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CACTUS DISEASE INVESTIGATIONS

An Outline of Objectives, Plans, And Accomplishments
On Project J-2-8

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1942	1st Week	2nd Week	3rd Week	4th Week
June :	:	: Reconnaissance	: Report	: Reconnaissance
:	:	: Tucson Mt. Park	:	: Tucson Mt. Park
July :	:	:	:	:
: Sample Plot	:	:	: Saguaro	:
: Note Forms	:	:	: Sample Plots	:
Aug. :	:	:	:	:
:	:	: Detailed Survey Tucson Mountain Park (?)	: 1 Asst.	:
Sept.:	:	:	:	:
:	: Permanent Plots - - Tucson Mountain Park (?)	:	: 1 Asst.	:
Oct. :	:	:	:	:
: Read Tucson Mt.	: Stake missed	: Saguaro Sample	: Recheck	:
: Park Plots (?)	: plants on Sec. 17	: Plots	: Sec. 17	:
Nov. :	:	:	:	:
:	: Recheck	: Section	: 17	:
Dec. :	:	:	:	:
: Recheck	: Additional Sanitation Work on	:	:	:
: Sec. 17	: Sec. 17 (?)	: (3 Laborers)	:	:
<u>1943:</u>	:	:	:	:
Jan.:	:	:	:	:
: Tucson Mt. Park	:	: Saguaro	:	:
: Sample Plots (?)	:	: Sample Plots	:	:
Feb. :	:	:	:	:
:	: Suppression Experiment - Tucson Mountain Park (?)	:	:	:
:	: (3 Laborers)	:	:	:
Mar. :	:	:	:	:
:	:	:	:	:
Apr. :	:	:	:	:
: Tucson Mt. Park	:	: Saguaro	:	:
: Sample Plots (?)	:	: Sample Plots	:	:

PART I
DISEASE SUPPRESSION EXPERIMENTS

A. OBJECTS

1. To determine whether or not losses from bacterial rot can be effectually reduced by sanitation measures.

B. PLAN

1. To remove all diseased material from the 320 acres comprising the south half of section 17 (Figs. 1 and 2) in Saguaro National Monument by:
 - (a) Burying all badly diseased plants.
 - (b) Aseptically removing diseased tissue from lesions which had not reached lethal size.
 - (c) Burning all dead and dry plants.
2. To make detailed records of all cacti on the treated area and on the adjoining 320 acres to the north. The data from the north half to serve as a check or means of judging the effectiveness of the sanitation work.
3. To conduct detailed reexaminations on the entire section once a year for the next five years at least in order to compare the subsequent losses from disease on the two halves.

This plan was prepared after a conference at the University of Arizona on September 6, 1941, at which time representatives of the University, the National Park Service, and the Bureau of Plant Industry were present.

C. ACCOMPLISHMENTS

Sept. 1941 - March 1942

Each living cactus on the section was identified with a numbered wooden stake. The numbers starting with No. 1 in the SW corner of each 10-acre quadrat (Fig. 1) and progressing in north-south strips to the east edge of the quadrat. The staking was begun in September, 1941 and completed in January, 1942; 12,953 living saguaros were thus identified.

The dead dry skeletons on each 10-acre quadrat were counted, (a few were staked) 1,835 being present on the entire section.

Between November, 1941 and January, 1942 notes were taken on each cactus on the south half of the section, and those requiring removal were marked with paint. Marking and note-taking was done a day or two ahead of removal. The notes were kept in surveyor's level books, which were made available to the foreman of the removal crew, who entered the date on which each marked cactus was removed or treated by his crew, and in addition made a record of all cacti accidentally injured in the course of operation. Notes on each cactus showed:

- (a) It's height to the nearest 6 ft.
- (b) Serious mechanical injuries.
- (c) Disease Condition - extent and degree of activity.
- (d) Miscellaneous remarks pertinent to the object or operation of the project.

Similar notes were taken on the north half of the section (untreated area) between February 23 and March 17, 1942. Cacti that would have been removed or treated had they been on the

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South half were so indicated.

Typed copies of the notes have been made and both sets are filed in the Tucson office.

Surgical work of removing actively diseased tissue from cacti standing on the south half was done during February 16 to 20, 1942. Over 50 plants had been indicated for surgical treatment at the time the records were made, but of these only 3 showed active lesions at the time the surgical work was done, the rest having apparently "walled-out" the infection naturally. In some cases the callused lesions were operated upon to provide better drainage.

The sanitation work (Figs. 4, 5, 6) was started in November, 1941, and was completed January 10, 1942. Cacti marked for removal were felled, bucked, loaded on trucks, and dumped into one of four pits which had been previously excavated on the area (see Fig. 1). The cacti in the pits were fumigated and then immediately covered with at least a foot of earth. In a few cases it was possible to amputate diseased arms and leave an apparently disease-free plant. After the removal and burial of all marked cacti, the dry snags or skeletons were gathered up (late December to January 10), piled on the burial pits and burned. At the completion of the work the pits were back-filled and the more evident trails visible from the main roads were obliterated. A more detailed account of the work follows:

Statistics

a. Number of living cacti removed and buried:

313 diseased; 12 healthy (injured in the operation)

b. Excavation of pits:

No. of pits - 4

Cubic yards excavated - 1,000

Equipment - 65 h. p. bulldozer, 29½ hrs. (rented)

c. Sanitation work:

Equipment (loaned by National Park Service)

1 - crane truck (2 months)

2 - 1½ ton dump trucks (2 months)

1 - 1½ ton dump truck (1 month)

d. Labor:

1 foreman (3 months)

5 laborers (2 months)

3 truck drivers (2 months)

Methods

Felling

A belt was adjusted 10-12 ft. above ground on the cactus and attached to a tow line on a truck. Main roots of cactus were cut. The cactus was pulled over by the truck. Undercutting was impossible as a means of directing the fall because of the uneven balance of the plants.

Bucking

The upper ends of the plants were chopped into about 1-foot bolts with broadaxes, but where more than two or three axe strokes would be required to finish a cut, a saw was used. Excessive

chopping was discouraged in order to minimize the amount of debris resulting from the operation.

Loading

Short bolts were loaded into dump trucks by hand. Long bolts (up to 5 ft.) from the basal parts of cacti were loaded into dump trucks with the aid of a crane mounted on a truck.

Clean-Up

All debris created in dismembering a cactus was picked up and carried to the pits in the truck. The stake used to identify the cactus was replaced where the plant originally stood. The foreman did not record a cactus as removed until he had inspected its former site. On tiers 1 to 5 inclusive (Fig. 1) the soil around a diseased cactus and also the exposed root bases were sprayed with about a gallon of calcium hypochlorite solution (1% free chlorine). This practice was discontinued on tiers 6, 7, and 8 which received no soil disinfection.

Fumigation

Every three to four days, the cactus sections which accumulated in a pit were fumigated with a solution of 20 lbs. of para-dichlorobenzene dissolved in 55 gallons of kerosene. This was poured on the pile at the rate of 1 gallon per cactus, and the pile was immediately covered with tarpaulins to form a fairly air tight cover. After three or four days, the tarpaulins were removed and the cacti were covered with about a foot of soil.

Disposal of dry snags

After all living diseased plants had been buried, the snags were gathered up in trucks and a tally kept of the number taken from each 10-acre quadrat. They were dumped on Pits No. 1, 3, and 4 (Fig. 1) and burned shortly thereafter.

Final backfilling

On January 21, a bulldozer was rented to backfill all excavated soil into the pits. This required 6½ hours operating time.

Obliteration

After burning the snags, a few man-days were spent in late January obliterating the more obvious truck trails that had been made in the course of the work. In doing this, every effort was made to carry out the suggestion of administrative Park Service officials. Thorough obliteration was not attempted. The truck trails will receive occasional use for the next several years in the course of completing the experiment.

Records

About 800 feet of 16 mm. color film were used in a motion picture record of the various activities of the operation. Mr. Marvin E. Frost of Tucson graciously donated his time, equipment and skill to help us obtain this record. In addition, numerous still-photographs in both color and black and white were taken during the work.

The height and condition of each cactus was recorded by a pathologist in surveyor's level books; cacti requiring removal or treatment were also indicated. The books were given to the foreman

of the removal crew who entered the date beside the proper number when a cactus was removed or when an arm was amputated. In case a cactus was damaged or had to be removed because of accident incidental to the operation, the foreman also made note of these facts in the book.

D. RESULTS

A comparison of the conditions on the north and south halves of the experimental section respectively is given in Table 1. While the total population on each half is surprisingly similar, the plants less than 19 feet tall on the north half are much more abundant (3,568) than on the south half (2,911), which might explain the difference in the percentages of diseased plants on the two areas.

Table 1 also shows (Column 5) that disease is heaviest in the larger plants.

E. FURTHER WORK

1. Summer, 1942.

Stake all plants missed in original operation. This will require about two weeks for one man.

2. Fall, 1942.

Recheck entire Section 17 and obtain figures comparing disease incidence and mortality on north and south halves respectively. This will require about six weeks for one man in the field.

3. Fall, 1942.

Remove or give surgical treatment to infected plants on the south half of the section if this is considered advisable.

There is plenty of burial space in hole No. 1 at S. W. corner of the section and some space in hole No. 3. It is estimated that this work will take about two weeks time for one technical man plus the help of some laborers and a team.

4. Winter, 1942-43.

Start new suppression experiment on the Tucson Mountain Park if this is considered advisable.

Part II

SURVEYS

A. OBJECT

April 1941

1. To determine the distribution and spread of the bacterial rot and to estimate losses caused by it.

B. PLAN

1. To observe and record the location of the disease wherever observed or reported, in order to determine its general distribution.
2. To estimate the intensity of the disease on the Saguaro and Organ Pipe Cactus National Monuments, in order to evaluate current damage and to establish a starting point from which fluctuations in disease intensity can be detected quantitatively.

C. ACCOMPLISHMENTS

1. Records on the general distribution of the disease thus far have been limited to those made incidental to auto and train travel for other purposes. A list of general observations is given below:
 - (a) Saguaro National Monument - disease heavy at north and becoming less intense southward.
 - (b) Tucson Mountain Park - disease generally present, heavy in scattered areas especially to the north.
 - (c) Papago Indian Reservation - disease generally present along Ajo Road.

- (d) Organ Pipe Cactus National Monument - disease light but widely distributed.
- (e) Picacho Peak - heavy losses from disease.
- (f) Casa Grande - extremely heavy losses.
- (g) Phoenix and vicinity - heavy losses.
- (h) Florence Junction to Globe - disease present.
- (i) Tonto National Monument - disease present.
- (j) Salome to Congress - disease present in scattered places.
- (k) Salome to Buckeye - disease present in scattered places.
- (l) Ajo to Gila Bend - disease present in scattered places.
- (m) Gila Bend to Casa Grande - heavy losses.
- (n) Roosevelt Dam to Apache Junction - disease present in scattered places.
- (o) Reddington and Vicinity - disease present.

2. Quantitative Surveys.

Saguaro National Monument

Between October, 1940 and May, 1941 a section of land (Section 17, R16E, T14S) was gridded into 10-acre blocks, the corners of which were identified with wooden stakes. This work was performed by N.Y.A. engineering students from the University of Arizona under the direction of the Monument Custodian. The section appeared to represent average disease conditions in the older stands and was selected for an intensive survey. For this purpose, four separate drawings of 10 numbers were made from a lot of 64. Each number represented a particular 2 1/2 acre block in a quarter section and each drawing thus applied to a particular quarter section only.

The distribution of the forty - $2\frac{1}{2}$ -acre blocks selected under this procedure is shown in Figure 1. After selecting the sample areas, they were located by pacing and compass, and a tally was made of the healthy and diseased cacti in each. The basic data thus obtained are given in Table 2.

Organ Pipe Cactus National Monument

On this Monument the survey was made in June, 1941 by establishing strips 1000 feet long and 100 feet wide at scattered locations where some disease could be found. A central line was run with a staff compass and steel chain, stakes being set at 200 feet intervals. The width of the strip was obtained by pacing from the center line. Cacti on the strip were tallied according to the height class and condition with respect to disease, the following classifications being used:

Height: I- 6 inches to 3 feet

II- 4 feet to 6 feet

III- 9 feet to 16 feet

IV- 17 feet and over

Condition:

Healthy

Old Dead - (dead over three years)

Recent Dead - (dead less than three years)

Infected - (diseased but living)

SYMBOL.

H

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RD

I

Following are descriptions of the eight survey strips established in June, 1941.

Plot I

Area: 2.3 acres (1000' x 100')

Long axis: E-W

Location: West side of Ajo - Sonoyta highway 6.7 + miles from
U. S. Customs House at Int. Boundary.

Total number of plants: 23

General topography: flat and rocky.

Plot II

Area: 2.3 acres (1000' x 100')

Long axis: N.N.W. - S.S.E.

Location: Dowelling Well Road 1.25 + miles from Customs House,
marked by a small stone monument on N. side of road.

Total number of plants: 70

General topography: flat

Plot III

Area: 2.3 acres (1000' x 100')

Long axis: E - W.

Location: Short distance above Dowelling Well, 2.35 + miles from
Customs House.

Total number of plants: 92

General topography: Rolling and rocky.

Plot IV

Area: 2.3 acres (1000' x 100')

Long axis: E - W

Location: E side of the Ajo-Sonoyta highway 12.6 + miles from
the N. boundary of the Monument.

Total number of plants: 39

General topography: Flat.

Plot V

Area: 2.3 acres (1000' x 100')

Long axis: E - W

Location: E. side of the Ajo-Sonoyta highway 10.6 + miles from
the N. boundary of the Monument.

Total number of plants: 50

General topography: flat

Plot VI

Area: 2.3 acres (1000' x 100')

Long axis: E - W (40° S of E)

Location: 200' So. of the N. road to Alamo Canyon 0.1 mi. from
the Ajo-Sonoyta road.

Total number of plants: 51

General topography: flat.

Plot VII

Area: 2.3 acres (1000' x 100')

Long axis: E - W

Location: On the W. side of the Ajo-Sonoyta highway, 14.0 + miles
from the north boundary of the Monument.

Total Number of plants: 52

General topography: flat.

Plot VIII

Area: 2.3 acres (1000' x 100')

Long axis: N - S

Location: In Growler Pass, 500' on each side of the road.

Total number of plants: 66

General topography: Rough, rocky pass in the hills.

All plots were reexamined during the week ending May 30, 1942.

Basic data from this survey are given in Tables 3 and 4.

Tucson Mt. Park

As this report is being written a preliminary survey of
disease conditions on the Tucson Mountain Park is being made.

D. RESULTS

The general survey work indicates that the disease probably
exists throughout the range of saguaro in Arizona, although it seems
to be serious only in fairly well circumscribed areas. While a
more systematic and complete survey of its distribution would be
extremely helpful in planning further study of the disease, it is

doubtful if such an undertaking would be warranted at this time in view of the scarcity of automotive equipment.

The 100 acre sample on section 17 of the Saguaro National Monument (See Fig. 1) showed that 3% of the 2230 cacti tallied were either badly diseased or had died within the past three years and that an additional 6% had been dead probably longer than three years.

Of the 444 cacti in eight survey plots at Organ Pipe Cactus National Monument approximately 7% have been dead over three years and 2% have been dead less than three years. There is very little active infection at the present time. These percentages, while not extremely low, are of minor importance, since 33.6% of the healthy cacti are 3 feet or less in height and 16.3% are between 4 feet and 8 feet in height. With so much reproduction taking place little importance can be attached to a loss of 7% in older stands. The data from the May, 1942 reexamination have not been analyzed but superficial inspection shows that there has been little or no increase in disease.

E. FURTHER WORK

1. Summer, 1942.

If considered advisable, a quantitative survey of the disease in the Tucson Mountain Park should be made in July or August. This would be especially advisable if a suppression experiment were planned for that area since the data from the survey will be very helpful in planning the physical requirements of the suppression work.

It is estimated that one man could conduct an adequate survey in about three weeks.

2. April, 1943

Resurvey the strips on the Organ Pipe National Monument.

This should take one man about a week.

PART III

PERMANENT SAMPLE PLOT STUDIES

A. OBJECTS

April 1941

1. To learn to recognize incipient stages of the disease.
2. To observe the progress and behavior of lesions.
3. To observe the progress and behavior of disease incidence and mortality in stands.
4. To determine whether or not there are seasonal or annual changes in disease incidence or mortality and to determine the meteorological or other causes of such changes.

B. PLAN

April 1941

To establish permanent observation plots in the Saguaro and Organ Pipe Cactus National Monuments on which detailed case histories shall be kept on each saguaro or organ pipe cactus present. Thorough reexamination will be made at stated intervals, their frequency depending on the accessibility of the plots and the need as it appears from analysis of previous records.

C. ACCOMPLISHMENTS

Saguaro National Monument

Establishment of plots.

During April and May, 1941 six 5-acre plots were established and case histories started on the 979 saguaros thereon. Pertinent information for each plot is given below:

Plot A

Area: 5 acres (5x10 chains)

Long axis: N-S

Location: $N\frac{1}{2}$ of the SW1/4 of the SW1/4 of the NE1/4 of S.17

T. 14 S., R. 16 E.

Total number of saguaros: 209

General topography: flat (Fig. 2)

Plot B

Area: 5 acres (5x10 chains)

Long axis: E-W

Location: $S\frac{1}{2}$ of the SE1/4 of the SE1/4 of the SW1/4 of S. 17

T. 14 S., R. 16 E.

Total number of saguaros: 187*

General topography: flat (Fig. 2)

*All badly diseased plants were removed from this plot
in the course of the suppression experiment.

Plot C

Area: 5 acres (5x10 chains)

Long axis: E-W

Location: $S\frac{1}{2}$ of the SE1/4 of the SW1/4 of the SW1/4 of S. 33,

R. 16 E., T. 14 S.

Total number of saguaros: 291

General topography: Lower mountain side having numerous rock
outcrops (Fig. 7)

Plot D

Area: 5 acres (5x10 chains)

Long axis: N-S

Location: NE1/4 of the SE1/4 and the SE1/4 of the NE1/4 of the SW1/4 of the SE1/4 of S. 20, R. 16 E., T. 14S.

Total number of saguaros: 106

General topography: Rolling hills.

Plot E

Area: 5 acres (5x10 chains)

Long axis: E-W

Location: NE1/4 of the NE1/4 of the SW1/4 and the SE1/4 of the NE1/4 of the SE1/4 of S. 17, R. 16 E., T. 14 S.

Total number of saguaros: 126

General topography: Rolling hills

Plot F

Area: 5 acres (5x10 chains)

Long axis: E-W

Location: NE1/4 of the SW1/4 of the SW1/4 of the NE1/4 of S. 21, R. 16 E., T. 14 S.

Total number of saguaros: 60

General topography: Flat (Fig. 2)

Examination of Plots.

Formal examinations of the plots were made on the following dates:

Plot A - 5/25/41 - 7/15/41 - 10/21/41 - 1/22/42

Plot B - 5/23/41 - 7/16/41 - 10/22/41 - 1/28/41

Plot C - 4/25/41 - 7/21/41 - 10/24/41 - 1/29/42

Plot D - 5/16/41 - 7/17/41 - 10/23/41 - 1/28/42

Plot E - 5/20/41 - 7/17/41 - 10/23/41 - 1/28/42

Plot F - 5/23/41 - 7/19/41 - 10/21/41 - 1/29/42

Organ Pipe Cactus National Monument

Establishment of Plots.

Descriptions of the five plots established in June, 1941 are given below. Plots I and II contain only organ pipe cactus whereas plots III, IV, and V apply only to saguaro.

Plot I - Organ pipe cactus, established 6/21/41.

Area: 0.9 acres (3x3 chains)

Location: Cement tanks on the S. W. side of the Big Ajo Mountains.

Total number of plants: 7

General topography: Flat and rocky.

Plot II - Organ pipe cactus, established 6/21/41.

Area: .9 acres (3x3 chains)

Location: At cement tanks, adjacent to plot I on the east.

Total number of plants: 18

General topography: flat and rocky.

Plot III - Saguaro; established 6/23/41.

Area: .9 acres (3x3 chains)

Location: East side of the Ajo-Sonoyta road 11.4 + miles
from the north boundary of the Monument.

Total number of plants: 20

General topography: flat.

Plot IV - Saguaro; established 6/24/41.

Area: .9 acres (3x3 chains)

Location: On the Alamo Canyon road 3.8 + miles from the
Ajo-Sonoyta highway.

Number of plants: 45

General topography: flat.

Plot V - Saguaro; established 6/25/41.

Area: .9 acres (3x3 chains)

Location: Above Dowelling Well 2.4 + miles from the Customs House
at the International Bdy. on the east slope of the hills.
Marked by a small stone monument on W. side of road.
Plot is approximately 450' W. of monument.

Number of plants: 72

General topography: Lower mountain side with numerous rock outcrops.

Reexaminations: A reexamination of all plots was made during the
week ending May 30, 1942.

D. RESULTS

Preliminary analyses (Table 5) of the data from five of the
Saguaro National Monument plots 1/ indicates that the necrotic spots,

believed to be incipient stages of the disease, appear in greatest numbers during the summer.

Over 200 new lesions were included in these analyses and about half of these appeared to have become naturally arrested in less than two months. Only about 2 percent of the lesions appeared to be active at the end of the 8-month period covered by the observations (Table 6). Further reexaminations will be essential in order to determine whether this apparently high degree of arrestment is permanent or whether the rot continues to work unseen behind the hard wound tissues of many apparently calloused lesions.

The figures from the Organ Pipe plots (Table 7) tell the same story as the survey of that Region viz., a low percentage of dead plants and very low infection at the present time. The data from the May, 1942 reexamination of these plots have not been analyzed but there was no obvious increase in disease intensity at that time.

1/ Plot B was not included in the analyses since it was located in the sanitation area and therefore no longer comparable to the others.

PART IV

MISCELLANEOUS

PHOTOGRAPHIC RECORDS

Since the beginning of the project an attempt has been made to obtain a complete photographic record of the work and the disease. Over 100 photographs are now on file at Tucson.

Repeat photographs showing the progress of the disease by approximately 1-month intervals have been made of the several cacti. Completed series are illustrated in Figures 9 and 10.

DISTRIBUTION

A map showing the distribution of saguaros, kindly made available by Dr. Forrest Shreve, is shown in Figure 12.

WEATHER ANALYSES

Weather Analyses of the Tucson area have been made and are included in this report (Figs. 13, 14, 15 and Tables 8 and 9).

ROUND CALLUS FORMATION

Samples of saguaro tissue that have been exposed to the weather for different periods have been collected and preserved for future study.

TABLE 1

COMPARISON OF POPULATION AND DISEASE ON THE NORTH
AND SOUTH HALVES OF SECTION 17

January, 1942

Height		Total No.	Diseased Living Plants Removed 1/			
Class		Living Plants	Frequency %	No.	% of Class	% of Total
(1)		(2)	(3)	(4)	(5)	(6)
South half (treated area)						
0-6'	I	274	4.3	3	1.1	1.0
1'-12'	II	717	11.2	22	3.1	7.0
13'-18'	III	1,920	30.0	64	3.3	20.4
19'-24'	IV	2,061	32.1	105	5.1	33.5
25' +	V	1,423	22.2	114	8.0	36.4
Unclassified 2/		13	0.3	5	-	1.6
Total		6,413	100.0	313	4.9	100.0
North half (untreated check area)						
0-6'	I	404	6.2	2	.5	.7
7'-12'	II	921	14.0	13	1.4	4.8
13'-18'	III	2,243	34.2	43	1.9	15.9
19'-24'	IV	1,520	23.2	71	4.7	26.2
25' +	V	1,411	21.5	100	7.1	37.0
Unclassified 2/		56	0.8	42	-	15.5
Total		6,555	100.0	271	4.1	100.0

1/ Plants that would have been removed in N. 1/2

2/ Plants mechanically damaged so that height could not be determined.

TABLE 2

10-Acre		Quarter	Number of Plants		
Quadrat No.	Field: Office:		Diseased 2/		
		of	Old	Recent	Healthy
16-17	: 8H	: SE	:	12	: 50
	: 8H	: SW	:	5	: 77
13-14	: 5H	: NW	: 7	: 6	: 27
45-18	: 8G	: SW	: 3	: 1	: 84
	: 8G	: SE	: 5	: 6	: 64
34-47	: 6F	: NE	: 1	: 3	: 66
43-34	: 5F	: SE	: 9	: 8	: 102
55-35	: 5E	: NE	: 19	: 19	: 211
56-57	: 7E	: NE	: 4	: 5	: 65
57-20	: 8E	: NE	: 2	: 7	: 55
	:	:	:	:	:
12-13	: 4H	: NE	:	:	: 16
11-12	: 3H	: SW	:	:	: 2
10-11	: 2H	: SW	:	:	: 5
9-10	: 1H	: NW	:	:	: 1
	: 1H	: SW	: 4	: 3	: 7
42-43	: 4G	: SW	: 11	: 4	: 38
	: 4G	: SE	:	: 2	: 7
53-54	: 3E	: NE	: 2	:	: 18
	: 3E	: SE	: 1	: 1	: 6
6-52	: 1E	: SE	: 4	: 3	: 34
	:	:	:	:	:
61-60	: 4D	: NE	: 5	: 2	: 40
62-61	: 3D	: NE	: 1	: 2	: 9
63-62	: 2D	: SE	: 7	: 1	: 48
4-64	: 1C	: NE	: 3	: 9	: 61
66-67	: 4C	: NW	: 2	: 1	: 25
73-72	: 4B	: NW	: 8	: 7	: 54
75-74	: 2B	: SW	: 1	: 4	: 101

TABLE 3

SURVEY PLOTS
ORGAN PIPE NATIONAL MONUMENT

June 1941

Plot No. 1/	Height Class											
	Block:	Class I 2/	Class II	Class III				Class IV				
		H	H	H	OD	RD	I	H	OD	RD	I	
I	1	2	1	2	1			2	1			
	2	3	2		1			1				
	3	1										
	4	1		2				1				
	5		1		1							
Totals		7	4	4	3			4	1			(23)
II	1	4						2				
	2	1	4	3				4	2			2
	3	2	1	4				6				
	4	1		6	2			8				1
	5	5		4	1			6	1			
Totals		13	5	17	3			26	3			3 (70)
III	1	5	6	2	3			9	1			
	2	2	8	2				8	1		2	
	3	4	4 (1-I)	1	2			7	1			
	4	4	2	1				3	1		1	
	5		1	3				7				
Totals		15	22	9	2			34	4		3	(92)
IV	1	4	1	1	1	1		4			1	
	2	1	1	3				1				
	3			1								
	4	1	3	2	1							
	5	7	4		1							
Totals		13	9	7	3	1		5			1	(39)
V	1	6 (1-RD)	3	1		2		1				
	2	7	2									
	3	4	2	1				1				
	4	1	1	1	2							
	5	11 (1-RD)	2 (1-OD)									
Totals		31	11	3	2	2		2				(51)
VI	1	3	1		1			4			1	
	2	7	3	1	1			1				
	3	4	1		2			3	1			
	4	7						2	3			
	5	1	2					2				
Totals		22	7	1	4			12	4		1	(51)

TABLE 3 (Contd.)

Survey PlotsOrgan Pipe National MonumentJune 1941

		Height Class													
Plot No. 1/	Block:	Class I 2/		Class II		Class III			Class IV						
		H		H		H	OD	RD	I	H	OD	RD	I		
VII	1	1				2	3			2					
	2	8		2		2	1			5	1				
	3	8													
	4	4					2			2					
	5	3		1		2				2		1			
Totals		24		3		6	6			11	1	1	(52)		
VIII	1	1				1				4	1		1		
	2	2		2		1	1			7			1		
	3	5				1					1				
	4	11		6 (1-I)		1				7					
	5	5		2		4									
Totals		24		11		8	1			13	2		2 (66)		
Grand Total Cacti														(444)	

1/ Plots are 1000' by 100' wide and cacti were tallied by blocks 200' long and 100' wide.

2/ Cacti were divided into four classes: Class I, cacti from 6" to 3', Class II, 4' to 8'. Class III, 9' to 16', and Class IV, 17' and over. In addition, classes III and IV were subdivided into H-healthy, OD-old dead, RD-recently dead (not over three years), and I-visibly infected.

TABLE 4

SURVEY PLOTS
CRENN PIPE NATIONAL MONUMENT

Plot No.	Total	Class III						Class IV					
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
		Cacti	OD	OD	RD	RD	I	CD	OD	RD	RD	I	I
I	23	3	13.0	0	0.0	0	0.0	1	4.3	0	0.0	0	0.0
II	70	3	4.3	0	0.0	0	0.0	3	4.3	0	0.0	3	4.3
III	92	5	5.4	0	0.0	0	0.0	4	4.3	3	3.2	0	0.0
IV	39	3	7.7	1	2.6	0	0.0	0	0.0	1	2.6	0	0.0
V	51	2	4.0	2	4.0	0	0.0	0	0.0	0	0.0	0	0.0
VI	51	4	7.8	0	0.0	0	0.0	4	7.8	1	1.9	0	0.0
VII	52	6	11.5	0	0.0	0	0.0	1	1.9	1	1.9	0	0.0
VIII	66	1	1.5	0	0.0	0	0.0	2	3.0	2	3.0	0	0.0
Totals	444	27	6.1	3	0.7	0	0.0	15	3.4	8	1.4	3	1.1

Of the 444 cacti, 33.6% were in Class I, 16.3% were in Class II, 19.6% were in Class III, and 30.5% were in Class IV. 37.3% of the plants were healthy.

OD - Old Dead (plants dead over three years)

RD - Recently Dead

I - Infected

TABLE 5

TIME OF YEAR LESIONS ORIGINATE
BASED ON OBSERVATIONS OF SAMPLE PLOTS A, C, D, E, F
SAGUARO NATIONAL MONUMENT

July 1941 to January 1942

<u>No. and % of Lesions Originating</u>			
<u>May - July</u>	<u>July - Oct.</u>	<u>Oct. - Jan.</u>	<u>Total</u>
127	58	16	201
63.1%	28.9%	8%	100%

TABLE 6

LONGEVITY OF LESIONS
BASED ON OBSERVATIONS OF SAMPLE PLOTS A, C, D, E, F
SAGUARO NATIONAL MONUMENT

July 1941 to January 1942

Percent of Lesions Remaining Active		
Less than	2 - 5	5 - 8
2 months	months	months
51	34	2

TABLE 7

SAMPLE PLOTS
CHUGCHILIP NATIONAL MONUMENT

Plot Number:	Total Cacti:	Dead		Dying		Diseased	
		No. :	%	No. :	%	No. :	%
I O.P.	7	0	0.0	0	0.0	1	16.6
II O.P.	18	2	11.1	0	0.0	1	5.5
Totals	25	2	8.0	0	0.0	2	8.0
III S.	20	6	30.0	0	0.0	0	0.0
IV S.	45	0	0.0	0	0.0	1	2.2
V S.	72	6	8.3	0	0.0	0	0.0
Totals	137	12	8.8	0	0.0	1	.7

TABLE 8

ABNORMAL TEMPERATURES AT TUCUM, ARIZONA

From 1938 to 1941

Jan '38 - '40 - '41 very warm
Feb '39 very cold
 '41 very warm
Apr '41 very cold
 '39 very warm
May '40 very warm
June '41 very cold
Nov '38 very cold
 '39 very warm
Dec '39 very warm
 '40 very warm
 '41 (?) cold (no report)

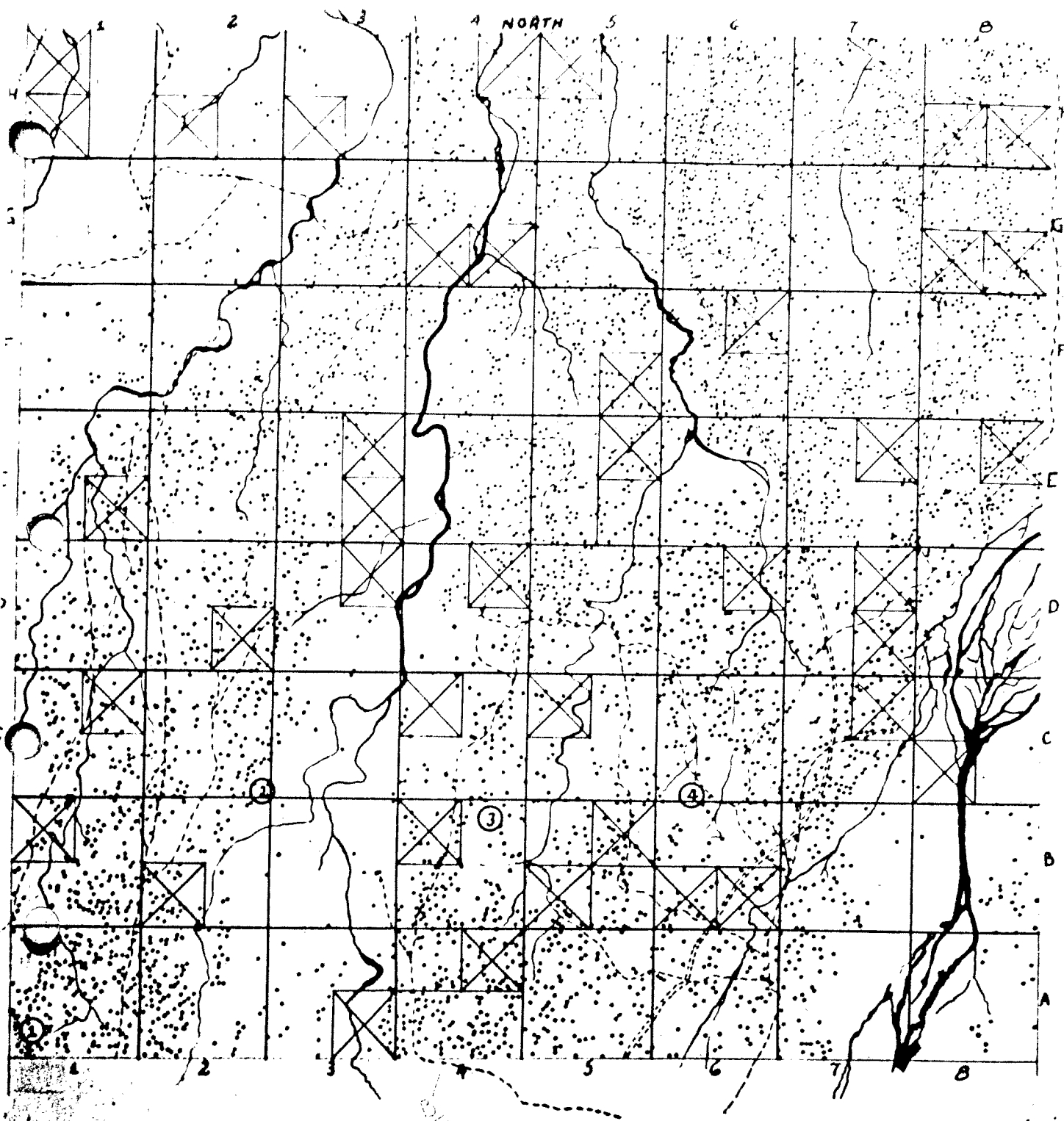


Figure 1. Map of the experimental section at Saguaro National Monument (S17,R16E,T14S) traced from an aerial photograph made at 5000 ft. by courtesy of the U.S. Army Air Corps. Rows A to D incl. were given a sanitation treatment, rows E to H inclusive were not treated.

Legend



Random 2 1/2-acre survey plot of April, 1941.



Location of burial pit for sanitation work.

- Saguaros visible on air photograph.

Permanent Sample Plots:

A = S1 35 B = S1 A4

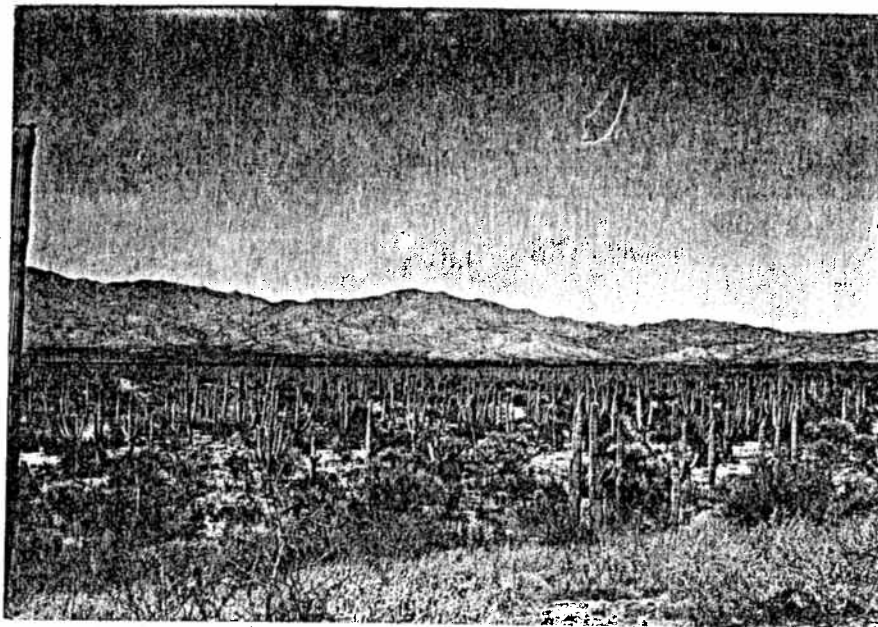


Figure 2. General view of the saguaro forest on the experimental area (Section 17).

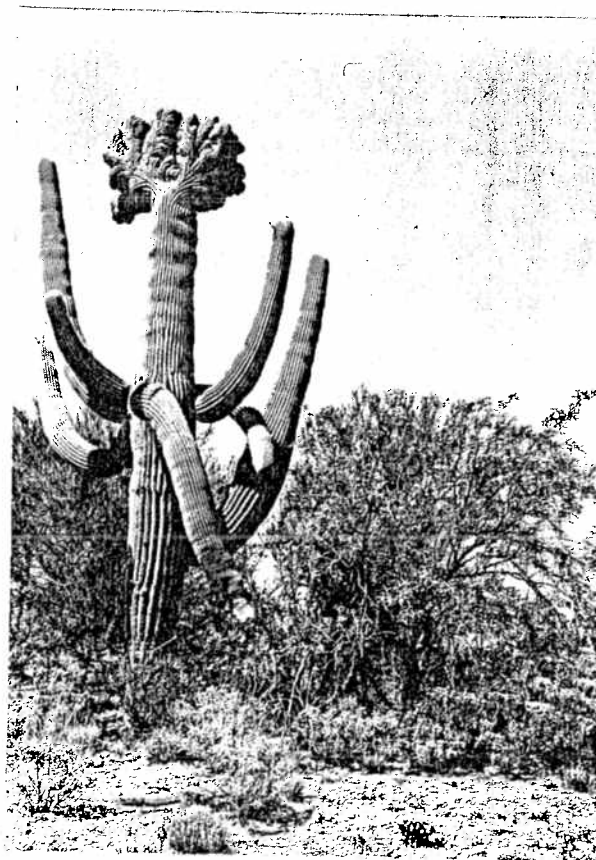


Figure 3. One of the unique features of the old stands on Saguaro National Monument is the large number of interesting fasciated specimens.



Figure 6. Diseased cacti were dumped into pits about 9 feet deep. As the sections accumulated they were treated with a solution of para-dichlorobenzene in kerosene, covered with canvas tarps for several days, and finally covered with at least a foot of earth. At the close of the operation all dirt was backfilled over the pit.

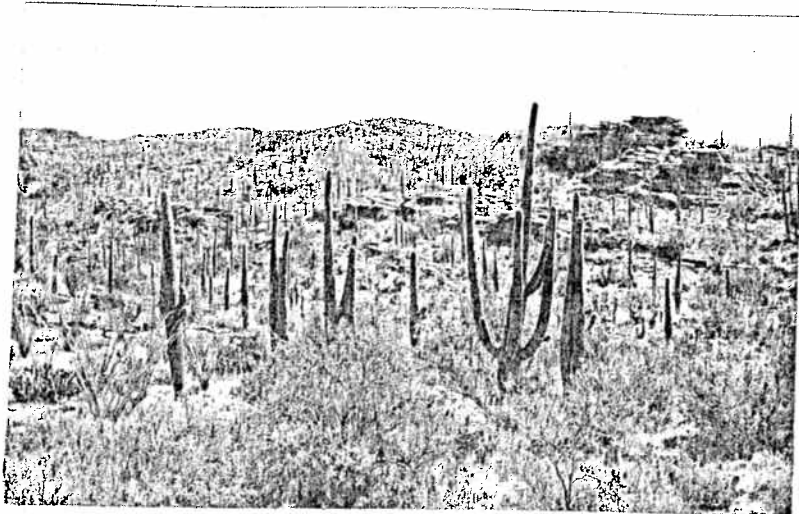


Figure 7. Sample Plot C located on a rocky hillside. All other plots were located in terrain similar to that shown in Figure 2.

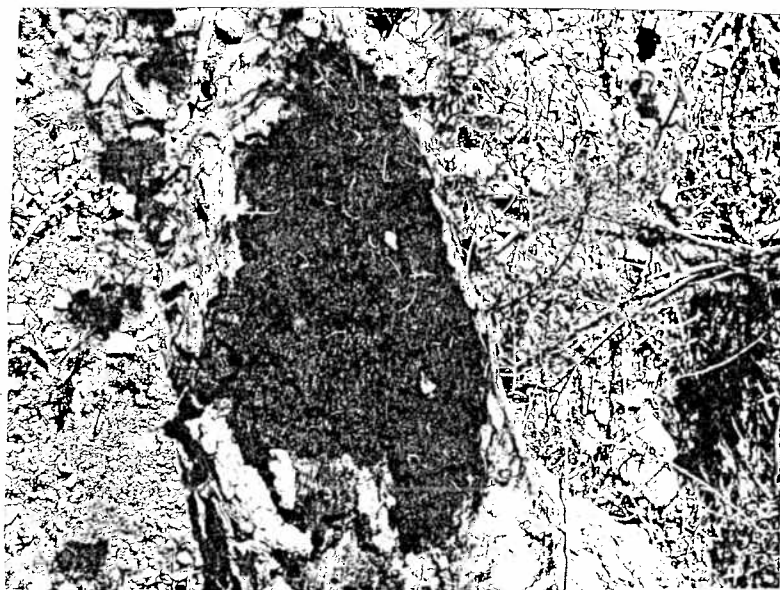
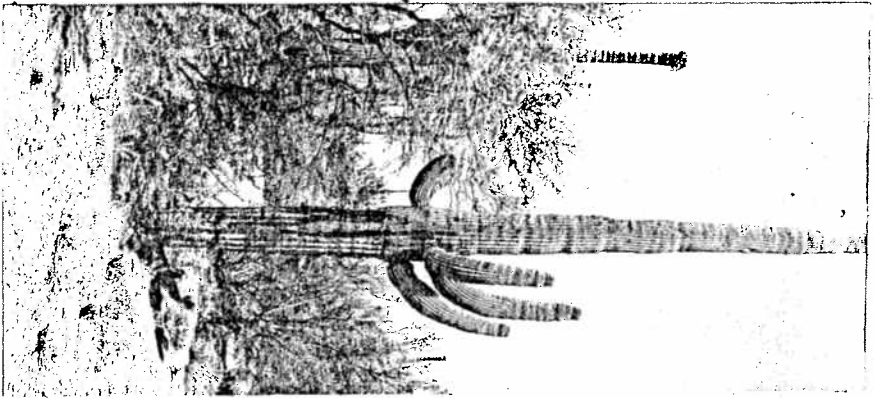
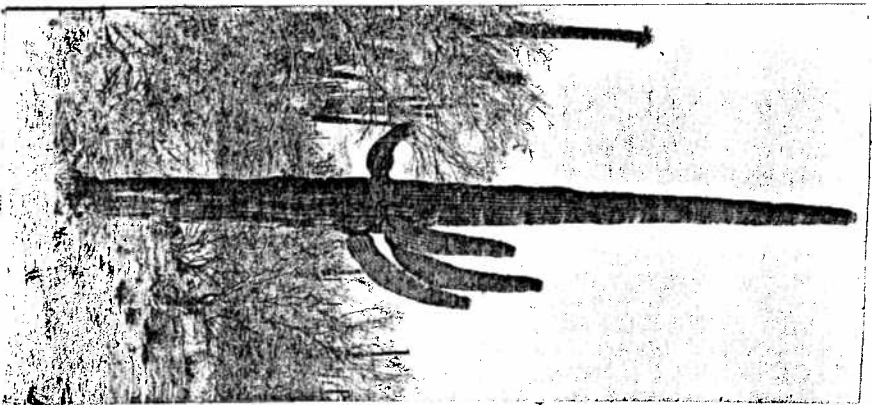


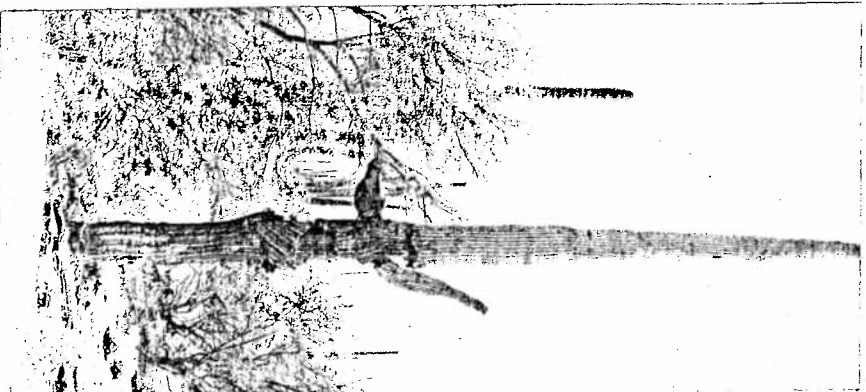
Figure 8. Rot pocket on main (exposed) root of a large saguaro.



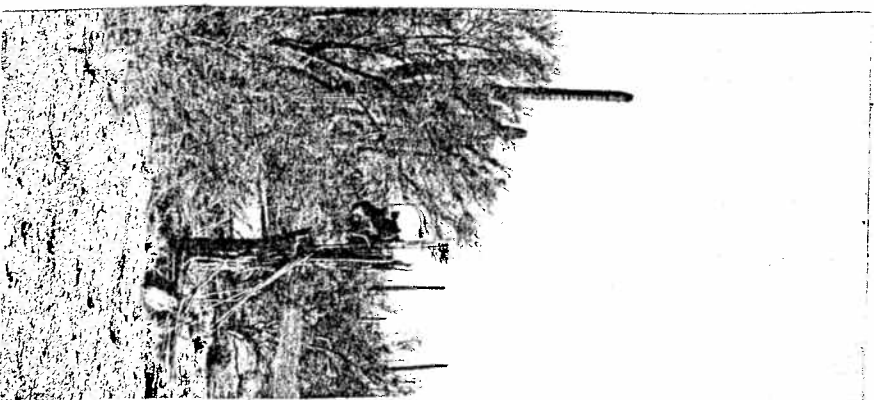
June 12, 1941



July 9, 1941



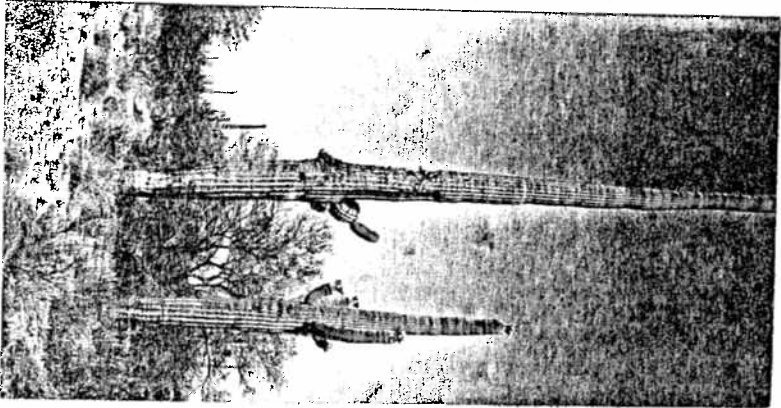
Aug. 25, 1941



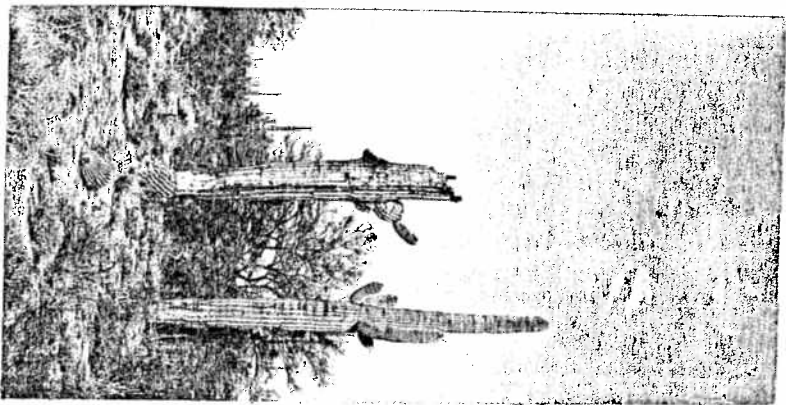
Oct. 22, 1941

Figure 9. Progressive stages of bacterial rot.
Plot A.

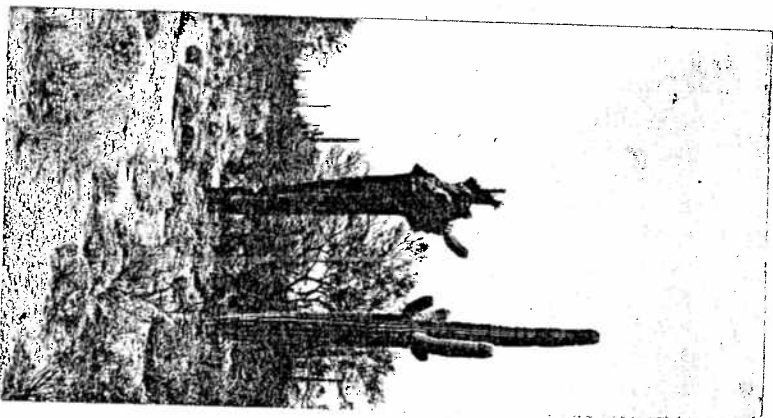
Cactus No. E5-274



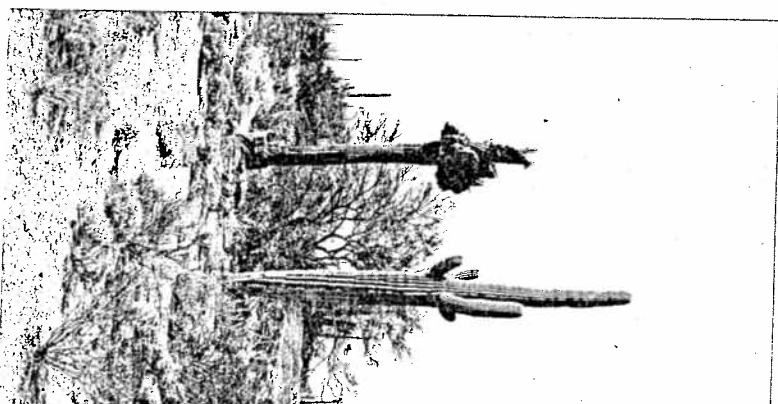
June 12, 1941



July 22, 1941



Aug. 25, 1941



Oct. 22, 1941

Figure 10. Progressive stages of bacterial rot.
Cactus No. A4-128
Plot B.

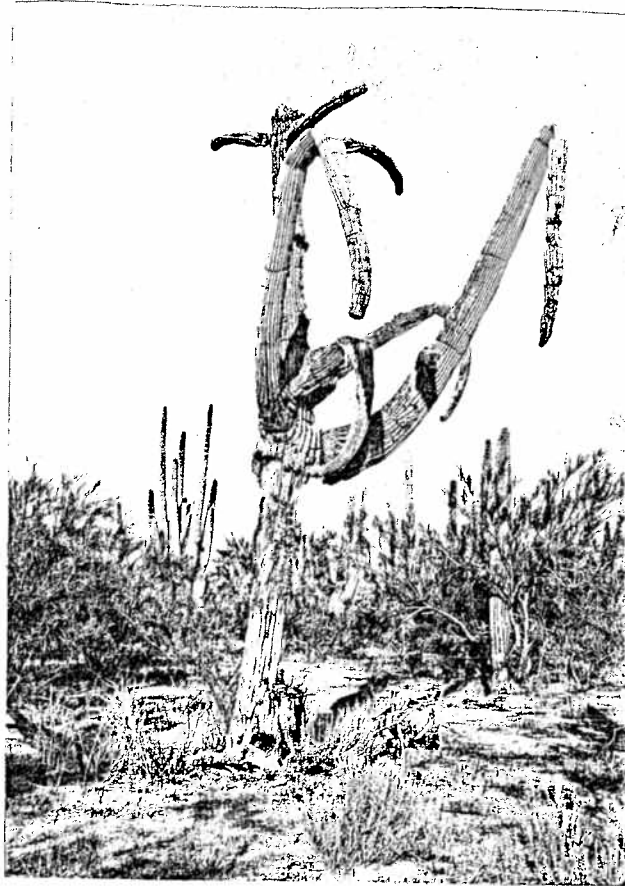


Figure 11. This once fine specimen has probably not been dead more than six months

ALBUQUERQUE, N. M.

Office Memorandum • UNITED STATES GOVERNMENT

TO : Custodian, Saguaro National Monument,
Route 2, Box 544, Tucson, Arizona

FROM : L. S. Gill, Senior Pathologist, Division of
Forest Pathology, Albuquerque, N. M.

SUBJECT: Analysis of Mortality in Saguaro Cactus.

DATE: September 4, 1946

Enclosed is a progress report of the subject title which is forwarded for your information and comment.

The primary purpose of the experiment on which the report is based was to determine the effectiveness of sanitation measures for controlling loss from bacterial rot in giant cactus. The war prevented us from carrying out the experiment according to the original design which called for the removal and destruction of diseased plant material for several successive years. It is therefore impossible to determine the true effects of the original sanitation work though there are indications that it may have held the disease in check to some extent. These indications are discussed in the section of the report entitled "Effect of Sanitation."

Since the report was prepared there are even stronger indications that the organism responsible for the rot is capable of killing plants regardless of their vigor once it has been introduced. This point is discussed in the section entitled "Mortality in Relation to Size."

L. S. Gill

Enc.