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Testing the Baobab's Mettle: An Evaluation of the Sustainability and Economic Potential of Harvesting Adansonia digitata

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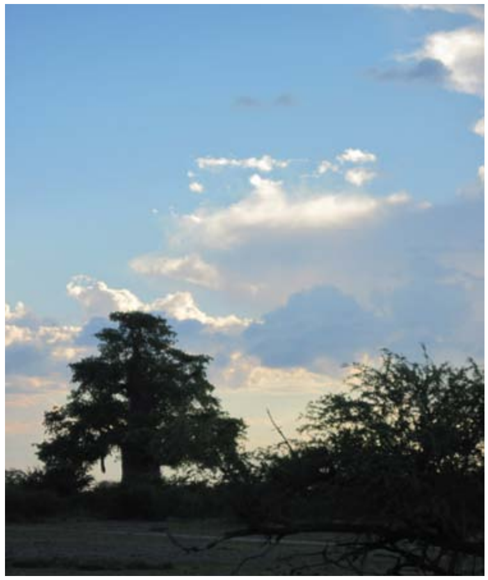
Testing the Baobab's Mettle: An evaluation of the sustainability and economic potential of harvesting *Adansonia digitata*



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Submitted in partial fulfillment of the requirements for Botswana: Conservation and Ecology, SIT Study Abroad,

Fall 2009

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Cover photo: Baobab number 6 at sunset

Abstract:

In light of southern Africa's growing population and economy, as well as the increasing international market for *Adansonia digitata* products, it seems important to ascertain whether or not rural baobab harvesting is having an impact on the health of the trees and whether it could be improved or expanded to increase benefits to communities. This study focused on 72 trees in and around the village of Gweta, Botswana, examining local usage and harvesting practices and exploring their correlations with the health of the trees.

Results suggest that baobab harvesting in its current form is detrimental to the trees' health and may not be sustainable in the long term, given Botswana's rapid population growth. Human usage was linked to increased branch loss and to the severity of infection by rot fungi. However, recovery from these effects seems possible with time, meaning that altering harvesting practices and techniques could result in a marked improvement in both the trees' health and their yield. This would protect the baobabs—and their important ecological niche along with them—while increasing long-term benefits to the community.

Further research is necessary, but this study's preliminary recommendation is to refine methods of fruit, bark, and root removal and to promote the protection of a set percentage of the area's trees in order to facilitate recovery. If these goals can be met, it may be possible to sustainably expand Gweta's local baobab usage or perhaps even to delve into larger economic ventures.

Acknowledgements:

I would like to take this opportunity to acknowledge everyone who helped make this study possible. First off, many thanks to my advisor, Dr. Moffat Setshogo, for his knowledge and his willingness to share it, despite my frequent and lengthy periods of being unreachable.

Much affection and gratitude also goes out to the staff of Planet Baobab, whose kindness, company, and midnight visits to my tent with bags of sugar and canned food kept me going through my two weeks of practical isolation.

Also instrumental to my study was the staff of the Harry Oppenheimer Okavango Research Center in Maun. The use of their facilities proved indispensable, and their generosity will not be forgotten.

Finally, I want to express my heartfelt appreciation for my guide in Gweta, who willingly put up with my transience, my overzealous data collection, and many long days spent trekking from one big tree to the next. His knowledge of baobab crafts and recipes was invaluable and will continue to see good use in the future.

Introduction:

The African baobab, *Adansonia digitata*, is one of the most unique plant species alive today. Indigenous to Africa, it has spread around the world and now covers a range from the Caribbean to East Asia. With a diameter of up to 15 meters, it is the world's broadest tree, and has the second largest overall volume in Africa. In addition, it contains between 40% and 75% water, classifying it as the largest succulent on the planet. Age estimation is difficult at best, but the baobab is thought to live anywhere from 1000 to 4000 years. Because of its size, age, and unique appearance, it takes a central part in the legends and superstitions of southern Africa. Even more important than this, however, is the role it plays in the day-to-day lives of the people who live around it, through its usefulness as a source of food, medicine, and crafts. The fruit pulp contains six times the vitamin C of an orange, more calcium than milk, numerous antioxidants, and a high concentration of vitamin A. The leaves are also high in vitamin A, can be eaten as a green, and are used medicinally to treat fevers and diarrhoea. The bark can be used to make rope, strong and durable enough for use in fishing nets, and for numerous applications in traditional medicine, including the treatment of malaria. The roots also serve medicinal purposes and produce a red dye when boiled (www.underutilized-species.org).

The baobab is capable of recovering fully from extensive damage, including fire, ringbarking, and root removal, any of which would kill most other trees. Because of this remarkable resilience, humans have been able to harvest all parts of the tree with impunity for many generations, and they have come to depend on it as a reliable supplier of nourishment and materials year after year. Houses, jails, post offices, and bars have even been built inside the trunks, and hollow trees are sometimes used to store water in remote areas (Roodt 1996). All of these uses have become ingrained into the cultures of southern Africa, and are central to the livelihoods of many in the region. However, as populations expand and infrastructures develop, pressure on heavily harvested species like the baobab is increasing considerably. In Botswana specifically, the population has more than doubled since the country gained independence in 1966 and is now approaching two million. In addition, in late 2008 the European market was opened to baobab products, and in September of 2009 the United States Food and Drug Administration followed suit, allowing the sale of baobab fruit as a health product and food ingredient (www.npicenter.org). The potential benefit of these new markets to southern Africa has been estimated at $1B US per year, and eight sub-Saharan countries, including Botswana's neighbor Zimbabwe, have already begun ramping up their export of baobab products (SCUC, 2006). Tourism, and with it the demand for traditional products such as those derived from the baobab, is also on the rise, having overtaken agriculture as Botswana's second most important source of income. These new revenue flows could be a tremendous boon to both the country and the region's economy and development, but at the same time could present problems for the baobab, which is already coming under pressure on a local level from population increases.

Troubles have already arisen in Namibia, Botswana's western neighbor, in the form of a fungal infection (suspected to be of the *Botryosphaeria* genus) that causes rot in the limbs and trunk, eventually killing the tree in severe cases. The fungus tends to infect trees that have been ringbarked by elephants, which eat baobab bark for its high water and fiber content. This trend is typical of rot fungi; infection usually occurs when preexisting damage to the bark leaves the inner trunk vulnerable. The University of Pretoria's 2006 study of this problem intended to investigate trees in Botswana as well, but because of logistical difficulties this segment of the survey was largely omitted (de Meyer, 2006). This leaves open the possibility that damage arising from baobab consumption, human and otherwise, is occurring in Botswana. Few, if any, studies have attempted to address this lack of information in any significant detail. Because of these facts and the increasing demand for baobab products, which could open the door to greater economic development in rural areas, it seems necessary that a more thorough evaluation of baobab harvesting in Botswana be carried out.

- *Study Area*

This study aims to investigate the sustainability and potential for expansion of baobab harvesting in and around the village of Gweta, Botswana. Gweta, population roughly 5000, is situated on the northern outskirts of the Makgadikgadi pans in the country's Central District and is one of the main entry points for tourists visiting the pans. Two lodges, Gweta Lodge (in the village itself) and Planet Baobab (5 km to the northeast) make up the majority of the tourism industry there. Aside from this, the village's economy is based almost exclusively on cattle farming. It is fairly isolated; the nearest village is thirty kilometres away and the nearest major population center, Maun, is over two hundred kilometres to the west.

The study took place in an area of roughly 15 square kilometres, bordered to the north by highway A3 and to the west by Gweta and its main connecting road to the highway. These borders were chosen because of the scarcity of baobab trees beyond them. The eastern and southern boundaries were largely undefined; because of the relative density of the baobab populations there, every effort was made to survey all known trees in those directions. Planet Baobab, where I was based for the duration of the study period (November 11th through 22nd, 2009), is situated in the northeast corner of the study area. The lodge, opened for business in 2000, contains an area of approximately 0.25 square kilometres and is surrounded by an electric fence. It includes a restaurant, bar, pool, seven guest huts, campsites, and staff housing, all constructed near or around the lodge's sizable population of baobab trees. Because of the proximity to the village, wildlife in the study area is very limited. Aside from occasional incursions by elephants, jackals, and small antelope, very few wild animals populate the region. Most of the area is used as rangeland for the village's cattle and donkeys. As such, it is impacted fairly heavily by humans, as will be detailed later in this report. Appendix A contains a map of the study area, with all trees outside of Planet Baobab lodge labelled.

- *Study Objectives*

In order to achieve the study's stated goal of evaluating the sustainability and expandability of Gweta's baobab harvesting, I set out with a number of smaller objectives. These objectives are as follows:

1. Discover the ways in which baobab trees and baobab products are used in the village.
2. Determine how, where, and to what extent these products are harvested.
3. Determine, with as much precision as possible, the number and location of baobab trees in the study area.
4. Find out information on the history, particularly the harvesting history, of any tree or group of trees that is of particular importance to the village.
5. Survey as many trees as possible in and around Gweta and evaluate their health using as many indicators as possible.
6. Determine whether or not there is any correlation between harvesting and declines in tree health.
7. Evaluate the economic and ecological implications of any such correlation.

8. Attempt to suggest ways in which harvesting practices can be altered in order to protect the area's baobab population while maximizing benefits to the community.

Materials and Methods:

Before actual data collection on individual trees began, it was necessary to ascertain the location and usage of the various baobabs around Gweta. Because of this, the first step in the study was to obtain the assistance of a local resident, who became my guide and informant for much of the study period. Most of the information on harvesting practices, history, and use of baobab products came first from this guide and was later confirmed through informal interviews with other locals and through literature consultation when possible. No formal, pre-planned interviews were conducted either with my guide or with others. Preliminary information pertaining to tree numbers, locations, and uses was gathered prior to beginning the study proper. After data collection began, I obtained descriptions of harvesting practices and histories of individual trees from my guide as we came across them. Later conversations with guides at Gweta Lodge and Planet Baobab confirmed and elaborated upon the information he gave me.

Once the rough locations of the baobab populations near Gweta had been obtained, the survey of individual trees began. Because baobabs are generally the largest and most distinctive form of vegetation in the Makgadikgadi, finding them, especially with the assistance of a knowledgeable guide, was fairly simple. Starting from Planet Baobab, we walked progressively farther each day in the direction of the main stands of trees, collecting data on each one we came across before moving on. Once the biggest groups had been surveyed, we combed other areas to collect data on scattered stands and individual trees. The entire study area was covered several times over in this manner. One day was also reserved for a tour of the trees in and immediately outside the village proper. The numbering of the trees in Appendices A and B reflects the order in which they were encountered. Young trees were numbered separately and surveyed slightly differently because of the differences in morphology and prevailing health characteristics between them and mature trees.

When a mature baobab was encountered, its height and width were approximated and notes were made of any distinguishing characteristics, including the presence of birds' nests, ladders for fruit harvesting, traditional medicine sites, local nicknames, and any folklore associated with the tree. A description of the crown was also recorded based on shape and leaf/branch density. Shape was classified as either broad (crown was wider than it was tall) or conical (taller than it was wide) and was recorded purely for ease of identification later. Crown density was on a relative scale and divided into four categories: sparse, sparse-medium, medium, and dense. These were later assigned numerical values 1 through 4 respectively. Enough trees were observed before data collection started to make a consistent relative scale possible.

After the description was recorded, the extent of human impact was measured. Bark and root removal were the main factors taken into account. These were ranked in one of four categories for each tree, depending on how much of the tree's circumference (for bark) or exposed roots had been removed or damaged: light (up to 25% of bark or roots), medium (25% to 50%), heavy (50% to 75%), and severe (75% to 100%). For data analysis purposes, these categories were assigned numerical values 1, 2, 3, and 4, respectively. The age of the damage was also noted and assigned to one of four categories: recent (damage had yet to start healing), mid-recent (slightly healed), mid-old (mostly healed), and old (completely healed). These were again assigned values 1-4. Because elephants had also impacted some trees in the study area, the source of the damage (human or elephant) was recorded, though the two types were generally treated as equivalent.

After data had been taken on the extent of harvesting, the health of the tree was measured using three indicators: branch loss, flower density, and the presence of rot fungi. Fungal infection was in turn ranked in severity according to three commonly used indicators: black discolorations and growths on the bark, depressions in the bark, and patches of rot in the limbs (rot was only counted as fungal when coupled with the other two indicators). These three symptoms, as well as branch loss, were all ranked light to severe using the same scale as for bark and root removal. Flower density was graded on a relative scale: very low (numerical value 1), low (2), average (3), and high (4). Again, observations prior to data collection ensured a consistent scale.

For the purposes of this study, mature trees were generally considered to be those that had a width of at least 1.5m, a height of at least 10m, and a clearly developed crown. Any tree failing to meet one or more of these requirements was considered immature and recorded separately under the "young tree" category. Data for these trees was recorded in the same way as for mature ones whenever possible, but most had not developed a crown or begun bearing fruit, so these categories were often eliminated. Because most young trees had not fully leafed out, the extent of leafing was recorded where applicable. There are some exceptions to the classification criteria listed above, owing to the highly variable nature of baobab size and appearance. Because Planet Baobab has been fenced off since it opened its doors in 2000, the trees inside have been relatively protected for nearly a decade. Because of this fact, the baobabs within the lodge were used as a basis for comparison with recently impacted trees in the study area, helping to judge the baobabs' ability to recover and the time required to do so.

Results:

- *Local Usage*

Before and during formal data collection, information was gathered on the various uses of baobab trees so as to better understand the local population's relationship with them. Over the course of this study, I learned through informal interviews with various Gweta residents that baobabs are used for a wide variety of purposes. The first to be mentioned was invariably the food aspect. Baobab fruit is widely consumed in the region. It is extremely nutritious and can be eaten raw; however, the high acetic acid content can cause toothaches, so most residents prefer to mix it with water or milk and sugar, forming a pudding-like dish. The fruit can remain hanging from the trees for over a year, and if kept dry can be stored off the tree for again that long. This makes it a very reliable source of nutrition throughout the year, even if it is not a central part of the local diet. Additionally, young leaves are eaten as a spinach, and the seeds can be eaten as a snack either raw or roasted. These foods, however, are consumed much less frequently than the fruit.

Baobabs also play a role in the making of crafts, albeit a limited one. The shells of the fruit are used to make bowls, cups, and jars. When polished with sand, they can be carved or painted, and are said to keep water cool far better than glass or plastic bottles. In addition, the fibers of the inner bark can be made into rope and coarse cloth, though this practice occurs fairly rarely in Gweta and is confined mainly to the Okavango Delta, where the rope is used for fishing line and nets. The roots, when boiled, produce a red-purple dye that is suitable for dying fabric.

One of the main uses of both roots and bark, which in large part drives their harvesting, is in traditional medicine. Both are popular in Gweta for treating various problems related to fertility and menstruation. When boiled, the bark produces a bitter drink that is used to treat irregular menstrual cycles. A stronger mixture is frequently used to induce abortions early in pregnancy. Other applications include the treatment of various fevers, including malaria when conventional treatments are unavailable. Although Gweta has a fairly extensive medical center, traditional medicine is still extremely popular, especially among women, driving up the demand for baobab roots and bark. The bark is also a favorite food of elephants, especially in the dry season. They periodically make incursions into the northern parts of the study area, though their regular home range is farther to the north and east.

Another important use of baobabs requires no harvesting whatsoever. They are sometimes planted within family compounds in town, where they serve a variety of purposes. They are, of course, important as a source of fruit. Moreover, they provide excellent shade and shelter, and their large, plentiful flowers make them an ideal decorative tree. Local superstition also has it that a compound containing a baobab tree will never be struck by lightning. However, these benefits are counteracted by a fairly serious disadvantage: once the tree begins to grow large, its roots will expand significantly and cause serious damage to the compound's buildings. One compound in the village had been abandoned because of this, and in another the owners had attempted, unsuccessfully, to kill their tree before it grew too large.

- *Harvesting Techniques*

One of the most important aspects of baobab harvesting is the manner in which it is carried out. While in some areas there are specialized tools and techniques for sustainably gathering fruit and bark, the practices around Gweta are much less refined. Fruit is obtained in one of several ways. While ladders of nails or spikes are built into the trunks of the more sought-after trees, the baobab's outer bark is very smooth and slippery, making climbing hazardous at best. Villagers prefer to either knock fruit down one by one by throwing sticks and rocks or, when possible, to throw a rope around the most fruit-laden branches and simply snap the entire branch off. Both bark and roots are harvested using axes. They are simply chopped off haphazardly when being used for traditional medicine purposes, whereas when the bark is to be used for rope or crafts a rectangular strip of bark is usually removed, sometimes spanning the entire circumference of the tree (ringbarking). It is important to note that, though some of Planet Baobab's trees have undergone fruit harvesting on a regular basis, they have had cables attached to their trunks rather than spike ladders. These allow for much safer climbing while decreasing the number of nails put into the trunk.

- *Health Survey Results & Correlations*

During the study itself, 72 individual baobab trees were surveyed as described in the Methods section above. Of these, 55—39 mature and 16 young—were outside Planet Baobab, and the remaining 17—11 mature and 6 young—were contained within the lodge's fence. Of the 50 adult trees, only two (4%) had not undergone harvesting or equivalent damage, and both of these were inside fenced compounds in the village. Of the remaining trees, 45 (94%) had had their bark or roots removed by humans, and 18 (37.5%) had been damaged by elephants. The damage age was fairly evenly distributed between the four categories, old to recent. Among the 39 mature trees outside the lodge, 27 (69%) appeared to have been damaged or harvested repeatedly (i.e. the damage spanned multiple age categories). Because of the long recovery period, determining the damage duration for trees within Planet Baobab was generally not possible.

Health declines among the mature baobabs turned out to be nearly as widespread as harvesting. Branch loss was observed among 46 (92%) of the trees surveyed, and 43 (86%) displayed one or more of the indicators associated with fungal infection. Though these indicators do not guarantee the presence of rot fungus, the extent of apparent infection had a negative correlation with flower density, linking them to health declines and suggesting that they do generally represent some type of problem with the tree. In addition, fruiting bodies and mycelia were found on tree 32 in a discoloured patch of trunk around an axe wound, and appeared to be the cause of rot in that area. Similar patches, some with fruiting bodies, were observed on other trees, but no others were close enough to the ground for detailed study. This links discoloration, the most prevalent indicator, to rot fungus, suggesting that fungal infection is a justifiable assumption in trees showing the above-mentioned signs.

Picture 1. Side view of fruiting bodies and mycelia in the trunk of baobab 32.

Both the extent of harvesting and the extent of health declines varied greatly from tree to tree, making it possible to draw correlations between the two. Data analysis showed mixed results, but overall greater exploitation appeared to lead to greater health impacts. For example, Figure 1 below shows the proportion of each level of branch loss among trees in each harvesting/damage level. Though the correlation is not overwhelming, it is clear to see that medium and heavy branch loss increase with greater harvesting, while the proportions of no loss and light loss decrease along the same range.

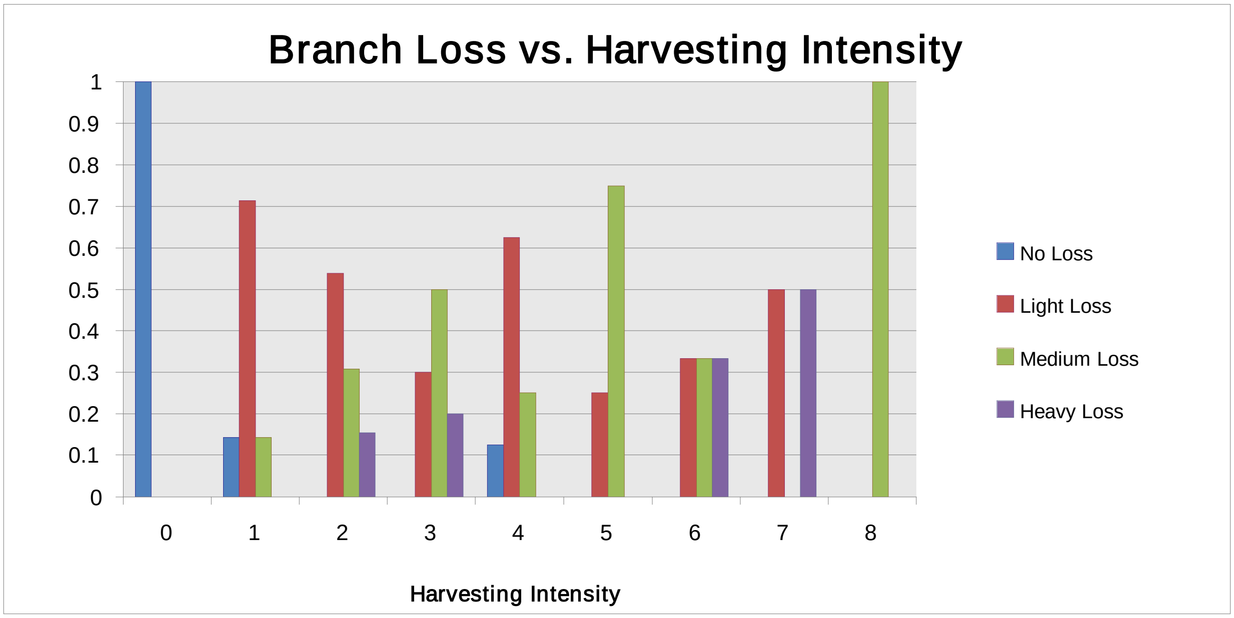


Figure 1. Medium and heavy branch loss as a proportion of the total baobab population increase with harvesting intensity. No loss and light loss show a relative decrease as harvesting increases.

There is a somewhat stronger correlation linking harvesting intensity to the apparent severity of fungal infection, as measured by the amount of discoloration, depressions in the bark, and areas of rot in the trees. Figure 2 below demonstrates this trend. It is borne out by the tendency of the trees most important to Gweta residents, such as Masukiri and Mowana Basarwa, to have the most severe infections.

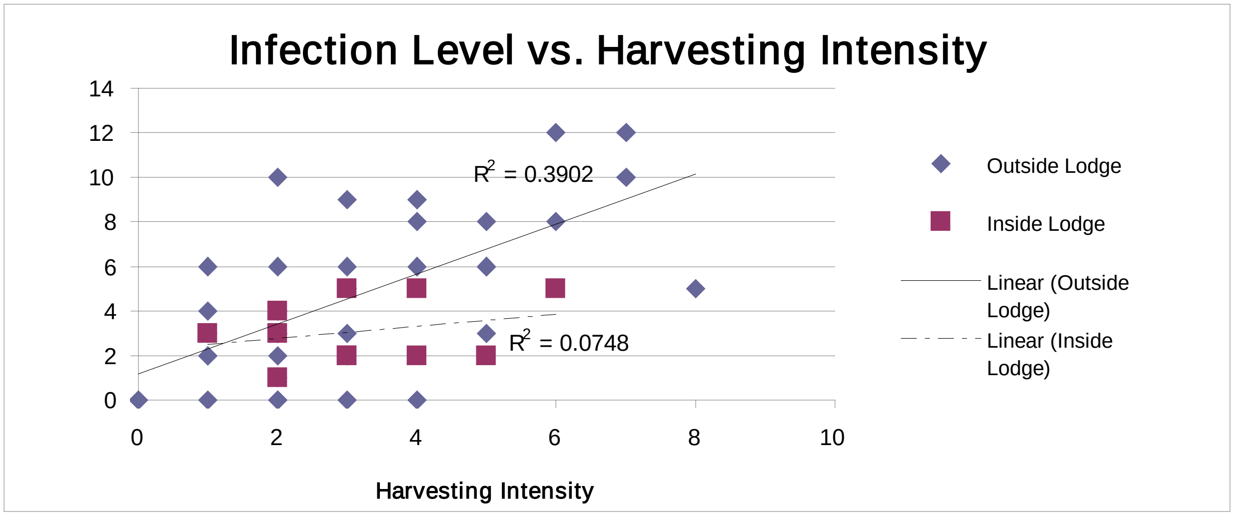


Figure 2. There is a fairly strong positive correlation between harvesting intensity and severity of infection among trees outside Planet Baobab, especially when the outlying point (8, 5) is ignored. Within Planet Baobab, the trend is also positive but is much weaker. Numerical values for the two variables were determined using the system outlined in the Methods section.

Human harvesting appears to have a pronounced effect on flower density. For trees both inside and outside Planet Baobab, greater harvesting tends to lead to declines in flower abundance. This trend is slightly stronger within the lodge but notable throughout the study area. This is a logical continuation of the tendency of harvesting to promote fungal infection, as a negative correlation was also found between infection level and flower density. Branches with rot or significant bark depressions tended to have few or no flowers on them, even if they were alive and had leaves. This led to a decline in the overall density of flowers on the tree, with severely infected trees being impacted worse than those with milder infections. Harvesting level was not shown to have an appreciable impact on crown density.

Also of note is the correlation between the duration of damage and the severity of infection. Duration of damage was measured as the number of ages of damage (old, mid-old, mid-recent, recent) that were observed on a tree. There is a marked increase in infection level as damage duration goes up, as Figure 3 shows below. This is again borne out by observations of heavily used trees such as Masukiri, which has undergone significant harvesting for a long period of time and had one of the most severe fungal infections observed during the study.

The age of damage, as opposed to the duration, appears to have a weak effect on infection level. The overall trend is for the indicators of infection to decrease slightly with older damage, but the relationship is relatively insignificant. Damage age does, however, have a strong impact on extent of recovery. Trees that had not been harvested for bark or roots recently had recovered more overall from health declines than those with newer damage. This trend is pronounced for all trees in the study area, both inside and outside the lodge.

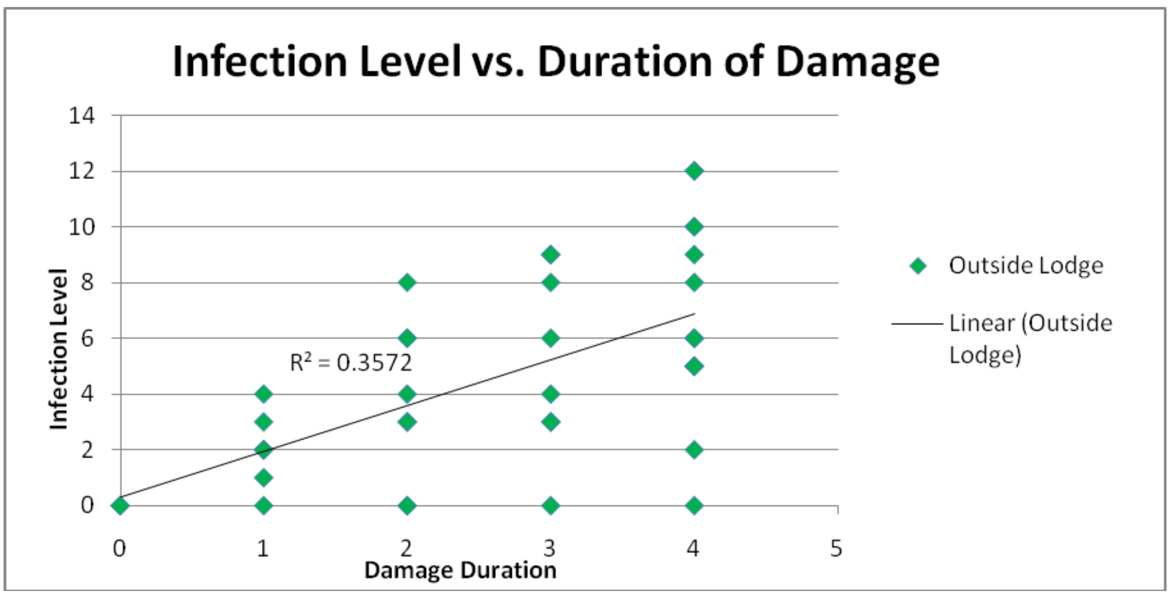


Figure 3. Damage duration appears to have a marked effect on the severity of infection, though some trees in each duration category showed no signs of fungus. Because determining damage duration with any accuracy was practically impossible within Planet Baobab, only data from trees outside the lodge is displayed.

Tree size appears to have an impact on the nature of health declines. There is a positive correlation between tree diameter and the extent of their recovery from branch loss and infection.

This trend is weak, though still observable, outside the lodge, but within Planet Baobab it is fairly pronounced. Diameter was not shown to have any significant effect on the initial level of infection.

Overall, recovery was higher inside Planet Baobab than outside, as shown in Figure 4 below. Interestingly enough, however, flower density within the lodge did not differ significantly from that outside. The numerical mean inside Planet Baobab was 2.27, representing a density of somewhere between low and average, while that outside was 2.26.

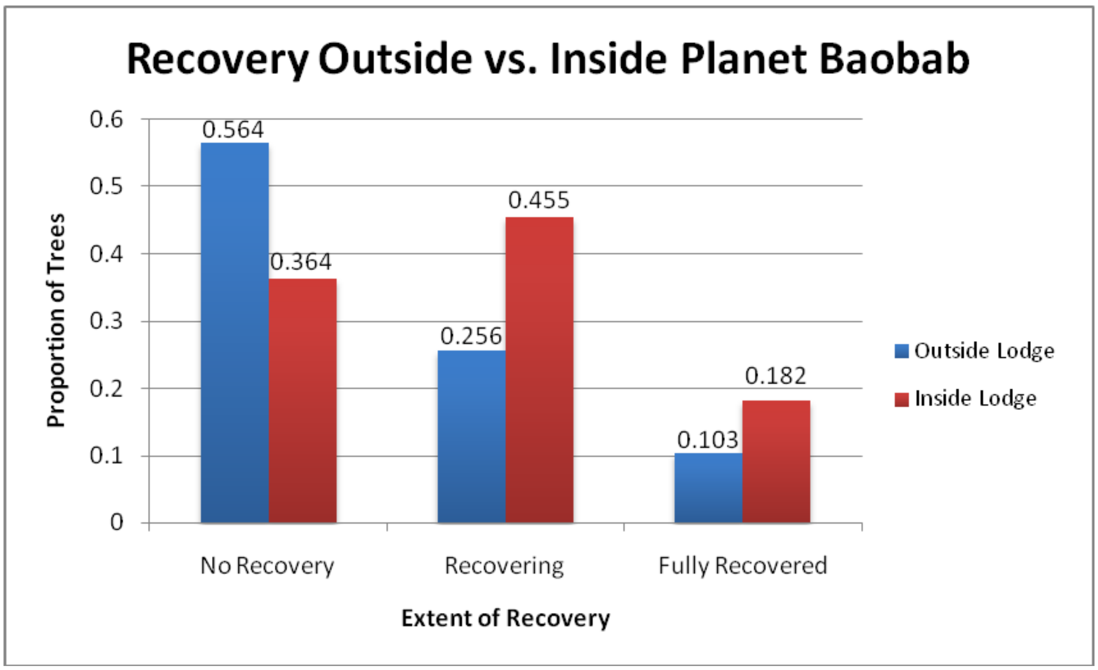
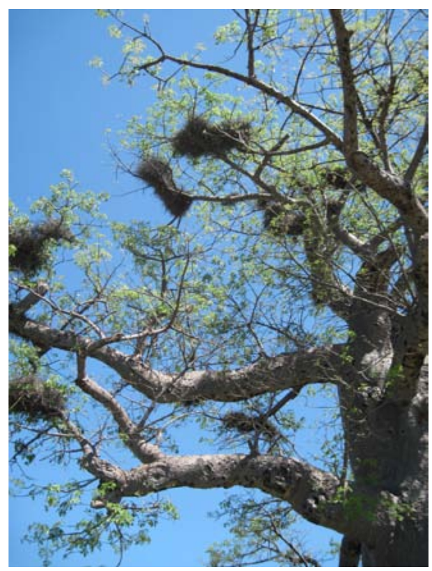


Figure 4. The proportions of recovering and fully recovered trees were higher inside Planet Baobab than outside, while the proportion showing no signs of recovery from branch loss and infection was considerably greater outside the lodge. Numerical values for proportions are displayed above their respective bars.

As mentioned above in Methods, young trees were recorded and analyzed separately from mature ones owing to differences both in morphology and in health and damage characteristics. 22 young trees were surveyed in total, both inside and outside the lodge. They spanned a large range of ages and sizes, varying in height from 1.5m to 9m. Out of these trees, 17 (77%) had suffered some type of damage, usually harvesting by humans or browsing by elephants. Four (18%) had been knocked over, presumably by elephants, and showed evidence of having been browsed since. Another four showed signs of fungal infection. All of the trees were leafing at least to some extent, and several, including one (tree PBY3 in Appendix B) that had been knocked over, had begun to flower. Young trees inside Planet Baobab appeared to be leafing somewhat later than those outside, and one tree there (PBY1) had not grown at all since it was transplanted in 2000. Seven (32%) had been severely stunted, broken, or otherwise damaged, including those that had been knocked over by elephants. Discounting the transplanted tree, young trees accounted for 29% of the overall baobab populations both inside and outside the lodge.

Baobabs appear to play a significant ecological role in that they provide the main nesting site for the red-billed buffalo weaver (*Bubalornis niger*). 34 of the 72 trees (47%), including some of the larger young ones, contained weaver nests. The nests tended to be constructed towards the ends of branches and were situated almost exclusively on the western side of the trees. The mean number of nests per tree was 5; the minimum and maximum were 1 and 13, respectively. No buffalo weaver nests were seen in trees other than baobabs. Larger baobabs also appear to support black-backed vultures; these were seen nesting in Green's Baobab, which was not included in the study because of its distance from Gweta.



Picture 2. *Bubalornis niger* nests in the branches of Mowana Basarwa (tree 34).

For a full list of results, see Appendix B.

Discussion:

The results of this study suggest that human harvesting of baobab bark, roots, and fruit is having a detrimental effect on the health of the trees. Both harvesting intensity and harvesting duration, particularly the latter, show clear correlations with the apparent severity of fungal infection, and a similar one appears to exist between harvesting intensity and branch loss. Declining flower density also seems to be linked to both harvesting intensity and severity of infection. The implications of these connections for the local community are fairly apparent. Assuming that the relationships above are valid, they show that harvesting practices at present are causing damage to the trees and will result in diminishing returns to the village over time, especially where fruit is concerned. No evidence was seen of baobabs being killed in large numbers by the health declines observed, so root and bark harvesting could presumably go on more or less unchecked, but if this leads to branch loss and decreasing flower density it will clearly impact the fruit yield to a greater and greater extent as time passes. This is already visible in trees like Masukiri, which, although its fruit is seen as the most desirable in the area, has been harvested for so long and to such an extent that it produces only a small number of flowers. It shows signs of severe fungal infection throughout its trunk and limbs and is experiencing considerable branch loss. This is a common situation among the most heavily exploited trees in the area and, assuming that this study's results are correct, could become prevalent if harvesting of other trees continues to grow.

As regards recovery, there is a strong connection between the age of harvesting damage and the extent to which the trees have recovered from branch loss and infection. Tree diameter also seems to have a considerable effect on recovery. These trends suggest that baobabs, especially older and larger ones, can live up to their reputation for resilience and rebound from the health declines caused by human exploitation if given time. This is supported by data from the Planet Baobab population, which, after nearly ten years of protection, seems to be recovering much more as a whole than the population outside the fence.

Given the number of trees surveyed, the likelihood that these correlations appeared due entirely to chance or experimental error is fairly low. However, the data, especially where the Planet Baobab population was analyzed independently, would certainly be strengthened both by the presence of more trees and by a suitable control population. A true control group was not possible in this study because nearly every tree in the study area had been harvested to some extent. The two mature trees that had been left unscathed were not suited to be a control because of their relative youth, the fact that they had been planted, tended, and raised by townspeople, their position on private property, and the absence of other, similarly unaffected trees. The lack of a control group meant that judging which health indicators were natural and which were truly indicative of damage was difficult at best. With no healthy basis of comparison, each tree had to be judged either on the percentage scale outlined in Methods or simply by contrasting it with the population's average. This made data interpretation difficult largely because of the inconsistent nature of baobabs. No two trees are alike; even the fruit varies tremendously in taste from tree to tree. Their shapes, sizes, and crown structures can be completely different, even in trees of roughly the same age. This makes it difficult to judge, based purely on visual observation, which discolorations, flower and crown density changes, and depressions were caused by differences in harvesting intensity. Similarly, some branch loss is a natural part of the baobab's life cycle, especially during dry weather. Though this problem was mitigated by the fact that the trees usually do not naturally lose limbs during the wet season when they have flowers or fruit, it still confounds any effort to reliably determine just how much branch loss is to be expected in a healthy tree. Were there an undamaged control group present, it would have been easier to determine the healthy norms for the various indicators used, which would in turn have made data more reliable. However, despite the absence of a control, the correlations determined by this experiment should still be valid, since they were drawn using a large number of subjects, variables, and indicators but still point consistently to the same conclusion. The data's precision as regards the severity of human impact and the strength of the correlations could be improved, but the broad trends it shows should hold true.

Conclusions:

It is fairly obvious that baobab harvesting in and around Gweta is far from perfect. It is likely to be causing damage to the trees, which will continue and probably worsen as long as practices stay the same. At the moment, fruit yields are almost certainly declining as a result of human exploitation. In the face of a growing human population, pressure on the trees will increase, and as a result the benefits they provide to the community will gradually wither away. If pushed farther, even the trees themselves could begin to be killed as has happened with fungus-infected baobabs in Namibia. Even a plant as hardy as the baobab cannot hold out forever.

At present, trees do not appear to be being killed as a result of human activities around Gweta. This is due in large part to their impressive regenerative abilities, which allow them to heal their bark within a period of 6-10 years (SCUC, 2006) and appear to be putting the protected baobabs in the lodge on the path to recovery after nearly a decade of relative isolation. This suggests that a change in harvesting practices now could allow the baobabs to recover, eventually bringing fruit yields back up to their former levels. A change of this sort would thereby benefit both the trees and the community.

The ecological implications of a shift towards more sustainable harvesting are not inconsiderable. At the moment, buffalo weavers are threatened by branch loss, which can and does cause their nests to drop from the trees. It has been shown that decreased exploitation leads to decreased branch loss; therefore, it stands to reason that better harvesting practices would serve to protect the main—if not the only—local nesting site of an important bird species.

One of the main motivations for carrying out this study was the recent opening of American and European markets to baobab products. Among the project's goals was determining the potential for expansion of Gweta's baobab harvesting, both for economic and subsistence purposes. As explained above, any expansion of local usage would most likely be unsustainable without an accompanying shift in harvesting practices. Such a change could potentially also open up a path to economic development. This study found 39 mature, fruit-bearing trees that were accessible to the village. Given the efforts made to cover every tree possible, it seems reasonable to assume that no more than 50 such trees exist in close proximity to Gweta. Baobab fruit sells for roughly US $6.40 per kilogram on the international market (SCUC, 2006). Assuming that the villagers would receive the full sum of this revenue, 50 trees producing 100 fruits per year, each weighing 0.2 kg, would bring in US $6400 annually. The revenue, fruit numbers, and fruit weight used in this calculation are all generous estimates. In a village of around 5000, a maximum gain of $6400 per year is considerable, but the benefits would come at the cost of using the entire baobab harvest for export. In addition, the infrastructure and bureaucracy needed to go about such a project would have to be set up, an undertaking with little if any precedent in the fairly secluded village. Gweta does, however, have easy access to a major highway. This could make the endeavour possible, but only with a great deal of coordination and planning.

While obtaining the management and the quantity of baobab products needed for a successful export business might be difficult for a village like Gweta, there is a somewhat more realistic option for economic expansion in the form of cultural tourism. Planet Baobab is a very successful lodge that bases much of its business on the novelty of baobab trees; however, beyond the existence of the trees themselves, baobabs play a fairly minimal role in the local tourism industry. If products like fruit, cups, and jars were to be marketed, if demonstrations of baobabs' uses in traditional medicine were made available, or even if simple tours of the area's most notable baobabs, such as Mowana Basarwa, were given, this could open up an opportunity to move away from the system of enclave tourism so often practiced in the Makgadikgadi and bring income directly to the community itself. A more sustainable harvesting system would still be needed to facilitate this expansion of the local baobab industry, but the pressure increase on the trees would likely be manageable in the long run.

Recommendations:

Because of the limitations inherent in this study, further research is highly recommended. It is especially important to determine the identity of the rot fungus described in this report and to reassess its prevalence based on a more thorough understanding of both the fungus itself and of healthy *A. digitata* populations. A more thorough evaluation of the Gweta baobabs' economic potential is also in order.

The preliminary results obtained by this study suggest that an overhaul of baobab harvesting practices in Gweta would be prudent. An easy change would be to abandon the practice of breaking off fruit-laden branches and instead to use tools, such as the long, bladed poles used in other regions, to harvest the fruit.

A somewhat more difficult alteration would be to implement a system by which some trees would be protected and allowed to recover. Access to a certain proportion of the population would have to be denied for a predetermined period of time. Based on the data from the trees within Planed Baobab, ten years would be the minimum duration of protection needed to allow full recovery. The protected area, which would ideally encompass 25% or more of the population, would be shifted to cover a different set of trees after each recovery period. In addition, constant protection should be given to all young trees, as they seem to suffer the most from human harvesting and are already under considerable pressure from elephants. Over time, these regulations would minimize the overall damage to the area's baobabs and improve their health as a whole.

Should these improvements in sustainability be made, it would appear that there is some potential for baobab-related economic expansion. An export business would likely be too ambitious at this point in time, but Gweta's status as a main entry point to the Makgadikgadi salt pans makes cultural tourism a fairly easily accessible form of revenue. If a trust or community-based natural resource management program could be set up in the community and could gain the cooperation of the local lodges, baobabs and baobab products could provide the novelty needed to make it a successful endeavor. As mentioned above, further research is recommended to determine whether such a program would be advisable and, if so, how the people of Gweta should go about establishing it.

Works Referenced:

"*Adansonia digitata*." Global Facilitation Unit for Underutilized Species. <http://www.underutilized-species.org/species/species_details.asp?id=25>

"Baobab Fruit Gets Green Light for Entry into the United States." Phyto Trade Africa, 9 September 2009. <http://www.npicenter.com/anm/templates/newsATemp.aspx?articleid=24937&zoneid=5>

De Meyer, Elsie. *Baobab Health Survey in Botswana and Namibia*. University of Pretoria: Pretoria, South Africa, 2006. <http://www.fabinet2.up.ac.za/cthb/baobab_health>

Pakenham, Thomas. The Remarkable Baobab. Weidenfeld & Nicolson: London, 2004.

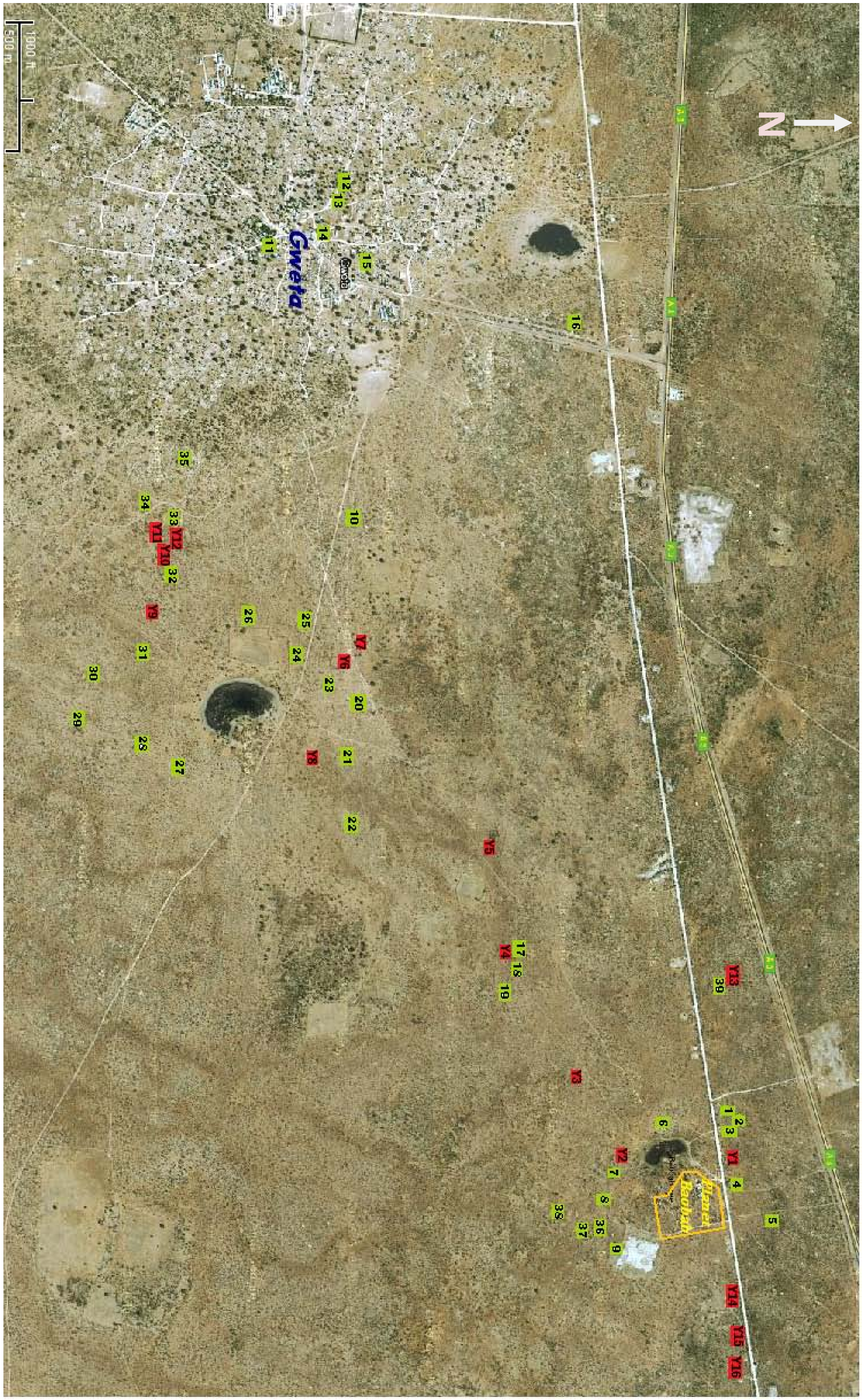
Roodt, Veronica. Trees and Shrubs of the Okavango Delta. Shell Oil Botswana (Pty) Ltd: Gaborone, Botswana, 1998.

SCUC (2006), Baobab Manual, Field Manual for Extension Workers and Farmers, University of Southampton, Southampton, UK. <http://www.discoveringbotswana.com/baobab.pdf>

Ian Sinclair, Phil Hockey, and Warbick Tarboton. Birds of Southern Africa. Princeton University Press: Princeton, NJ, 2002.

Appendix A:

At right is a map of the study area, with the baobabs surveyed outside of Planet Baobab lodge labeled. Mature trees are shown in green, young ones in red. Planet Baobab can be found in the northeast corner of the map, Gweta in the west.



Appendix B:

Below is the full set of data collected over the course of the study. Tree dimensions are given in the format Width x Height. Widths are accurate to within ±0.5m, heights to within ±2m, with accuracy increasing for smaller trees. Unless otherwise mentioned, health effects described occurred throughout the tree's crown.

Tree	Description	Harvesting	Health	Notes
1	3m x 10m Broad, sparse medium crown	Medium bark removal: human + elephant, mid-old to mid-recent Light root removal: human, old	Recovering from heavy branch loss Low flower density No discoloration/depressions/rot	
2	3.5m x 12m Broad, medium crown	Severe bark removal: elephant, old to recent Light root removal: human, old to recent	Medium ongoing branch loss, heaviest in lower crown Average flower density Medium discoloration and depressions	
3	3m x 12m Conical, sparse medium crown	Light bark removal: human, old Heavy root removal: human, old to mid-recent	Light ongoing branch loss Very low flower density Heavy discoloration and depressions	6 buffalo weaver nests
Y1	1.5m x 9m Conical, medium crown	Light bark removal: elephant, mid-old Small 2nd trunk knocked down by elephants	No branch loss Average flower density Light discoloration	
4	2.5m x 12m Broad, medium crown	Light bark removal: human + elephant, old to mid-old	Light ongoing branch loss Average flower density Medium discoloration, light depressions	9 buffalo weaver nests
5	3m x 13m Broad, sparse medium crown	Light bark removal: human + elephant, old to mid-old	No branch loss Average flower density No discoloration/depressions/rot	4 buffalo weaver nests
6	5m x 22m Conical, medium crown	Severe bark removal: human + elephant, old to mid-recent Light root removal: human, old	Recovering from medium branch loss, heaviest in lower crown Average flower density Light discoloration	7 buffalo weaver nests
7	3m x 12m Conical, sparse crown	Heavy bark removal: human + elephant, old to recent Heavy root removal: human, old to recent	Heavy ongoing branch loss Low flower density Severe discoloration, depressions, and rot	
Y2	0.5m x 3m	Knocked over by elephants	Apparently recovering; some leaf growth	
8	4m x 12m Broad, medium crown	Light bark removal: elephant, mid-old Light root removal: human, mid-old	Recovering from light branch loss Average flower density Medium discoloration	4 buffalo weaver nests
9	3m x 13m Conical, sparse crown	Light bark removal: human + elephant, old to mid-recent Light root removal: human, old to recent	Heavy ongoing branch loss No flowers Heavy discoloration, depressions, and rot	2 buffalo weaver nests
10	4m x 15m Conical, sparse medium crown	Heavy bark removal: human, old to recent Heavy root removal: human, old to recent Ladder of nails in trunk	Light ongoing branch loss Very low flower density Heavy discoloration, depressions, and rot	6 buffalo weaver nests
11	2.5m x 11m Conical, medium crown	None	No branch loss No flowers No discoloration/depressions/rot	Inside a fenced compound in Gweta

12	2.5m x 14m Conical, sparse crown	Heavy bark removal: human, old to recent	Medium ongoing branch loss Low flower density Heavy discoloration and depressions	In town, but not fenced
13	2m x 10m Conical, dense crown	Bark stripped (medium) and tree burned, recent	No branch loss No flowers No discoloration/depressions/rot	n a fenced compound Owners attempted to kill tree b/c roots damage houses
14	1.8m x 10m Conical, dense crown	None	No branch loss Average flower density No discoloration/depressions/rot	Inside a fenced compound
15	3m x 13m Conical, medium crown	Light root removal: human, mid-old to mid-recent Bits of metal imbedded in trunk	Light ongoing branch loss Average flower density Heavy discoloration	In town, but not fenced
16	4.5m x 25m Conical, medium crown	Severe bark removal: human, old to recent Severe root removal: human, old to recent	Medium ongoing branch loss No flowers Medium discoloration and depressions, light rot	Has never borne fruit Main traditional medicine site in Gweta 2 buffalo weaver nests
Y3	1m x 7m Broad, sparse medium crown	Severe bark removal: human, old (fully ringbarked at least once when younger)	Medium ongoing branch loss Low flower density Medium discoloration and depressions	2 buffalo weaver nests
17	2.5m x 12m Broad, sparse crown	Light bark removal: human + elephant, old Light root removal: human, old Ladder on companion sycamore	Recovering from medium branch loss Average flower density Heavy depressions	
Y4	1m x 5m	Knocked over by elephants Browsed by elephants: mid-recent Light root removal: human, mid-old	Recovering, leafing fully No flowers	
18	3.5m x 17m Conical, medium crown	Light bark removal: elephant, old to mid-recent Light root removal: human, old	Recovering from light branch loss High flower density Medium discoloration and depressions	13 buffalo weaver nests
19	3.5m x 15m Conical, sparse crown	Light bark removal: human + elephant, old to mid-old Light root damage: non-human, old	Heavy ongoing branch loss Very low flower density Heavy discoloration, medium depressions	3 buffalo weaver nests
Y5	1.5m x 8m Conical, sparse crown	Medium bark removal: human, old to mid-recent Light root removal: human, mid-recent	Medium ongoing branch loss Low flower density Heavy discoloration and depressions	2 buffalo weaver nests
20	2.5m x 9m Conical, medium crown	Medium bark removal: human, old to mid-recent Light root removal: human, old to mid-recent Metal rod imbedded in trunk	Medium ongoing branch loss Low flower density Heavy discoloration, depressions, and rot	5 buffalo weaver nests
21	4m x 12m Broad, dense crown	Light root removal: human, old	Recovering from light branch loss Average flower density Medium discoloration and depressions	4 buffalo weaver nests
22	4m x 15m Conical, medium crown	Light bark removal: human, old to mid-recent Medium root removal: human, old to recent	Recovering from medium branch loss Average flower density Medium discoloration	3 buffalo weaver nests
Y6	0.5m x 3m	Severe bark removal: human, old to recent	Severely stunted; bark stripped for many successive years	
Y7	0.75m x 4m	Knocked over (by elephants?) Medium bark removal: human, old	Recovering; leafing on most branches	

23	3m x 12m Conical, sparse crown	Medium bark removal: human, old to recent Light root removal: human, old	Heavy ongoing branch loss Low flower density Heavy discoloration, depressions, and rot	
24	3.5m x 12m Broad, medium crown	Light bark removal: human, old Light root removal: human, old	Has recovered from medium branch loss Average flower density Light discoloration and depressions	4 buffalo weaver nests
25	3.5m x 14m Broad, sparse medium crown	Medium bark removal: human, old to mid-old Medium root removal: human, old to mid-recent	Medium ongoing branch loss Low flower density Heavy discoloration, depressions, and rot	2 buffalo weaver nests
26	5.5m x 20m Conical, medium crown	Light bark removal: human, old to mid-old Light root removal: human, old	Light ongoing branch loss Average flower density Medium discoloration and depressions	7 buffalo weaver nests
Y8	0.75m x 2.5m	Light bark removal: human, mid-old Top 1/3 broken off: elephant, mid-old	Leafing somewhat where undamaged	
27	3.5m x 15m Conical, sparse medium crown	Light root removal: human, mid-old to mid-recent	Medium ongoing branch loss Low flower density Heavy discoloration and depressions	5 buffalo weaver nests
28	4m x 10m Broad, medium crown	Light root removal: human, old	Recovering from light branch loss Low flower density Medium discoloration	
29	3m x 12m Conical, sparse crown	Light root removal: human, old	Light ongoing branch loss Low flower density Light discoloration and depressions	
30	3.5m x 13m Conical, medium crown	Light bark removal: human, old to mid-old Light root removal: human, old	Has recovered from light branch loss High flower density No discoloration/depressions/rot	Hollow; holds water
31	6m x 20m Conical, sparse crown	Medium bark removal: human, old to recent Medium root removal: human, old Evidence of old ladders and wires for harvesting fruit	Medium ongoing branch loss Low flower density Severe discoloration, depressions, and rot	10 buffalo weaver nests Known as "Masukiri" (the sweet one); has the most highly sought-after fruit in the area
Y9	0.75m x 5.5m	Light bark removal: human, old to mid-old Some limbs sawn off: mid-old	Leafing on most branches	
32	4m x 10m Broad, sparse crown	Medium bark removal: human, old to mid-old Medium root removal: human, old to mid-old	Light ongoing branch loss Low flower density Severe discoloration, medium depressions and rot	3 buffalo weaver nests Mycelia and fruiting bodies visible in discoloration around axe scar
Y10	1.75 m x 8m	Severe bark removal (completely ringbarked at one point): human, old to mid-old Small second trunk sawn off: mid-old	Light ongoing branch loss in lower branches Very low flower density Light discoloration Lower growth (branches and trunk) is severely stunted	Buffalo weaver nest fallen from tree
Y11	0.75m x 6m	None	Leafing throughout; crown developing	
Y12	0.5m x 6m	Light bark removal: non-human, mid-recent	Leafing, top first; crown developing	
33	5m x 15m Conical, medium crown	Light bark removal: human, old to recent Medium root removal: human, old to mid-recent	Light ongoing branch loss Average flower density Heavy discoloration, medium depressions	5 buffalo weaver nests

34	4.5m x 18m Conical, sparse crown	Heavy bark removal: human, old to recent Heavy root removal, old to recent Fire pit (for traditional medicine) built into a depression in the lower trunk	Heavy ongoing branch loss throughout Very low flower density Severe discoloration, heavy depressions and rot	13 buffalo weaver nests; several fallen from tree Called "Mowana Basarwa." According to legend, a Mosarwa climbed the tree, fell inside, and was trapped (a footprint-shaped indentation can be seen in the trunk). It is now taboo for anyone to climb the tree. Important traditional medicine spot.
35	2.5m x 18m Conical, medium crown	Severe bark removal: human, old to recent Light root removal: human, old to mid-old	Light ongoing branch loss Average flower density Heavy discoloration and depressions	2 buffalo weaver nests
36	2m x 9m Broad, sparse crown	Medium bark removal: human, old to mid-recent Medium root removal: human, old to mid-recent Ladder of nails built into trunk	Medium ongoing branch loss Low flower density Heavy discoloration and depressions, medium rot	5 buffalo weaver nests; one fallen from tree
37	3m x 10m Broad, medium crown	Light bark removal: elephant, old to mid-recent Light root removal: non-human, old to mid-old	Recovering from medium branch loss Low flower density Light discoloration, medium depressions	2 buffalo weaver nests
38	4 trunks (3x2m, 1x1.5m) 8m tall Broad, dense crown	Medium bark removal: elephant, old to recent Large limb broken from one trunk, mid-recent	Light ongoing branch loss on all trunks Average flower density Heavy discoloration, medium depressions	2 buffalo weaver nests
39	5m x 15m Conical, dense crown	Light bark removal: elephant, old to recent	Has recovered from light branch loss High flower density No discoloration/depressions/rot	5 buffalo weaver nests Fresh elephant dung containing mostly bark found nearby
Y13	1.75m x 7m Broad, medium crown	Light bark removal: elephant, mid-old	Light ongoing branch loss Very low flower density Medium discoloration and depressions	3 buffalo weaver nests
Y14	0.3m x 3.75m	Axe damage, mid-old	Starting to leaf, top first	
Y15	1.2m x 7m	Lower branches broken (elephant?)	Fully leafed out Low flower density No discoloration/depressions/rot	
Y16	0.8m x 6m	Heavy bark removal, mid-old (possibly scars from presence of a companion tree)	Leafing, top first	Inside a fenced farm Companion tree was cut down and burned, possibly to help the baobab survive
PB1	4m x 15m Conical, medium crown	Light bark removal: human, old Heavy root removal: human, old to mid-old (since 2000)	Recovering from medium branch loss Average flower density Medium discoloration and depressions, light rot	Fruit not heavily harvested b/c it's reputed to be tasteless
PBY1	0.1m x 1.75m	None	Beginning to leaf	Planted in 2000, but has barely grown

PBY2	0.75m x 5m	Light bark removal: human, old	Leafing, top first	
PB2	3.5m x 12m Conical, sparse medium crown	Light bark removal: elephant, old Medium root removal: human, old to mid-old	Medium ongoing branch loss Low flower density Medium discoloration and depressions, light rot	
PB3	3.5m x 15m Conical, sparse medium crown	Light bark removal: elephant, old	Light ongoing branch loss Average flower density Light discoloration, depressions, and rot	7 buffalo weaver nests
PBY3	1m x 9m	Knocked down in 2006 (mid-recent) by elephants	Leafing fully Low flower density	
PB4	4m x 15m Conical, sparse crown	Light bark removal: human, old Severe root removal: human, old Cable nailed to trunk, used for climbing and harvesting	Light ongoing branch loss Very low flower density Medium discoloration and depressions, light rot	Also known as "Masukiri" for its sweet fruit. Was preferred and heavily harvested by the village until the lodge's construction.
PB5	5m x 17m Conical, medium crown	Light bark removal: human, old Medium root removal: human, old	Recovering from medium branch loss Average flower density Light discoloration and depressions	1 buffalo weaver nest
PB6	4.5m x 16m Conical, medium crown	Light root removal: human, old Cable nailed to trunk	Has recovered from medium branch loss Average flower density Light discoloration	
PB7	8m x 20m Conical, medium crown	Light bark removal: human, old Medium root removal: human, old Cable nailed to trunk	Has recovered from light branch loss, mainly in lower 2/3 of crown Very low flower density Light discoloration and depressions	7 buffalo weaver nests Estimated to be over 3000 years old May be hollow
PB8	4m x 16m Conical, sparse medium crown	Light bark removal: human, old Light root removal: human, old	Recovering from medium branch loss Low flower density Medium discoloration and depressions	Trunk has many large growths and holes; seems to be an old, persistent disease
PBY4	2 trunks (2x0.25m), 2.75m tall	Heavy bark removal: human, old Light branch damage: recent, unknown cause Metal imbedded in trunk	Leafing, top first Growth is stunted throughout one trunk and on the lower third of the other.	
PB9	2.5m x 10m Broad, sparse medium crown	Light bark removal: human, old Light root removal: human, old	Light ongoing branch loss, only in lower crown Low flower density Light discoloration, depressions, and rot	
PB10	3.5m x 13m Conical, sparse medium crown	Medium bark removal: human + elephant, old Light root removal: human, old Cable nailed to trunk	Recovering from light branch loss Average flower density Light discoloration and depressions	Black growths on trunk are easily scraped off; not just discolored bark
PBY5	0.25m x 4.5m	None	Leafing, top first, slightly later than other young trees	
PBY6	0.3m x 6m	None	Leafing, top first, a bit behind PBY5	
PB11	3.5m x 12m Conical, sparse medium crown	Light bark removal: human, old Light root removal: human, old Cable nailed to trunk	Recovering from light branch loss Low flower density Light discoloration and depressions	Fruit was sought after, though not as much as Masukiri's, because of its yogurt-like taste.

ISP Evaluation Appendix:

-Did the process of doing the ISP modify your learning style? How was this different from your previous style and approaches to learning?

Though it may not have had a huge impact on my overall style of learning, this ISP has certainly affected the way I approach scientific projects and studies. I have never had to conceive, plan, and execute a study entirely independently, and I have never before worked with such large constraints on time and materials. This project has made me more creative and efficient, especially when it comes to systematic data collection. I learned to plan out my days in advance to spend as much time as possible gathering information, in order to maximize the time available for review and analysis later in the study period.

-What were the principal problems you encountered while doing the ISP? Were you able to resolve these and how?

The lack of a valid control group for this project was by far the most aggravating problem I encountered. Though using quantitative analysis and comparison to population means helped to mitigate the difficulties arising from this, I have no doubt that it still detracted somewhat from the precision of my results. Similarly, my lack of experience with mycology and the absence of any books or other materials to help me identify the rot fungus found on the baobabs left my data analysis and conclusions with very obvious limitations. Because of the lack of time and materials, I was unable to obtain a usable sample of the fungus to be identified by more knowledgeable persons in Gaborone. Aside from these limitations, my only troubles arose from the variability inherent in a project like this that deals with more or less unknown aspects of a relatively small natural population. Quantitative data analysis was again instrumental in working around this problem.

-What general methods did you use? How did you decide to use such methods?

I ended up abandoning my original intentions to spend a considerable amount of time carrying out formal interviews and stuck instead to a relatively small number of limited informal interviews that supported and reinforced one another. This change was due simply to my desire to spend as much time as possible gathering data on the health of the trees. Since this comprised the bulk of my project, it was important to obtain as much information on as many subjects as possible in order to reduce error, improve statistical validity, and discover more correlations between variables.

-Comment on your contact with your advisor. Indispensable? Occasionally helpful? Not helpful? At what point was your advisor most helpful? Were there cultural differences that influenced your relationship? Differences in understanding the educational processes and goals?

My contact with my advisor was sporadic and limited at best, but when we were both available for correspondence it was fairly helpful. The information he gave me proved important in certain sections of my analysis and conclusions.

-Did you reach any dead ends? Hypotheses that turned out not to be useful? Interviews or visits that had no application?

All in all, my project was fairly straightforward. Though there were no correlations between some variables and only very weak ones between others, there were enough strong trends present to make analysis, discussion, and conclusions very easy. Almost all of the data I collected was instrumental to the study in one way or another.