

Annotated bibliography of sources to aid in future long-term saguaro monitoring.

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for

Saguaro National Park (SAGU)
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Alcorn, S.M., and C. May. "Attrition of a saguaro forest." Plant Disease Reporter 46, No. 3: 1962

This, one of S.M. Alcorn's long-term surveys from the original USDA "cactus disease investigations" site (section 17) of Saguaro National Monument took place from 1942-1961. The data he recovered led to some rather grim conclusions, including the proposition that due to such low recruitment levels the "cactus forest" area may vanish by the year 2000. *The plots sampled in this study may be the same as the plots that have continued to be sampled (through 2006) by Tom Orum and Nancy Ferguson (Available in NRBIB-SAGU).

Boyle, Alice M. "Further studies of the bacterial necrosis of the giant cactus." Phytopathology, Vol. XXXIX, No. 12, pp. 1029-1052. December 1949.

Boyle's study ran from 1942 through 1945 and her results were published in this report. Her work focused largely on the spread of necrosis. Her findings from those years lead her to conclude that the disease was spread through the larvae of a common moth, *cactobrosis fernaldialis*. Due largely to these findings the sanitation methods at the nearby USDA experimental test area were deemed illogical and were subsequently abandoned (Available in NRBIB-SAGU).

Duriscoe, D. M., and S.L. Graban. "Epidermal browning and population structure of giant saguaro cactus (*carnegiea gigantea*) in saguaro national monument, Arizona." Eridanus Research Associates: California, 1991.

The Duriscoe study is, of course, the foundation of future long-term saguaro plot studies. It provides the framework to which all subsequent studies (including the Turner-Funicelli 2000 survey) should adhere. It gives plot locations, graphs and diagrams as well as a host of data for both the 200 x 200m and 10 x 10m plot sizes. The attachments (i.e. overhead quadrangle maps, hand-drawn plot maps and data, and color slides of individual saguaros) are also vital to future study. This study was repeated in 2000 by Saguaro

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National Park (e.g., by Turner and Funicelli) and the park intends to repeat it every 10 years (Available in NRBIB-SAGU).

Funicelli, C.S., P.J. Anning, and D.S. Turner. "Long-Term Vegetation Monitoring at Saguaro National Park: a Decade of Change." November 2000.

This, the final report of Funicelli and Turner's resurvey of the original 45 10 x 10m "ecological" Duriscoe plots gives an in-depth analysis of the growth, recruitment and mortality of not only saguaros but also all coexisting vegetation within each plot. Report contains large, fold-out color maps of each plot as well as data and GPS coordinates of each plot corner (Available in NRBIB-SAGU).

Funicelli, C.S., and D.S. Turner. "Relocation and restudy of historic saguaro plots at Saguaro National Park." July 2002.

This study is the resurvey of the initial saguaro plots established by the Gill and Lightle in 1941/42 and studied again by Steenbergh and Lowe in 1975. Eleven (11) plots of 100 x 200m (2-ha) were surveyed in both districts. Plots were relocated from a map drawn by W.F. Steenbergh and studied from February 2001 through May 2002. GPS devices were used to mark the plot corners. Using the 1941 data as a foundation, saguaro density and recruitment data was collected. This study contains raw data, maps and diagrams from the 2002 survey (Available in NRBIB-SAGU).

Gill, L.S., and P.C. Lightle. "Analysis of mortality in saguaro cactus: a progress report on the experimental area (section 17 R16 ET14S) established in the Saguaro National Monument in 1941 for the study of bacterial rot." Saguaro National Monument, 1946. [in] Steenbergh, Warren F. "USDA bureau of plant industry, cactus disease investigations: reports and related correspondence, 1941-1951." National Park Service, 1980.

This is a 1946 progress report of the original USDA experimental test area. The overall findings were that the mortality rate seemed to be decreasing since the study began five years prior. However, due to the slow growth and reaction of the saguaro it was still unclear if this decrease was due in part to the sanitation measures of 1941/42. Long-term predictions were unclear due to the brevity of the survey and the uncertainty of the downward mortality trend (Available in NRBIB-SAGU master file and in SAGU-RMD library under: QK 495.C115 U72).

Gill, Lakes S. "Mortality in the giant cactus at Saguaro National Monument, 1941-1950." Saguaro National Monument, 1951. [in] Steenbergh, Warren F. "USDA bureau of plant industry, cactus disease investigations: reports and related correspondence, 1941-1951." National Park Service, 1980.

This 1951 report is a 10-year resurvey of the original USDA plot in section 17. A 60-acre section was carved out of the center of the original 640-acre study area. This resurvey of stem rot found that the condition is positively associated with height (and therefore presumably age). This, combined with the general absence of stem rot on younger specimens (those less than 12 feet in height), led to the consensus that bacterial necrosis is not in a position to obliterate the saguaro as a species (Available in NRBIB-SAGU master file and SAGU-RMD library under: QK 495.C115 U72).

McAuliffe, Joseph R. "Case study of research, monitoring, and management programs associated with the saguaro cactus (*Carnegiea gigantea*) at Saguaro National Monument, Arizona" USDI, 1993.

This report is a must read for any and all persons involved with saguaro monitoring. It provides a detailed history of the founding of the park and the earliest accounts of saguaro monitoring. Most importantly it illustrates the progression of the surveys' focal points since the preliminary cactus disease investigations up through the Duriscoe & Graban saguaro census/epidermal browning assessment. Also pay special attention to the literature cited, for this report contains a great deal of useful sources. (Available in NRBIB-SAGU).

McGregor, S.E., S.M. Alcorn, and G. Olin. "Pollination and pollinating agents of the saguaro." *Ecology* 43: 259-267, 1962.

This source is quoted widely in Joseph McAuliffe's "Case study of research, monitoring, and management programs associated with the saguaro cactus (*carnegiea gigantea*) at saguaro national monument, Arizona". It discusses pollination methods and the fertility and recruitment nature of saguaro cacti. It also case studies the differing pollinating effects of bats, doves and bees as included in McAuliffe's report (Available in NRBIB-SAGU).

Mielke, James L. "Summary of results of control experiments on saguaro disease, saguaro national monument." July 12, 1944.

This brief report gives a follow-up account of the progress on the USDA experimental test area (section 17). It provides some of the preliminary census results that reinforced the positive effect of the sanitation measures from 1941/42. It also represents some of the initial findings that bacterial necrosis is spread through moth larvae and that many lesions can be cured simply by removing the directly infected area, thereby allowing the cactus' natural healing processes to take over (Available in NRBIB-SAGU master file and SAGU-RMD library under QK 495.C115 U72).

Mitich, L. W., and J.C. Bruhn. "The saguaro—a bibliography." Supplemental Volume of the Cactus & Succulent Journal, pp. 56-64. 1975.

This source is similar to Steenbergh's "the saguaro giant cactus: a bibliography." It provides an extensive list of sources, many of which are listed in Steenbergh's. Sources from authors such as Alcorn, Lightle, Hastings, Shreve, Gill and Steenbergh are listed here. Several sources from this very bibliography are listed in Mitich's as well (Available in NRBIB-SAGU).

Niering, W.A., R.H. Whittaker and C.H. Lowe. "The saguaro: a population in relation to environment." American Association for the Advancement of Science. Science 142 (3588): 15-23, 1963.

This study is unique in that there are three distinct study areas. One runs along the Mt. Lemmon highway in the Catalina Mountains. Another lies along the western slopes of the Tucson Mountains, and the third being along the lower western slopes of the Rincons. The study identified numerous threats to the saguaro's survival, among these grazing, rodent tunneling and frost. Grazing was determined to be the most pervasive threat and was blamed for poor soil quality and saguaro recruitment levels in the Catalinas and Rincons (Available in NRBIB-SAGU).

Orum, Thomas V. "Report on the long term saguaro mortality study, Saguaro National Monument, Rincon Mountain Unit, section 17." December, 1991.

This report summarizes Tom Orum's findings on saguaro density, mortality and recruitment up through 1991. His findings come from a set of six 10-acre plots in the "cactus forest" region of the park which have been studied on a near annual basis since their establishment by L.S. Gill and P. Lightle in 1941. These are the same plots studied throughout the later fifties and sixties by S.M. Alcorn (Available in NRBIB-SAGU).

Shreve, Forrest. "The rate of establishment of the giant cactus." The Plant World. Vol. 13, No. 10, 1910.

This, regarded as Shreve's most significant work, provided initial data on saguaro growth, recruitment and density. His study area on Tumamoc Hill near present-day TMD represents the first noted in-field saguaro monitoring survey. His findings were also first to suggest a fall in the rate of establishment of the saguaro (Available in NRBIB-SAGU).

Shreve, Forrest. "The influence of low temperatures on the distribution of the giant cactus." The Plant World Vol. 14: 136-146, 1911.

This survey, performed in 1910-1911, provides some of the initial data on frost and freezing temperatures as principle limiting factors of the saguaro. Shreve's surveys took place in both the laboratory as well as in the field. His study location was the saguaro population near Tumamoc Hill, just east of present-day TMD. This is regarded as his second most important study, second only to "The rate of establishment." What's amazing about these two studies is how despite nearly a century of technological, scientific and botanical advancement, their conclusions remain true and insightful.

Steenbergh, W.F., and C.H. Lowe. "Critical factors during the first years of life of the saguaro (*cereus giganteus*) at saguaro national monument." *Ecology* 50: 825-834, 1969.

This study examines the terrain habitats of saguaros from rocky slopes to flat desert scrubland in the "cactus forest" region northwest of Tanque Verde ridge in RMD. It focuses on the germination, survival and growth of young saguaros from February 25, 1965 through November 13, 1966. This study discusses how terrain plays a major role in the success of saguaro populations and gives a map of plot locations within RMD (Available in NRBIB-SAGU).

Steenbergh, Warren F. "The saguaro problem: information, misinformation and desperate enterprise." [in] "Proceedings of the meeting of research scientists and resource managers of the National Park Service." pp. 2-15, April 1970.

This source is valuable not only because of its focus on recommendations for saguaro survival, but also because of the extensive bibliography that follows. This report from 1970 encapsulates the early years of permanent saguaro plot studies in that it mentions the alarming population deterioration of the saguaros since the days of the first surveys in 1941/42. No data, photos or direct plot information is included, but Steenbergh gives an interesting layout of the evolutionary focus of saguaro surveys (Available in NRBIB-SAGU).

Steenbergh, Warren F. "USDA bureau of plant industry, cactus disease investigations: reports and related correspondence, 1941-1951." National Park Service, 1980.

These "cactus disease investigations" were a major reason for the establishment of the permanent saguaro monitoring plots in 1941. This study began with the plot staking in September 1941 and ran through March 1942. The main objective was to determine whether or not bacterial rot could be deterred by sanitation measures which in this case manifested itself in the removal, fumigation and burial of infected cacti. The test area was a 640-acre section that comprised "section 17" of present-day RMD, including the "cactus forest" area. Detailed records of the 10-acre plots were kept, most of which are included in this study. The survey was continued through 1945 by James L. Mielke. (1 copy available in the SAGU-RMD library: QK 495.C115 U72)

Steenbergh, W.F., and C.H. Lowe. "Ecology of the saguaro I: the role of freezing weather in a warm-desert plant population" in "Research in the parks: transactions of the national park centennial symposium." National Park Service Symposium series 1, 1976.

This, the first of three (3) installments on saguaro ecology by Steenbergh and Lowe provides an in-depth account of the effects of inclement weather (particularly frost) on the saguaro population in saguaro national park. It provides graphs, diagrams and photos. This installment covers mortality and recruitment differentiations from various microhabitats such as flat versus rocky-sloped terrain, north versus south facing slopes and the effects of nurse plants (Available in NRBIB-SAGU).

Steenbergh, W.F., and C.H. Lowe. "Ecology of the saguaro II: reproduction, germination, establishment, growth, and survival of the young plant." National Park Service Scientific Monograph series number eight. Washington, D.C.: 1977.

This second installment builds upon the first, discussing the reproduction and germination tendencies of saguaro cacti, focusing primarily on the age before first reproduction. This is unique because the study goes beyond the borders of the park and includes surveys of saguaros coexisting with other cacti species throughout the Sonoran Desert. This source is quoted widely in Duriscoe and Graban's 1990 survey as well as in McAuliffe's case study report. It also offers management recommendations to park service management for improved care and protection of the park's saguaro population. (Available in NRBIB-SAGU and SAGU-RMD library).

Steenbergh, W.F., and C.H. Lowe. "Ecology of the saguaro III: growth and demography." USDS, National Park Service Scientific Monograph Series number seventeen. Washington, D.C.: 1983.

This installment "...provides, for the first time, comparative information on growth and age relationships and related population parameters for saguaros growing in three different climatic environments" (Steenbergh, xiii). This book also discusses the relationship between climatic factors and saguaro growth rates and population structures and dynamics. It contains photos, data and diagrams regarding saguaro population structure and growth rates. This source is quoted widely in both the Duriscoe and McAuliffe reports (Available in NRBIB-SAGU and SAGU-RMD library).

Steenbergh, Warren F. "Lightning-caused destruction in a desert plant community." *The Southwestern Naturalist* 16 (3&4): 419-429, 1972.

Discusses the effects of lightning strikes on the saguaro population of the Tucson Mountains. Plot analysis from Sept-Oct, 1969. Following a major storm on September 4, an area .5 miles northwest of TMD headquarters was surveyed. Twenty-two (22) 0.1-ha plots were developed and saguaro density and biomass information was collected. Survey contains photos and in-depth characteristics of lightning-struck saguaros. Plot data is also included (Available in NRBIB-SAGU).

Steenbergh, Warren F. "Rejection of bacterial rot by adult saguaro cacti (*cereus giganteus*).¹" *Journal of the Arizona Academy of Science*, vol. 6, pp. 78-81, 1970.

This brief and "unintentional study" of bacterial rot rejection commenced in the winter of 1968. Vandals at the Loma Verde Picnic Area in the "cactus forest" region of Saguaro National monument stabbed seven saguaros with a wooden saguaro rib. Bacterial necrosis soon set in and the plants were monitored from February 8, 1968 through June 19, 1968 at one to three week intervals and then at less frequent intervals through February 1969. Six of the seven injured plants recovered fully and the one mortality could not be definitely blamed on the sustained injuries (Available in NRBIB-SAGU).

Steenbergh, Warren F. "Saguaro population study plots at saguaro national monument: 1941-1975." June 30, 1986.

This source gives a brief history/outline of the permanent plot studies performed in both districts of the monument during the aforementioned years. It also gives a synopsis of the information collected in several of the studies as well as plot notes, maps and data from surveys. The data here is by no means complete or conclusive and is intended rather as an overview of the studies performed throughout the years (Available in NRBIB-SAGU).

*This source refers predominantly to Steenbergh's 1975 resurvey of the original six 5-acre Gill and Lightle permanent plots from 1941. It contains the passage "Original field notes and data, and computer tabulated data from these surveys is on file at the Cooperative National Park Services Resources Studies Unit at the University of Arizona." This location is now the Western Archaeological Conservation Center (WACC) in Tucson, Arizona.

*These plots were resurveyed by Funicelli and Turner in 2002. See [Funicelli, C.S., and D.S. Turner. "Relocation and restudy of historic saguaro plots at Saguaro National Park." July 2002.]

Steenbergh, Warren F. "The saguaro cactus: a bibliography." USDI, National Park Service, Western Region. San Francisco: 1974.

This source catalogs an extensive list of sources dealing with the saguaro cactus. Nearly every facet of the plant is covered here, including but not limited to population density, disease, mortality, recruitment, fertility, biological systems, range, terrain and germination. Several sources included in this very bibliography are included as well in Steenbergh's. Many of these sources are located at NRBIB-SAGU or at the Western Archaeological Conservation Center (WACC). Others still are not owned or held in reserve by the park service. This bibliography can also be found in Appendix II of "Ecology of the Saguaro II" (Available in NRBIB-SAGU).

Stone, C.P and E.S Bellantoni, eds. "Proceedings of the symposium on research in Saguaro National Monument." June 1992.

This source compiles a wide array of research in the park. It includes R. Turner's report on saguaro density, mortality and recruitment in both of his two permanent plots. This source also includes reports on epidermal browning, impact of livestock and grazing on saguaro establishment, "ecophysical and toxic elements" of the saguaro, and others. This source is also not limited to only saguaros. Included reports concern pollen harvests, bee colonies, urbanization, impact of exotic birds and air quality (Widely published).

Turner, D. S., and C. S. Funicelli. "Ten-Year Resurvey of Epidermal Browning and Population Structures of Saguaro Cactus (*Carnegiea Gigantea*) in Saguaro National Park, Arizona." August 2000.

This, the final report of Funicelli and Turner's ten-year resurvey of the original 45 200 x 200m Duriscoe-Grabau plots represents the first structured resurvey of plot lands in the park. The encouraging insight gained through this 2000 survey largely quelled the concern that saguaro populations in the park were dying out. This report and the included attachments provide a nearly identical compliment to the Duriscoe study. Report contains maps of plots, GPS coordinates, data and a CD copy of the report (Available in NRBIB-SAGU).

Turner, R.M., S.M. Alcorn and G. Olin. "Mortality of transplanted saguaro seedlings." Ecology 50, No 5, 1969.

This, one of Turner and Alcorn's more elaborate studies ran for ten years from July 1957 to the same month in 1967. This study focused on the survival of young transplanted saguaros due to the realization that the saguaro population at the Monument was deteriorating. Over 1,800 saguaros of 5 and 15cm tall were planted in plots within the original USDA experimental test area (section 17). Some plots were shaded, caged and watered while others were left unaltered. In 1963 Alcorn added plots of different altitudes in three distinct terrains to see how recruitment fared when compared to results from the typical desert lowland (Available in NRBIB-SAGU).

Turner, Raymond M. "Long-term saguaro population studies at saguaro national monument." [in] Stone, C.P and E.S Bellantoni, eds. "Proceedings of the symposium on research in Saguaro National Monument." June 1992.

This report summarizes Ray Turner's findings from his two 9.2-acre permanent monitoring plots. One was located in each district of the park. These plots represented two of ten plots established by Turner and Hastings in the late 1960s throughout southern Arizona and into Sonora, Mexico. These plots were studied up through 1989 and provided some of the initial encouraging growth and recruitment data that proved the saguaro population was making a surprising comeback (Available in NRBIB-SAGU).

Wilder, C.S., and J.C. Wilder. "Re-establishment of saguaros." Southwestern Monuments Special Report, number 26. National Park Service, pp. 153-160. 1939.

This study was one of the first recorded and published plot surveys in the monument. Although it was not intended for long-term monitoring, it does give some of the first insight into saguaro population density in relation to terrain habitat and the role of nurse plants in the establishment of young saguaros (Available in NRBIB-SAGU).

Other Sources

Day, Gerald I. "Climate and its relationship to survival of young javelina." Research Division, Arizona Game and Fish Department. August, 1977.

This study of Javelina is unique in that it compares the pervasiveness and survival of the animals in regards to precipitation and temperature in not only Saguaro National Park but also the Tortolita Mountains and the Three-Bar Wildlife area. This report contains a summary of ten years of monitoring data on javelina in the Rincon Mountain District. We have not yet located the transects or the original data (Melanie Bucci is working on this) (Available in NRBIB-SAGU).

Fishbein, Mark, V. Steinmann, S. McMahon, and A. Johnson. "Flora of Chimenea canyon, Saguaro National Monument, east unit: based on surveys in April-May 1994." Draft: May 18, 1984.

This list of flora, although appearing unofficial and unaccompanied by any field data, may act to assist future surveys of the Chimenea canyon region by providing a basis of floral species. This list may also be compared with current findings to understand population, extent, mortality and recruitment information on various plant species (Available in NRBIB-SAGU).

M'Closkey, Robert T. "Niche separation and assembly on four species of sonoran desert rodents." University of Chicago. *American Naturalist* Vol. 112, pp. 683-694, 1978.

Although this study has little to do with saguaros, it does focus on rodent/mammalian life of the saguaro scrubland habitat. The field work consisted of twenty one (21) survey plots (30 x 30m) to study floral, faunal and topographic diversity. Numerous trappings and markings of desert animals were made as well as vegetation transect analysis, including saguaros (Available in NRBIB-SAGU).

M'Closkey, Robert T. "Temporal and spatial patterns of seed collection in four species of heteromyid rodents." 1980.

This study is similar to M'Closkey's "Niche Separation" plot surveys of 1975 in that information gathered from these rodent trappings was used in both surveys. This study also includes two more trappings in 1976 and 1977 to explore more deeply the microhabitat and seed use/distribution of coexisting desert rodents (Available in NRBIB-SAGU).

Turner, Ray. Repeat photos, saguaro plot studies-RMD.

This folder of scanned images is of poor quality, but the digital images on [U (swann):/images/repeat-history/turner] may be influential in guiding future long-term plot surveys. They will also showcase the immense change the landscape has undergone since the Turner-Hastings studies began in the early 1960s.