grasses contain 4.24 and 4.39 Kc/gm, respectively.

Nitrogen values range from 1.20 to 2.36 percent for perennial grasses and perennial forbs, respectively. Shrubs have 2.10 percent nitrogen content and annual grasses have 1.32 percent.

Soils of this association are sandy clay with an average pH value of 4.93 and organic matter content of 1.03 percent. Nitrates occur in 3.00 ppm and Fe values are 17.60 ppm. Values for P and K are 7.43 and 202.67 ppm, respectively.

A complete list of plant species observed on the ranch to date is included in Table 9 of Appendix B. The five-letter acronym on the left was used for convenience and consists of the first three letters of the generic name and the first two letters of the species name (Latin). A

few exceptions to this rule were made in cases of duplication. These are all obvious from the table information.

Table 10 of Appendix B gives a listing of all species observed to occur in each association during 1972. Undoubtedly, some species were unobserved, but the list indicates the relative species composition of each association. Table 11 lists species by vegetation association which indicates the distribution of species with respect to the associations named. Information regarding the relative abundance of a species across the ranch can be inferred from this table.

PROSPECTUS

The vegetation and soil inventory in particular establishes a base upon which specific studies of an ecological nature can be conducted. These data are usually assumed to be available and are basic to any environmental study. Therefore, future projects will not be burdened with the collection of basic vegetation and soil inventory information for any part of the ranch.

Uses of this type of information were alluded to in the Introduction, but may also include others. Census data is needed for mammals, reptiles, insects, etc., as related to the plant communities of The Research Ranch. All ecosystem components, both biotic and abiotic, need to be described in detail before the ecological inventory is complete. This project was the genesis of such a goal.

GEOLOGY OF THE RESEARCH RANCH, SANTA CRUZ COUNTY, ARIZONA

by

Daniel H. Vice and Mari Ann Vice

The objective of this project was the construction of a geologic map of The Research Ranch on a 1:24,000 scale to assist an ecological study by Dr. Charles D. Bonham. Fieldwork for the project, completed on weekends during the spring of 1971, involved plotting rock units, contacts and structural geology on a base map constructed from U.S. Geological Survey 7 1/2-minute topographic maps. Detailed descriptions of samples were made from scattered outcrops. The color terms and associated numerical system used in the petrographic descriptions were taken from the Geological Society of America Rock Color Chart. Grain-size terminology was taken from Udden in Pettijohn (1957, p. 18).

PHYSIOGRAPHY

The study area is located at the southern edge of the Sonoita Basin within the mountain region of the Basin and Range physiographic province (Figure 3). The Huachuca Mountains border the study area on the east and the Canelo Hills on the south and west.

The study area is characterized by several north-northwest trending washes having a dendritic drainage pattern. These ephemeral streams drain into the Babocomari River located to the north of the study area. Bald Hill, elevation 1540 m, is an exception to the major drainage pattern. This hill has gentle, grass-covered slopes which are cut by a number of steep-sided washes draining in a radial pattern.

Bald Hill (Section 16) and some unnamed hills in the southern part of The Research Ranch, having elevations in excess of 1556 m, are the highest points in the study area. The lowest point occurs in O'Donnell

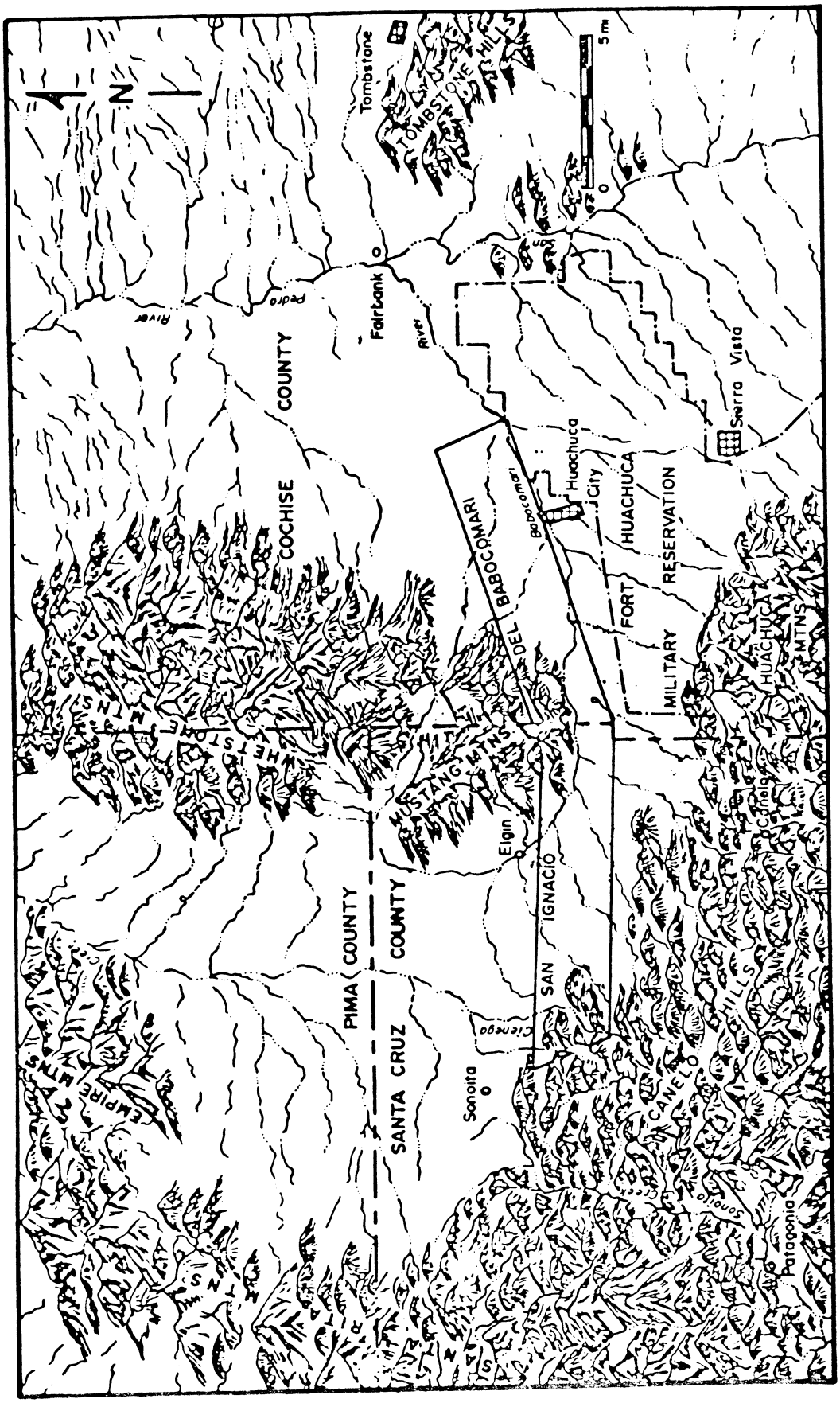


Figure 6. Physiographic diagram of the Sonoita Basin and the Upper San Pedro Valley, Arizona.

Canyon (elevation less than 1402 m) at the northern boundary.

GEOMORPHOLOGY

Five sets of paired terraces occur in O'Donnell Canyon, Hay Canyon and some of their larger tributaries. These terraces are the principal geomorphological features in the study area. These terraces may have been formed by climatic oscillations during the late Pleistocene and Holocene. Schumm (1965) suggests that the fluctuations of climate between glacial and interglacial stages during the Pleistocene caused changes in the vegetation (from bunch-grass cover to continuous-grass cover). These vegetative changes resulted in variations in the amount of sediment supplied to the streams (a change from bunch-grass cover to continuous-grass cover results in a decrease in sediment supplied to the streams and the reverse change — an increase in sediment). A decrease in the amount of sediment supplied results in the erosion of the stream banks with possible lateral erosion and down-cutting. An increase in sediment supply causes deposition along stream channels and in the floodplain, often forming a flat-floored valley such as O'Donnell Canyon. A succession of these changes may have formed the terraces in this area. The location of The Research Ranch within a transition zone between the desert-grassland and oak-woodland vegetation zones places it in an area that is highly sensitive to climatic changes.

The presence of one terrace more than is present along the Babocomari River on the Babocomari Ranch is anomalous. A minor climatic fluctuation may have been preserved here that was not preserved along the Babocomari River. A detailed study of the pediments of this river and its tributaries has not been completed; therefore, the complex geomorphology is not fully understood.

STRATIGRAPHY

Stratigraphic units present within the study area include sedimentary and igneous intrusive units of Cretaceous age, the lower unit of basin fill of Tertiary age, and the terrace deposits and alluvium of Quaternary age (Figures 6 and 7).

Sediments of the Bisbee Group Undifferentiated (early Middle Cretaceous) and the Fort Crittenden Formation (Late Cretaceous) occur within the extreme southern portion of the study area (SE 1/4, Sec. 34, and S 1/2, Sec. 35, T. 21 S., R. 18E). The base of these units are not exposed. The lowest stratigraphic exposure of these units is in fault contact with the lower unit of basin fill. An erosional unconformity exists between the Bisbee Group and the Fort Crittenden Formation.

A small dike of dark-gray (N 3) porphyritic basalt (possibly basaltic andesite), containing euhedral to subhedral, zoned plagioclase phenocrysts, cross-cuts the Bisbee Group Undifferentiated within Lyle Canyon (SW 1/4, Sec. 35, T. 21 S, R. 18 E.) A second pale greenish-yellow (10 Y 8/2) porphyritic basalt occurs in Lyle Canyon in the same general area as the first basalt. The second basalt contains anhedral phenocrysts of olivine (?). Even though the second basalt also cross-cuts the Cretaceous sedimentary units, the relationship with the first basalt is not known. The ages of these intrusives are not known.

The lower unit of basin fill underlies most of the study area (Plate I). The north-south strike is relatively uniform, and the dip averages 30° W. The data derived from the scattered outcrops indicate that this unit is relatively homogenous. The lower unit of basin fill may be of Pliocene age (Brown, 1966) or Miocene age (Damon, 1970, oral communication).

Figure 7. Geologic map of The Research Ranch. Legend: 1 = Quaternary Alluvium, 2 = Terrace Deposits, 3 = Lower Unit of Basin Fill, 4 = Basalt Dikes, 5 = Fort Crittenden Formation, and 6 = Bisbee Group Undifferentiated.

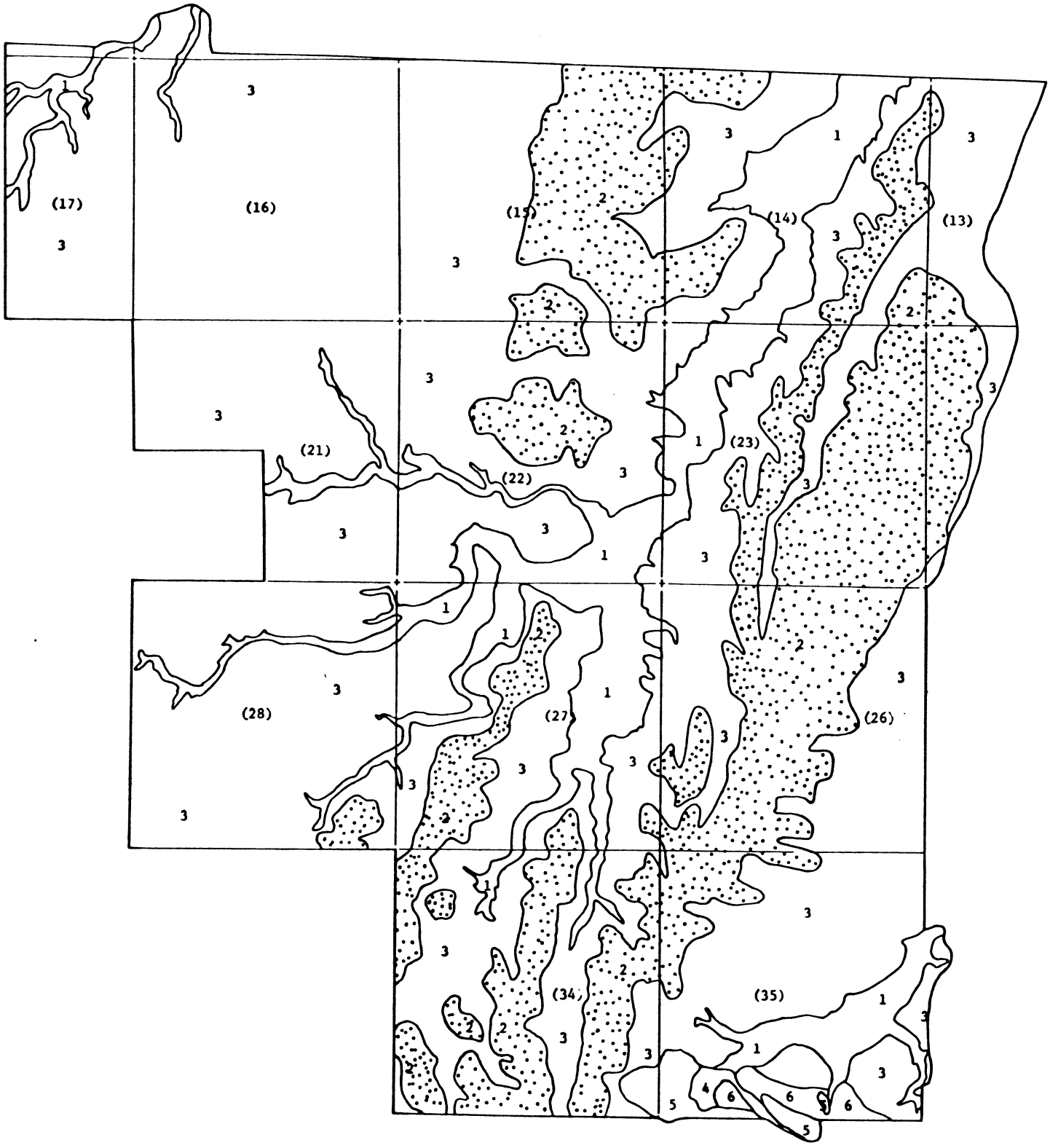


Figure 8. Stratigraphy of the Research Ranch, Santa Cruz County, Arizona.

UNIT	AGE & THICKNESS	CHARACTERISTICS
alluvium	Holocene-late Pleistocene; maximum about thirty feet	gray, sandy silt containing small gravel lenses within stream channels; occurs along major washes
terrace deposits	Pleistocene; about fifty feet	reddish, gravelly, unconsolidated silt
lower unit of basin fill	early Pleistocene -Miocene; 3,000-5,000 feet	coarse, poorly-sorted conglomerates and conglomeratic sandstones of varied composition and color
Fort Crittenden Formation	Late Cretaceous; 400-500 feet	well-lithified pebble conglomerate and conglomeratic sandstone of varied color
Bisbee Group Undifferentiated	Middle Cretaceous; about 500 feet	red silt unit and gray-green, thick-bedded to massive limestone unit

The Quarternary deposits unconformably overlie the lower unit of basin fill and, locally, the Cretaceous units. Poorly-consolidated, reddish, conglomeratic terrace deposits cover the interfluves within the study area. Alluvium forms the floors of the major canyons within the area. This alluvium is a light-gray (N 7), crudely-stratified, sandy siltstone.

PETROGRAPHY

Because of limited time, only macroscopic petrography is presented. Where applicable, microscopic data from a study of the Babocomari Ranch area immediately north of The Research Ranch is included.

The Cretaceous sediments include shales, sandstones and limestones. The Bisbee Group Undifferentiated within the study area consists of two distinct units. The lower unit (Morita Formation) is dominantly a shale with subordinate amounts of sandstone. The shale is pale red (10 R 6/2) to moderate red (5 R 5/2) in color and is massive. Calcareous material is contained. Subordinate amounts of grayish orange-pink (5 YR 7/2), well-lithified, medium- to fine-grained, massive, arkosic sandstone are present. The sandstones are composed of subrounded to well-rounded grains of quartz, feldspar and heavy minerals, with minor amounts of lithic fragments and calcareous cement.

Petrographic studies of similar sandstones occurring along the Babocomari River show that the sandstones range from subgraywackes to arkoses according to Pettijohn's classification (1952). The weathered and fresh colors of these sandstones range from grayish red (5 R 4/2) to pale red (10 R 6/2). The grain sizes range from medium sand to silt according to the Wentworth scale. The degree of rounding varies from subangular to

rounded. The framework is intact to partially disrupted. The framework grains are composed of quartz, feldspar, biotite and lithic fragments in varying amounts. The primary structure varies from medium bedded to very-thinly laminated, with local occurrences of cross-stratification in the more thinly bedded units.

The mudstones which occur along the Babocomari River are similar to the mudstones of the Bisbee Group Undifferentiated occurring within the study area. Petrographic data for the mudstones along the Babocomari River show that these are composed predominantly of clay material containing small mica flakes and calcareous material; locally, very fine sand- and silt-sized grains of quartz and feldspar are present.

Conformably overlying the Morita Formation is the light olive-gray (5 Y 6/1), massive Mural Limestone -- the second unit of the Bisbee Group Undifferentiated within the study area. This limestone is very finely crystalline, unfossiliferous, and very fractured. Irregular chert lenses, two to three feet long and about one foot wide, are present in some horizons. Other horizons contain minor amounts (up to 20 percent) of subrounded to rounded, medium to fine sand-sized grains of quartz and feldspar. These horizons grade over a few inches into a thirty-foot thick sandstone unit. This sandstone is a medium- to very fine-grained arkosic sandstone. The sandstone grades back into a very-light olive-gray (5 Y 6/1), massive, very finely crystalline limestone similar to the one occurring below the sandstone.

A thin section of the Mural Limestone which outcrops in Merritt Canyon several miles southeast of The Research Ranch shows this limestone to be micritic. Megascopically this limestone is medium gray (N 5) on both weathered and fresh surfaces, unfossiliferous and very finely crystalline.

A light purple sequence of sandstones and conglomerates of the Fort Crittenden Formation unconformably overlies the Bisbee Group Undifferentiated in the study area. The sandstone is a medium- to fine-grained, submature arkose. The conglomerate is a moderately lithified, petromict, cobble conglomerate having an intact framework.

Two separate igneous units occur in Lyle Canyon in SW 1/4, Sec. 35, T. 21 S, R. 18 E. A small, arcuate dike of dark-gray (N 3), porphyritic basalt or basaltic andesite cross-cuts Cretaceous sediments in this canyon. This dike is more resistant to weathering than the surrounding sediments. Euhedral to subhedral, zoned plagioclase phenocrysts occur within the aphanitic matrix.

A second porphyritic basalt occurs near the above basalt in Lyle Canyon. This second basalt macroscopically resembles the cienega basalt occurring within the Pantano Formation Equivalent along the Babocomari River. Altered olivine (?) phenocrysts are visible in hand specimen. Small, angular exotic fragments, and small, angular basaltic fragments are also present. Locally small phenocrysts of plagioclase are present.

The lower unit of basin fill is composed of coarse conglomerate and conglomeratic sandstones of variable composition. The clasts are rounded to angular: the degree of angularity increases toward the southern end of The Research Ranch. Even though the framework is usually disrupted, local occurrences of intact framework are noted. The clasts are composed of metamorphics, rhyolite porphyry, andesite, shale, basalt, quartzite, limestone (resembling limestones of the Concha and Colina Formations of Permian age), sandstone (one clast resembling the Fort Crittenden Formation sandstones), greenstones, conglomerate (resembling the conglomerates occurring within the Canelo Hills Volcanics of Triassic-Jurassic age),

jasper, chert, unidentified volcanics, and ash-flow tuff (?). Clasts of the rhyolite porphyry are present in all outcrops and are dominant in at least one outcrop (SE 1/4, NW 1/4, Sec. 23, T. 21 S., R 18 E.). The matrix is poorly sorted and generally composed of subangular to rounded, very coarse to very fine sand-sized grains of quartz, feldspar and lithic fragments. Silt and minor amounts of clay are also present. Calcareous cement is present in varying amounts. The color ranges from very pale orange (10 YR 8/2) to grayish pink (5 R 8/2) to light-brownish gray (5 YR 6/1). Indistinct bedding, striking N. 5° E. and dipping 50° W., is present in several outcrops.

The terrace deposits are composed of poorly-consolidated, poorly-sorted, coarsely conglomeratic, moderate reddish-brown (10 R 4/6) material. Sandstones, volcanics, limestones and other lithologies comprise the clasts. The subangular to rounded clasts vary up to boulders in size. The sandy-silty matrix is composed of subangular to subrounded grains of quartz, feldspar and lithic fragments.

The Quarternary alluvium occurs locally as coarse, poorly-sorted, brownish-gray (5 YR 4/1) conglomeratic material and light brownish-gray (5 YR 6/1) silty material. The conglomeratic material has an intact framework composed of angular to rounded pebble- and small boulder-sized clasts of various lithologies. The matrix is predominantly silt containing minor amounts of subangular to rounded, coarse to very fine sand-sized grains of quartz, feldspar and lithic fragments. Calcareous material and clay are present within the silty matrix. The coarser, elongate and flat clasts are imbricated toward the south. The light brownish-gray (5 YR 6/1) silty material has small subrounded to rounded pebbles of various lithologies scattered throughout the matrix.

GEOLOGIC STRUCTURE

The geologic structure of the study area is composed of several minor faults within the Cretaceous sediments and the lower unit of basin fill. In one outcrop in Lyle Canyon (SE 1/4, Sec. 35, T. 21 S., R. 18 E.), a fault having an apparent east-west strike and 90°-dip brings the Bisbee Group Undifferentiated in contact with the lower unit of basin fill. The estimated displacement of this dip-slip fault is approximately 5000 feet. This is the only significant fault observed within the study area.

DISCUSSION AND CONCLUSIONS

The wide area underlain by the lower unit of basin fill and the terrace deposits (Figure 6) indicate that these units have the greatest influence on the ecology of the study area. The heterogenous nature of these units indicate that the soil throughout most of the study area will have only minor variations in soil chemistry. The wide variety of rock types decomposing within the soil zone indicates that most elements will be present in relatively constant amounts in the soil. The dominant lithologies within these rock units are rhyolite, andesite, and other volcanics; these lithologies tend to decompose to form kaolinite and other clay minerals. The abundance of limestone clasts in localized areas is the principal factor distorting the relatively uniform soil chemistry. An example of this is an area in the center of Section 26 where pebble- and cobble-sized clasts of limestone have created a local soil environment that is sufficiently high in calcium to support calcium-loving plants such as ocotillo (*Fouquieria splendens* Englm.). Another area of The Research Ranch having a distinctive soil environment created by the weathering of bedrock is the area underlain by Cretaceous sedimentary rocks in the southern part of the study area. Again the limestone gives the soil a

decidedly calcareous nature.

Even though the authors believe that the terraces along the major washes in the study area were formed by changes in vegetation and erosional patterns induced by Pleistocene and Holocene climatic changes, a detailed study of the terraces must be completed before all of the questions regarding these terraces and their origin can be answered.

LEGEND

Quaternary	Qal	1	Quaternary Alluvium Unconsolidated brownish-gray conglomeratic silt with minor, imbricated gravel lenses, variable composition.
	Q_{Td}	2	Terrace Deposits Poorly consolidated, poorly sorted, reddish-brown conglomeratic material, variable composition.
Tertiary	T_{LBF}	3	Lower Unit of Basin Fill Moderately consolidated, poorly sorted, light brownish-gray conglomeratic sandstone, variable composition, calcareous cement, poorly defined bedding.
	BD	4	Basalt Dikes A porphyritic greenish-gray, andesite (?) and an aphanitic, medium to medium dark gray basalt with scattered, weathered olivine phenocryrts. The age of the basalt dikes is unknown.
Cretaceous	K_{FC}	5	Fort Crittenden Formation A light purple sequence of medium-to-fine-grained sandstone and pebble conglomerates.
	K_{UB}	6	Bisbee Group Undifferentiated Three litholies present; a reddish siliceous mudstone below, grading into a greenish-gray, massive, very fine crystalline limestone. A medium-to-fine-grained, well-sorted sub-rounded, quartoze sandstone lens is present in the limestone.

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APPENDIX A

Summary of INFOL

(The Computer storage-retrieval system

for The Research Ranch Environmental data)

APPENDIX

Description of INFOL

1. General Description

   1.1 Files established by control word followed by data descriptions and data.

   1.2 File - largest information unit in INFOL;
   - deals with one subject: vegetation type, Grid points

   Element - component of a file;
   An identical list of data pertaining to a single subject: one vegetation type, one Grid point

   Items - components of elements:
   individual characteristics of each element; defined by item descriptions; consists of unary and multiple items. Multiple item consists of several sub-items.

   1.3 Item descriptions followed by item numbers;
   item numbers always necessary and must precede all item data.

   1.4 Cannot use (,) * in INFOL character set.
   * is INFOL separator; other uses illegal.

   1.5 Blanks - used as INFOL word separators;
   used between INFOL word and following integer.
   Retrieval and extraction criteria have special blank requirements.

   1.6 Input treated as variable - length.

2. Main Phases

   2.1 Establishment - file created.

   2.2 Interrogation - retrieval criteria: user specified extractions.

   2.3 Update - modify or remove elements; add new elements.

   2.4 Revision - add items to an element.

3. Items

   3.1 Item categories - each item must be assigned a category.

   3.1.1 Unary - one value only: % Sand, Soil Nitrogen, Etc.
   3.1.2 Multiple - list of values (sub-items): e.g., cover - sub-items: cover for 100 species. Can apply criteria to total number of sub-items, sub-items individually and collectively.

   3.1.3 Association groups - formed by two or multiple items; sub-items directly related; requires strict ordering of sub-items.

3.2 Item types - independent of item category.

3.2.1 Alphanumeric - contains everything except *; number of characters < 1100 each.
3.2.2 Numeric - real or integer; ≤ 10 digits exclusive of sign and/or decimal point.
3.2.3 Date - allows dates to be processed and displayed.
3.2.4 Coded - allows items to have coded values instead of complete text; number - INFOL assigns number for each code; numeric - user assigned; alpha numeric.

3.3 Item numbers - associated with each item with the list; enclosed in **
300 max allowable item numbers for each file; must precede item value during input.

*** Item 1 must be unary and numeric ***. This uniquely identifies the element in the file (used during UPDATE to identify element).

3.4 Existence requirement - system checks each element to determine if item exists in that element.

*** Can impose an "existence - non-existence" criteria for any item.

4. Establishment - prepare information file.

4.1 ITEM DESCRIPTION N

Blanks required
N - number of items in the elements.

4.2 CATEGORY - TYPE

must be present

Required for each item in sequence.
Category precedes type.
ASSOCIATION - used only with multiple items.

4.3 VALIDATIONS

1. NECESSARY - item mandatory in all elements
   Item 1 always necessary.
2. MAXIMUM m - used by multiple items; 1 ≤ m ≤ 511.
   m = number of sub-items.
3. RANGE - integer range limits for numeric and date items.
4. CHARACTERS x - x < 4096; length of α-numeric items or sub-items.
5. NON-NUMERIC - cannot contain 0 through 9.
6. ALPHABETIC - contains A to Z, blank, 1 and (names,
7. INTEGER -

4.4 INITIAL INPUT n
Established initial version of the file
n = number of columns on each card used for identification (user defined); $0 \leq n \leq 12$

1. Item number enclosed in *.
2. All sub-items must be followed by *.
3. Last character in an element must be *.
4. Blanks adjacent to * are ignored.
5. Items may be omitted unless declared NECESSARY

5. INTERROGATION - examine each element in the file and subject to retrieval criteria.

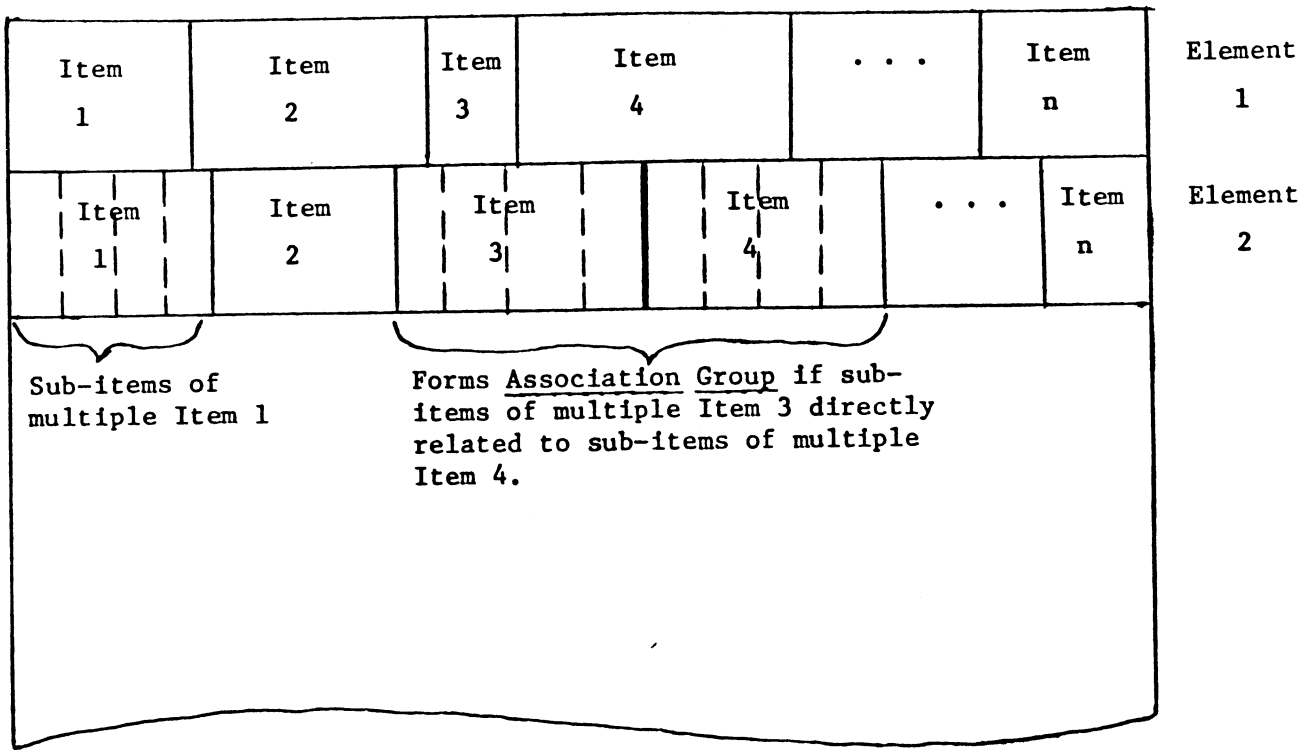
5.1 RETRIEVAL CRITERIA n

1. n = specification set number.
2. Indicates a set of retrieval criteria is in the following string of characters.
3. EXTRACTIONS n - n = same as above; must follow retrieval criteria string.

5.2 Retrieval criteria terminology - range from simple to complex

1. Item sub-criterion: apply to any item in an element;
   a. Existence sub-criterion - EXISTS or DOES NOT EXIST; EXISTS automatically checked for if other criteria exist.
   b. Relational sub-criterion - item values are =, ≠, >, < ≥, ≤ to user-furnished external value; for multiple items can impose criteria on one or more sub-items, all sub-items at once, or on a quantity derived from the sub-items (explicit, derived, group)
2. Item criterion - set of sub-criteria imposed on single item; use AND and/or OR between sub-criteria.
3. Retrieval criterion - set of item criteria; if AND or OR not present, AND assumed. (Entire set of item criteria must be true for extraction.)

FILE


Item 1
Item 2
Item 3
Item 4
. . .
Item n
Element 1
Item 1
Item 2
Item 3
Item 4
. . .
Item n
Element 2
Sub-items of multiple Item 1
Forms Association Group if sub-items of multiple Item 3 directly related to sub-items of multiple Item 4.

APPENDIX B

Tables of Data Obtained for Ecological Description of The Research Ranch

Table 2. Means of percent foliage ground cover of grass species by vegetation association. See Table 9 for interpretation of species symbols.

Association Number	SPECIES								
	ANDBA	ANDCI	ARIDI	ARIGL	ARITE	BOUCH	BOUCU	BOUER	BOUGR
1	0.0	0.0	4.5	0.0	5.2	20.3	0.0	.4	.7
2	2.1	0.0	5.1	0.0	.2	10.5	1.7	3.2	0.0
3	0.0	0.0	12.5	1.5	4.1	4.6	0.0	1.5	3.1
4	0.0	0.0	3.4	0.0	9.8	1.9	1.3	0.0	21.2
5	1.6	.4	.5	0.0	1.3	2.9	11.7	0.0	1.7
6	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	1.6
8	0.0	0.0	0.0	0.0	.1	0.0	2.9	0.0	0.0
9	.3	.5	0.0	0.0	.3	2.7	4.6	0.0	.5
10	0.0	0.0	.0	0.0	.7	0.0	6.4	1.2	1.1
11	0.0	0.0	1.3	0.0	2.1	4.8	0.0	.1	2.0
12	.0	0.0	5.0	0.0	1.5	2.7	.2	0.0	18.5
13	0.0	0.0	3.7	0.0	.9	4.0	.8	.0	8.8
14	0.0	0.0	5.8	0.0	2.6	0.0	2.6	.2	.0
15	3.5	0.0	2.5	0.0	.2	0.0	21.1	0.0	.4
16	1.3	0.0	1.1	0.0	11.6	1.6	.2	0.0	9.9

Association Number	SPECIES								
	BOUHI	BOURA	ERAIN	ERALE	ERILE	FESSP	HILBE	HILMU	LEPDU
1	9.7	.2	.3	0.0	0.0	.1	0.0	0.0	0.0
2	3.5	0.0	.3	0.0	.0	.5	6.5	0.0	0.0
3	3.3	0.0	.5	16.1	.3	0.0	.2	0.0	0.0
4	.4	0.0	1.6	0.0	.1	0.0	0.0	0.0	1.1
5	.6	.1	5.1	0.0	0.0	0.0	.0	0.0	.1
6	0.0	0.0	0.0	0.0	6.1	0.0	0.0	72.7	0.0
7	0.0	0.0	0.0	0.0	.2	0.0	0.0	22.2	0.0
8	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
9	.2	.2	1.6	0.0	0.0	0.0	3.0	0.0	0.0
10	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	5.5	0.0	1.3	0.0	0.0	0.0	.2	0.0	0.0
12	0.0	0.0	3.1	0.0	0.0	0.0	1.6	0.0	.1
13	10.5	0.0	.1	.1	0.0	0.0	1.8	0.0	.5
14	5.0	0.0	0.0	0.0	0.0	0.0	28.8	0.0	0.0
15	5.6	.9	0.0	0.0	0.0	0.0	12.1	0.0	0.0
16	.5	0.0	6.4	0.0	0.0	0.0	.0	0.0	0.0

Table 2. (Cont.)

Association Number	SPECIES							
	LYCPH	MUHRI	ORYSP	PANOB	PASSP	SORHA	SPOAI	ANNGR
1	1.6	0.0	0.0	0.0	.0	0.0	0.0	0.0
2	.9	0.0	0.0	0.0	0.0	0.0	0.0	1.3
3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.2	0.0	0.0	3.3	0.0	0.0	2.7	16.5
5	0.0	0.0	0.0	.1	0.0	0.0	0.0	1.2
6	0.0	0.0	0.0	.1	0.0	0.0	.9	3.7
7	0.0	0.0	0.0	.5	0.0	1.2	41.3	4.0
8	0.0	0.0	.6	0.0	1.1	0.0	.1	.2
9	0.0	0.0	0.0	.1	0.0	0.0	0.0	10.7
10	.4	1.9	0.0	0.0	0.0	0.0	0.0	.9
11	7.2	0.0	0.0	0.0	.0	0.0	0.0	2.4
12	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	1.1	0.0	0.0	.8	0.0	0.0	0.0	6.4
14	.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	.5	0.0	0.0	10.3	0.0	0.0	.4	0.0
16	.7	0.0	0.0	0.0	0.0	0.0	0.0	.1

Table 3. Means of percent foliage ground cover of forb species by vegetation association. See Table 9 for interpretation of species symbols.

Association Number	SPECIES AMBCO	BAHAB	BRADE	CACTA	COMDI	CONIN	CROCO	DYSDE	ERIWR	EVOSE
1	0.0	0.0	.5	0.0	0.0	0.0	1.3	.2	0.0	.4
2	.2	0.0	0.0	.0	0.0	0.0	1.2	0.0	0.0	.5
3	0.0	0.0	1.1	0.0	0.0	.6	0.0	0.0	0.0	.8
4	.2	0.0	2.5	0.0	0.0	.1	0.0	.1	.5	.0
5	0.0	.8	0.0	.0	.2	.0	.0	.6	0.0	.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	.1	0.0	0.0	0.0	.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	.1	.1	0.0	.5	0.0	.0
10	0.0	0.0	0.0	0.0	0.0	2.3	.0	0.0	0.0	0.0
11	.1	0.0	.3	0.0	0.0	0.0	.0	0.0	0.0	.5
12	0.0	0.0	.0	0.0	.2	.2	.5	0.0	0.0	0.0
13	.5	0.0	.3	0.0	0.0	.2	3.5	.6	0.0	.5
14	0.0	0.0	0.0	0.0	0.0	0.0	.2	0.0	0.0	.1
15	0.0	0.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	.0
16	1.0	0.0	0.0	.1	0.0	0.0	.0	0.0	0.0	.0

Association Number	SPECIES FERNS	GRALI	NOLTE	PHAHE	PSOTE	SIDPR	ZINGR	ANNFO	DALBR
1	0.0	.0	0.0	0.0	.1	.3	0.0	.6	0.0
2	0.0	.0	0.0	0.0	.3	.5	0.0	4.8	.3
3	0.0	0.0	0.0	0.0	.2	1.6	0.0	1.6	0.0
4	0.0	.1	0.0	.5	.0	.1	0.0	10.3	0.0
5	0.0	.2	0.0	0.0	.1	.0	0.0	18.3	0.0
6	.2	0.0	0.0	0.0	0.0	0.0	0.0	.6	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0
8	0.0	0.0	0.0	0.0	.0	0.0	0.0	.9	0.0
9	0.0	0.0	.1	0.0	0.0	.1	0.0	12.0	.2
10	.0	0.0	0.0	0.0	0.0	0.0	.5	16.3	0.0
11	0.0	.1	0.0	0.0	.0	.5	0.0	10.4	0.0
12	0.0	.0	0.0	0.0	0.0	.0	0.0	4.8	0.0
13	0.0	.0	0.0	0.0	1.3	2.7	0.0	4.7	.1
14	0.0	0.0	5.1	0.0	.1	.1	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0

Table 4. Means of percent foliage ground cover of tree, shrub and additional species by vegetation associations. See Table 9 for interpretation of species symbols.

Association Number	SPECIES ACAAN	DESCO	HAPSP	HAPTE	MIMBI	MIMDY	PINSP	QUEEM
1	.2	.1	.1	.2	1.8	0.0	0.0	0.0
2	0.0	1.4	.1	0.0	0.0	.1	0.0	0.0
3	0.0	0.0	.9	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	.1	0.0	0.0	0.0	0.0	.0	0.0	2.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	.1	.1	0.0	0.0	.5	2.2	1.7	1.6
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	.6	.9	0.0	0.0	.9	9.3	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	3.5	0.0	0.0	.9	0.0	0.0	0.0
14	0.0	.5	0.0	0.0	0.0	.5	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	.2	0.0	0.0	0.0	0.0

Association Number	SPECIES SENDO	SIMCH	PLAWR	APOUN	CASLE	CERBR	DACDE
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	1.1	.6	0.0	0.0
5	0.0	0.0	0.0	0.0	1.8	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7.3	0.0	5.5	0.0	.4	0.0	0.0
9	0.0	0.0	0.0	0.0	1.1	0.0	.0
10	0.0	2.2	0.0	0.0	0.0	3.3	0.0
11	0.0	0.0	0.0	0.0	6.0	0.0	1.8
12	.0	0.0	0.0	0.0	.1	0.0	0.0
13	.0	0.0	0.0	0.0	.1	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. Means of standing crop estimates (g/m^2) of the five life form classes in all vegetation associations.

Association Number	Forbs		Grasses			
	Annual	Perennial	Annual	Perennial	Shrubs	Total
1	13	33	8	151	5	210
2	20	18	8	137	13	196
3	11	14	5	197	5	232
4	49	20	61	199	3	332
5	59	27	9	156	3	254
6	10	12	11	240	3	276
7	64	9	17	600	3	693
8	10	14	6	94	14	138
9	34	15	26	79	20	174
10	44	15	8	85	3	155
11	41	18	5	90	35	189
12	24	17	5	77	1	124
13	8	11	5	49	72	145
14	19	32	19	70	10	150
15	10	14	5	101	3	133
16	16	24	6	120	4	170

Table 6. Means for gross energy (kilocalories per gram oven-dry weight) of the five life form classes in all associations.

Association Number	Forbs		Grasses		
	Annual	Perennial	Annual	Perennial	Shrubs
1	4.27	4.26	4.27	4.54	4.72
2	4.31	4.17	4.23	4.19	4.06
3	4.20	4.31	4.07	4.34	4.57
4	4.18	4.36	4.32	4.34	4.62
5	4.26	4.37	4.43	4.65	4.57
6	4.33	4.80	*	4.44	*
7	4.12	4.35	4.12	4.26	4.94
8	*	4.02	4.20	4.32	4.67
9	4.22	4.37	4.29	4.41	4.85
10	*	4.28	4.12	4.18	4.98
11	*	4.30	4.22	4.57	4.43
12	4.23	4.76	4.22	4.47	4.96
13	*	4.78	*	4.63	5.20
14	4.09	4.52	4.33	4.52	4.77
15	4.40	4.51	*	4.63	4.98
16	4.24	4.44	4.39	4.51	5.02

*Data values not available.

Table 7. Means for percent nitrogen of the five life form classes in all associations.

Association Number	Forbs		Grasses		Shrubs
	Annual	Perennial	Annual	Perennial	
1	3.61	2.21	1.40	1.20	2.18
2	1.59	1.95	1.48	1.26	2.18
3	1.56	2.34	2.10	1.16	2.17
4	1.48	2.06	1.28	1.22	2.02
5	1.75	2.25	1.05	1.25	2.12
6	2.94	1.94	1.45	1.27	*
7	2.38	2.89	2.02	1.50	3.74
8	1.94	1.81	0.00	1.04	2.23
9	1.84	2.07	1.38	1.42	1.74
10	1.78	2.14	0.00	1.34	1.65
11	1.44	2.17	1.72	1.32	2.51
12	1.02	2.02	2.07	1.49	2.05
13	*	1.59	*	1.27	1.19
14	1.81	1.80	1.53	1.66	1.91
15	1.44	1.54	*	1.20	0.96
16	1.81	2.36	1.32	1.20	2.10

*Data values not available.

Table 8. Average soil characteristics for vegetation associations at The Research Ranch.

Association	pH	Salts	% O.M.	P ppm	K ppm	ppm NO_3-N	Zn ppm	Fe ppm	% Sand	% Silt	% Clay	Texture
1	5.48	.34	1.14	10.88	181.2	1.32	.942	22.86	52.5	20.75	26.75	S.C.L.
2	6.32	0.98	1.70	6.50	222.57	17.18	0.99	11.13	48.60	15.20	36.20	S.C.
3	5.03	0.30	1.03	9.10	205.0	1.03	0.86	21.20	48.0	21.0	31.0	S.C.L.
4	5.87	0.27	1.33	26.10	423.0	1.53	1.38	24.10	59.0	16.0	25.0	S.C.L.
5	6.28	0.66	1.99	11.99	283.75	7.94	2.11	24.95	50.50	13.50	36.0	S.C.
6	7.57	0.50	1.73	5.53	534.33	2.23	0.71	2.90	0	19.0	81.0	C.
7	7.68	0.80	2.02	20.98	668.0	16.25	1.44	6.30	39.25	26.25	34.50	C.L.
8	7.70	0.47	0.10	4.17	84.0	0.73	0.28	5.80	80.0	2.0	18.0	S.L.
9	6.37	0.33	1.27	2.63	158.0	1.87	1.31	14.17	58.0	14.33	27.67	S.C.L.
10	7.80	0.57	1.00	6.70	151.67	3.47	0.39	3.40	60.33	16.33	23.33	S.C.L.
11	5.23	0.20	1.53	5.43	182.0	2.37	0.98	19.77	57.0	14.33	28.67	S.C.L.
12	5.00	0.28	1.00	9.93	217.50	3.17	1.01	16.07	46.67	17.33	35.67	S.C.
13	7.10	0.29	1.83	3.13	254.17	1.07	0.55	5.63	28.33	14.0	57.67	C.
14	5.23	0.44	1.60	8.50	227.67	3.40	1.27	25.50	46.0	19.50	34.50	S.C.L.
15	7.20	0.25	1.97	6.70	228.33	0.10	1.30	8.17	39.67	20.0	40.33	C.
16	4.93	0.27	1.03	7.43	202.67	3.00	0.96	17.60	49.33	14.67	36.0	S.C.

Table 9. List of plant species found on TRR, Elgin, Arizona*

ACAAN	Acacia angustissima	BOURO	Bouteloua rothrockii
AGASP	Agave Spp.	BRADE	Brayulinea densa
AMAPA	Amaranthus palmeri	CALRE	Calliandra reticulata
AMBCO	Ambrosia confertiflora	CASBA	Cassia bauhinioides
ANDBA	Andropogon barbinodis	CASLE	Cassia leptadenia
ANDCI	Andropogon cirratus	CASAU	Castilleja austromontana
ANTTO	Anthericum torreyi	CENPA	Cenchrus pauciflorus
APOUN	Apodanthera undulata	CERBR	Cercocarpus breviflorus
ARCPU	Arctostaphylos pungens	CHEAL	Chenopodium album
ARGPL	Argemone platyceras	CHILI	Chilopsis linearis
ARIAD	Aristida adscensionis	CHLVI	Chloris virgata
ARIBA	Aristida barbata	CHRNA	Chrysothamnus nauseosus
ARIDI	Aristida divaricata	CIRSP	Cirsium spp.
ARIGL	Aristida glabrata	COMDI	Commelina dianthifolia
ARITE	Aristida ternipès	CONIN	Convolvulus incanus
ARTLU	Artemisia ludoviciana	COWME	Cowania mexicana
ASCAS	Asclepias asperula	CROPU	Crotalaria pumila
ASCEN	Asclepias englemanniana	CROCO	Croton corymbulosus
ASTAR	Aster arenosus	CUPAR	Cupressus arizonica
ASTBI	Aster bigelovii	CYNDA	Cynodon dactylon
ASTSP	Aster spp.	CYPSP	Cyperus spp.
ASTTE	Aster tenacetifolius	DALAL	Dalea albiflora
ASTRA	Astragalus spp.	DALLA	Dalea lachnostachys
BACSP	Baccharis spp.	DALPO	Dalea pogonathera
BAHAB	Bahia absinthifolia	DASWH	Dasylirion wheeleri
BOECO	Boerhaavia coccinea	DATME	Datura meteloides
BOEPU	Boerhaavia purpurascens	DESBI	Desmanthus bicornatus
BOUAR	Bouteloua aristidoides	DESCO	Desmanthus cooleyi
BOUCH	Bouteloua chondrosioides	DIOTE	Diodia teres
BOUCU	Bouteloua curtipendula	DYSDE	Dyschoriste decumbens
BOUEL	Bouteloua eludens	ECHCR	Echinochloa crusgalli
BOUER	Bouteloua eriopoda	ELYEL	Elymus elymoides
BOUFI	Bouteloua filiformis	ERADI	Eragrostis diffusa
BOUGR	Bouteloua gracilis	ERAIN	Eragrostis intermedia
BOUHI	Bouteloua hirsuta	ERALE	Eragrostis lehmanniana
BOURA	Bouteloua radicosa	ERAME	Eragrostis megastachya

Table 9. (Cont.)

ERISP	Erigeron spp.
ERILE	Eriochloa lemmoni
ERIPO	Eriogonum polycladon
ERIWR	Eriogonum wrightii
EUPAL	Euphorbia albomarginata
EUPEX	Euphorbia exstipulata
EUPHY	Euphorbia hyssopifolia
EUPIN	Euphorbia indivisa
EVOAR	Evolvulus arizonicus
EVOPI	Evolvulus pilosa
EVOSE	Evolvulus sericeus
FESSP	Festuca spp.
FOUSP	Fouquieria splendens
FRAVE	Fraxinus velutina
FROAR	Froelichia arizonica
GAISP	Gaillardia spp.
GARWR	Garrya wrightii
GAUCO	Gaura coccinea
GILSP	Gilia spp.
GNAWR	Gnaphalium wrightii
GOMNI	Gomphrena nitida
HACGR	Hackelochloa granufloris
HAPGR	Haplopappus gracilis
HAPSP	Haplopappus spinulosus
HAPTE	Haplopappus tenuisectus
HETCO	Heteropogon contortus
HETPI	Heterosperma pinnatum
HETSU	Heterotheca subaxillaris
HILBE	Hilaria belangeri
HILMU	Hilaria mutica
HYMWI	Hymenothrix wislizeri
IPOCO	Ipomoea coccinea
IPOMC	Ipomoea costellata
JATMA	Jatropha macrorhiza
JUGMA	Juglans major
JUNDE	Juniperus deppeana
KALCA	Kallstroemia californica
KALGR	Kallstroemia grandiflora
LEPDU	Leptochloa dubia
LOTOR	Lotus oroboides
LYCPH	Lycurus phleoides
MENPU	Mentzelia pumila
MILBI	Milla biflora
MIMBI	Mimosa biuncifera
MIMDY	Mimosa dysocarpa
MOLRE	Mollugo reticula
MONAU	Monarda austromontanum
MUHAR	Muhlenbergia arenicola
MUHEM	Muhlenbergia emersleyi
MUHFR	Muhlenbergia fragilis
MUHRI	Muhlenbergia rigida
NOLTE	Nolina texana
OPUSP	Opuntia spinosior
ORYSP	Oryzopsis spp.
PANAR	Panicum arizonicum
PANCA	Panicum capillare
PANHA	Panicum hallii
PANOB	Panicum obtusum
PASSP	Paspalum spp.
PECLO	Pectis longipes
PENDA	Penstemon dasyphyllus
PHAHE	Phaseolus heterophyllus
PHYFE	Physalis fendleri
PINCE	Pinus cembroides
PLAWR	Platanus wrightii
POLTR	Polanisia trachysperma
POLPE	Polygonum pensylvanicum
POPFR	Populus fremontii
PORCO	Portulaca cornata
PORPA	Portulaca parvula
PORRE	Portulaca retusa
PORSU	Portulaca suffrutescens

Table 9. (Cont.)

PROPA	Proboscidea parviflora	SPOAI	Sporobolus airoides
PROTO	Prosopis torreyana	SPOCR	Sporobolus cryptandrus
PSOTE	Psoralea tenuiflora	SPOWR	Sporobolus wrightii
QUEAR	Quercus arizonica	STETE	Stephanomeria tenuifolia
QUEEM	Quercus emoryi	TALAU	Talinum aurantiacum
QUETU	Quercus turbinella	TETCO	Tetraclea coulteri
RHUTR	Rhus trilobata	THEME	Thelesperma megapotamicum
SALKA	Salsola kali	TRASE	Trachypogon secundus
SALSU	Salvia subincisa	TRAOC	Tradescantia occidentalis
SCHPA	Schedonnardus paniculatus	TRICA	Trichachne californica
SCHWI	Schkuharia wislizeni	TRIAR	Trichosteme arizonicum
SENLO	Senecio longilobus	TRIMU	Tridens muticus
SETLU	Setaria lutescens	TYPSP	Typha spp.
SETMA	Setaria macrostachya	VERBR	Verbena bracteata
SIDNE	Sida neomexicana	VIGAN	Viguiera annua
SIDPR	Sida procumbens	VITAR	Vitis arizonica
SIDSP	Sida spinosa	XANSA	Xanthium sacchartum
SISLI	Sisymbrium linearifolium	YUCSP	Yucca spp.
SOLEL	Solanum elaeagnifolium	ZEXPO	Zexmenia podocephala
SORHA	Sorghum halepense	ZINGR	Zinnia grandiflora

*Authority is Arizona Flora, Kearney and Peebles, 1969.

Table 10. Species observed to occur in associations in 1972.

Association #1

Acacia angustissima
Agave spp.
Ambrosia confertiflora
Andropogon barbinodis
Aristida divaricata
Aristida ternipes
Aster arenosus
Bouteloua chondrosoides
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua hirsuta
Cenchrus pauciflorus
Croton corymbulosus
Cyperus spp.
Desmanthus bicornatus
Desmanthus cooleyi
Dyschoriste decumbens
Eragrostis intermedia
Evolvulus pilosa
Evolvulus sericeus
Gnaphalium wrightii
Haplopappus gracilis
Haplopappus tenuisectus
Hilaria belangeri
Lycurus phleoides
Portulaca cornata
Senecio longilobus
Sida procumbens
Stephanomeria tenuiflora
Trichachne californica
Zinnia grandiflora

Association #2

Ambrosia confertiflora
Andropogon barbinodis
Andropogon cirratus
Argemone platyceras
Aristida divaricata
Aristida ternipes
Asclepias asperula
Astragalus spp.
Boerhaavia coccinea
Boerhaavia purpurascens
Bouteloua gracilis
Bouteloua hirsuta
Bouteloua rothrockii
Brayulinea densa
Cassia bauhinioides
Cassia leptadenia
Cenchrus pauciflorus
Cirsium spp.
Croton corymbulosus
Desmanthus bicornatus
Desmanthus cooleyi
Diodia teres
Dyschoriste decumbens
Eragrostis intermedia
Erigeron spp.
Eriogonum wrightii
Evolvulus arizonicus
Evolvulus sericeus
Froelichia arizonica
Haplopappus tenuisectus
Heteropogon contortus
Hilaria belangeri
Hymenothrix wislizeri
Jatropha macrorhiza
Lotus oroboides
Lycurus phleoides
Mimosa biuncifera
Mimosa dysocarpa
Pectis longipes
Portulaca cornata
Portulaca parvula
Psoralea tenuiflora
Phaseolus heterophyllus
Senecio longilobus
Sida procumbens
Solanum elaeagnifolium
Stephanomeria tenuiflora
Tradescantia occidentalis
Trichachne californica
Zexmenia podocephala
Zinnia grandiflora

Association #3

Andropogon cirratus
Aristida divaricata
Aristida ternipes
Bouteloua curtipendula
Cenchrus pauciflorus
Chilopsis linearis
Eragrostis intermedia
Eriogonum polycladon
Juglans major
Leptochloa dubia
Mentzelia pumila
Oryzopsis spp.
Panicum arizonicum
Populus fremontii
Salsola kali
Senecio longilobus
Sida spinosa

Association #4

Aristida divaricata
Aristida ternipes
Boerhaavia purpurascens
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua radicosa
Castilleja austromontana
Cercocarpus breviflorus
Elymus elymoides
Eragrostis intermedia
Garrya wrightii
Gilia spp.
Juglans major
Juniperus deppeana
Nolina texana
Oryzopsis spp.
Panicum capillare
Panicum obtusum
Quercus emoryi
Rhus trilobata
Sporobolus cryptandrus
Verbena bracteata
Yucca spp.

Table 10. (Cont.)

Association #5

Andropogon barbinodis
Aristida divaricata
Aristida ternipes
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua hirsuta
Brayulinea densa
Cenchrus pauciflorus
Commelina dianthifolia
Cyperus spp.
Eragrostis intermedia
Evolvulus pilosa
Evolvulus sericeus
Haplopappus gracilis
Lycurus phleoides
Opuntia spinosior
Quercus emoryi
Sida neomexicana
Sida spinosa

Association #6

Andropogon barbinodis
Hilaria mutica
Panicum obtusum
Prosopis torreyana

Association #7

Ambrosia confertiflora
Andropogon barbinodis
Argemone platyceras
Aristida divaricata
Baccharis spp.
Boerhaavia coccinea
Bouteloua curtipendula
Bouteloua gracilis
Brayulinea densa
Cirsium spp.
Commelina dianthifolia
Convolvulus incanus
Croton corymbulosus
Dyschoriste decumbens
Eriochloa lemmoni
Euphorbia hyssoipifolia
Gilia spp.
Heteropogon contortus
Hilaria belangeri
Leptochloa dubia
Mimosa dysocarpa
Panicum arizonicum
Panicum hallii
Panicum obtusum
Sporobolus airoides

Association #8

Ambrosia confertiflora
Andropogon barbinodis
Aristida divaricata
Aristida ternipes
Baccharis spp.
Bouteloua chondrosioides
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua hirsuta
Brayulinea densa
Cirsium spp.
Commelina dianthifolia
Croton corymbulosus
Cyperus spp.
Dalea albiflora
Desmanthus cooleyi
Dyschoriste decumbens
Eragrostis intermedia
Evolvulus arizonicus
Evolvulus pilosa
Evolvulus sericeus
Hilaria belangeri
Lycurus phleoides
Mimosa dysocarpa
Muhlenbergia fragilis
Portulaca parvula
Senecio longilobus
Sida procumbens

Association #9

Agave spp.
Andropogon barbinodis
Arctostaphylos pungens
Aristida adscensiones
Aristida divaricata
Aristida ternipes
Bouteloua chondrioides
Bouteloua curtipendula
Bouteloua eriopoda
Bouteloua gracilis
Bouteloua hirsuta
Bouteloua radicosa
Cercocarpus breviflorus
Commelina dianthifolia
Convolvulus incanus
Cowania mexicana
Croton corymbulosus
Dalea albiflora
Dasylirion wheeler
Desmanthus bicornatus
Desmanthus cooleyi
Dyschoriste decumbens
Echinochloa crusgalli
Eragrostis intermedia
Eriochloa lemmoni
Eriogonum polycladon
Eriogonum wrightii
Evolvulus arizonicus
Evolvulus sericeus
Garrya wrightii
Hilaria belangeri
Jatropha macrorhiza
Juniperus deppeana
Lycurus phleoides
Mimosa biuncifera
Nolina texana
Opuntia spinosior
Panicum arizonicum
Pinus cembroides
Polygonum pennsylvanicum
Portulaca suffrutescens
Quercus emoryi
Rhus trilobata
Sida procumbens
Typhus spp.
Yucca spp.
Zexmenia podocephala

Table 10. (Cont.)

Association #10

Apodanthera undulata
Cenchrus pauciflorus
Chilopsis linearis
Cowania mexicana
Datura meteloides
Eragrostis intermedia
Juglans major
Mentzelia pumila
Populus fremontii
Salsola kali
Sorghum halepense
Sporobolus airoides

Association #11

Acacia angustissima
Ambrosia confertiflora
Andropogon barbinodis
Aristida divaricata
Aristida ternipes
Asclepias asperula
Aster arenosus
Bouteloua chondrosioides
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua hirsuta
Brayulinea densa
Cenchrus pauciflorus
Croton corymbulosus
Cyperus spp.
Desmanthus bicornatus
Desmanthus cooleyi
Dyschoriste decumbens
Eragrostis intermedia
Evolvulus pilosa
Evolvulus sericeus
Cnaphalium wrightii
Haplopappus gracilis
Haplopappus tenuisectus
Hilaria belangeri
Lycurus phleoides
Panicum obtusum
Portulaca cornata
Senecio longilobus
Sida procumbens
Stephanomeria tenuiflora
Trichachne californica
Zinnia grandiflora

Association #12

Ambrosia confertiflora
Andropogon barbinodis
Aristida divaricata
Baccharis glutinosa
Bouteloua chondrosioides
Bouteloua gracilis
Bouteloua hirsuta
Circium spp.
Commelina dianthifolia
Convolvulus incanus
Croton corymbulosus
Cyperus spp.
Eragrostis intermedia
Hilaria belangeri
Jatropha macrorhiza
Lycurus phleoides
Mimosa biuncifera
Oryzopsis spp.
Panicum hallii
Prosopis torreyana

Association #13

Agave spp.
Andropogon barbinodis
Anthericum torreyi
Argemone platyceras
Aristida divaricata
Aristida ternipes
Astragalus spp.
Boerhaavia coccinea
Boerhaavia purpurascens
Bouteloua curtipendula
Bouteloua eriopoda
Bouteloua gracilis
Bouteloua hirsuta
Brayulinea densa
Cenchrus pauciflorus
Croton corymbulosus
Datura meteloides
Desmanthus bicornatus
Desmanthus cooleyi
Dyschoriste decumbens
Eragrostis intermedia
Euphorbia albomarginata
Evolvulus arizonicus
Fouquieria splendens
Gaura coccinea
Haplopappus spinulosus
Hilaria belangeri
Mimosa dysocarpa
Nolina texana
Panicum obtusum
Phaseolus heterophyllus
Prosopis torreyana
Psoralea tenuiflora
Senecio longilobus
Sporobolus airoides
Yucca spp.
Zexmenia podocephala

Association #14

Ambrosia confertiflora
Andropogon barbinodis
Aristida divaricata
Aristida ternipes
Baccharis spp.
Bouteloua chondrosioides
Bouteloua curtipendula
Bouteloua hirsuta
Cassia bauhinioides
Cirsium spp.
Dalea albiflora
Desmanthus cooleyi
Eragrostis intermedia
Eragrostis lehmanniana
Evolvulus pilosa
Evolvulus sericeus
Haplopappus tenuisectus
Hilaria belangeri
Lycurus phleoides
Mimosa biuncifera
Mimosa dysocarpa
Prosopis torreyana
Sida procumbens
Sporobolus cryptandrus
Zinnia grandiflora

Table 10. (Cont.)

Association #15

Andropogon barbinodis
Anthericum torreyi
Argemone platyceras
Aristida divaricata
Asclepias nummukeria
Astragalus spp.
Bouteloua curtipendula
Bouteloua gracilis
Bouteloua hirsuta
Bouteloua radicosa
Brayulinea densa
Castilleja austromontana
Cenchrus pauciflorus
Cirsium spp.
Convolvulus incanus
Cowania mexicana
Croton corymbulosus
Dasylirion wheeler
Dyschoriste decumbens
Eragrostis intermedia
Euphorbia indivisia
Evolvulus arizonicus
Evolvulus pilosa
Evolvulus sericeus
Gaillardia spp.
Garrya wrightii
Haplopappus gracilis
Haplopappus tenuisectus
Hilaria belangeri
Jatropha macrorhiza
Juniperus deppeana
Mimosa biuncifera
Nolina texana
Panicum obtusum
Prosopis torreyana
Psoralea tenuiflora
Quercus emoryi
Rhus trilobata
Salvia subincisa
Solanum elaeagnifolium
Sporobolus cryptandrus
Verbena bracteata
Vitis spp.
Yucca spp.
Zexmenia podocephala
Zinnia grandiflora

Association #16

Andropogon barbinodis
Aristida divaricata
Baccharis spp.
Bouteloua curtipendula
Bouteloua gracilis
Brayulinea densa
Cirsium spp.
Commelina dianthifolia
Convolvulus incanus
Croton corymbulosus
Desmanthus bicornatus
Dyschoriste decumbens
Evolvulus arizonicus
Evolvulus sericeus
Froelichia arizonica
Haplopappus tenuisectus
Hilaria belangeri
Ipomoea coccinea
Jatropha macrorhiza
Lycurus phleoides
Mimosa biuncifera
Panicum obtusum
Phaseolus heterophyllus
Portulaca cornata
Portulaca suffrutescens
Prosopis torreyana
Senecio longilobus
Setaria macrostachya
Sida procumbens
Solanum elaeagnifolium
Stephanomeria tenuifolia
Trichachne californica
Zinnia grandiflora

Table 11. Species occurrence in vegetation associations in 1972.

Species Recorded	Association															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acacia angustissima	X										X					
Agave spp.	X								X				X			
Ambrosia confertiflora	X	X					X	X			X	X		X		
Andropogon barbinodis	X	X			X	X	X	X	X		X	X	X	X	X	X
Andropogon cirratus		X	X													
Anthericum torreyi													X		X	
Apodanthera undulata										X						
Arctostaphyl s pungens									X							
Argemone platyceras		X					X						X		X	
Aristida adscensionis									X							
Aristida divaricata	X	X	X	X	X		X	X	X		X	X	X	X	X	X
Aristida ternipes	X	X	X	X	X			X	X		X		X	X		
Asclepias asperula		X									X					
Asclepias spp.															X	
Aster arenosus	X										X					
Astragalus spp.		X											X		X	
Baccharis spp.							X	X				X		X	X	
Boerhaavia coccinea		X					X						X			
Boerhaavia purpurascens		X		X									X			
Bouteloua chondrosioides	X							X	X		X	X		X		
Bouteloua curtipendula	X		X	X	X		X	X	X		X		X	X	X	X
Bouteloua eriopoda									X				X			
Bouteloua gracilis	X	X		X	X		X	X	X		X	X	X		X	X
Bouteloua hirsuta	X	X			X			X	X		X	X	X	X	X	
Bouteloua radicosa				X					X						X	
Bouteloua rothrockii		X														
Brayulinea densa		X			X		X	X			X		X		X	X
Cassia bauhinioides		X												X		
Cassia leptadenia		X														
Castilleja astromontana			X												X	
Cenchrus pauciflorus	X	X	X		X					X	X		X		X	
Cercocarpus breviflorus				X					X							
Chilopsis linearis			X							X						
Cirsium spp.		X					X	X				X		X	X	X
Commelinia dianthifolia					X		X	X	X			X				X

Table 11. (Cont.)

Species Recorded	Association															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Convolvulus incanus							X		X			X			X	X
Cowania mexicana									X	X					X	
Croton corymbulosus	X	X					X	X	X		X	X	X		X	X
Cyperus spp.	X				X			X			X	X				
Dalea albiflora								X	X					X		
Dasylirion wheeler									X						X	
Datura meteloides										X			X			
Desmanthus bicornatus	X	X							X		X		X			X
Desmanthus cooleyi	X	X						X	X		X		X	X		
Diodia teres		X														
Dyschoriste decumbens	X	X					X	X	X		X		X		X	X
Echinochloa crusgalli									X							
Elymus elymoides				X												
Eragrostis intermedia	X	X	X	X	X			X	X	X	X	X	X	X	X	
Eragrostis lehmanniana														X		
Erigeron spp.		X														
Eriochloa lemmoni							X		X							
Eriogonum polycladon			X						X							
Eriogonum wrightii		X							X							
Euphorbia albomarginata													X			
Euphorbia hyssoipifolia							X									
Euphorbia indivisa															X	
Evolvulus arizonicus		X						X	X				X		X	X
Evolvulus pilosa	X				X			X			X			X	X	
Evolvulus sericeus	X	X			X			X	X		X			X	X	X
Fouquieria splendens													X			
Froelichia arizonica		X													X	
Gaillardia spp.														X		
Garrya wrightii				X					X						X	
Gaura coccinea													X			
Gilia spp.				X			X									
Gnaphalium wrightii	X										X					
Haplopappus gracilis	X				X						X				X	
Haplopappus spinulosus													X			
Haplopappus tenuisectus	X	X									X			X	X	X
Heteropogon contortus		X					X									

Table 11. (Cont.)

Species Recorded	Association 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hilaria belangeri	X	X					X	X	X		X	X	X	X	X	X
Hilaria mutica						X										
Hymenothrix wislizeri		X														
Ipomoea coccinea																X
Jatropha macrorhiza		X							X			X			X	X
Juglans major			X	X						X						
Juniperus deppeana				X					X						X	
Leptochloa dubia			X				X									
Lotus oroboides		X														
Lycurus phleoides	X	X			X			X	X		X	X		X		X
Mentzelia pumila			X							X						
Mimosa biuncifera		X							X			X		X	X	X
Mimosa dysocarpa		X					X	X					X	X		
Muhlenbergia fragilis								X								
Nolina texana				X					X				X		X	
Opuntia spinosior					X				X							
Oryzopsis spp.			X	X								X				
Panicum arizonicum			X				X		X							
Panicum capillare				X												
Panicum hallii							X					X				
Panicum obtusum				X		X	X				X		X		X	X
Pectis longipes		X														
Phaseolus heterophyllus		X											X			X
Pinus cembroides									X							
Platanus wrightii								X								
Polygonum pennsylvanicum									X							
Populus fremontii			X							X						
Portulaca cornata	X	X									X					X
Portulaca parvula		X						X								
Portulaca suffrutescens									X							X
Prosopis torreyana						X						X	X	X	X	X
Psoralea tenuiflora		X											X		X	
Quercus emoryi				X	X				X						X	
Rhus trilobata				X					X						X	
Salsola kali			X							X						
Salvia subincisa															X	
Senecio longilobus	X	X	X					X			X		X			X

Table 11. (Cont.)

Species Recorded	Association															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Setaria macrostachya																X
Sida neomexicana					X											
Sida procumbens	X	X						X	X		X			X		X
Sida spinosa			X		X											
Sorghum halepense										X						
Solanum elaeagnifolium		X													X	X
Sporobolus airoides							X			X			X			
Sporobolus cryptandrus				X										X	X	
Stephanomeria tenuiflora	X	X									X					X
Tradescantia occidentalis		X														
Trichachne californica	X	X									X					X
Typhus spp.									X							
Verbena bracteata				X											X	
Vitis spp.															X	
Yucca spp.				X					X				X		X	
Zexmenia podocephala		X											X		X	
Zinnia grandiflora	X	X									X			X	X	X

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