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Enhancing Opportunities for Improved Community Capacity Building in the Lower Kuiseb Valley

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Prepared By:

Anna Davies
Annalise Sauter-Ortiz
Kate Tomlinson
Tyler Rivera

Abstract

With the expansion of the burgeoning tourism industry in the Namib Sand Sea, Gobabeb Research and Training Centre could have a unique opportunity to improve its relationship with the Topnaar communities neighboring the Centre through the implementation of its "Benefit-Sharing in the Namib Sand Sea" proposal. Since the Topnaar people are currently illegal residents of the Namib-Naukluft Park (NNP), we conducted a case study analysis of the Kyaramacan Association for the Khwe San in the Bwabwata National Park to assess the viability of the residency association model for the Topnaar people. We conducted a literature review and interviewed representatives from the World Wide Fund for Nature and the Integrated Rural Development National Council to determine how aspects of this successful model could be applied in the NNP. In addition, this study interviewed the following key stakeholders to assess the current perception of the Gobabeb-Topnaar relationship, Gobabeb's capacity building potential, and to gain insight into potential improvements in the future: current and past Gobabeb employees, Topnaar community members, the Topnaar Traditional Authority, Namibia's Ministry of Environment and Tourism, and Namibia's Department of Sport and Recreation. Using the deductive approach to qualitative research, four central themes emerged from these interviews: communication, continuity, collaboration, and commitment. The importance and implications of each for the proposal were discussed separately. Finally, a comprehensive review of unpublished, internal documents that chronicled the history of Gobabeb's interaction with the Topnaar community was conducted, and an internal, anonymous survey of current Gobabeb staff was administered. Through the integration of the interview findings, document analysis, and internal survey, this study attempted to bridge Gobabeb's past—its history, previous outreach efforts, and relationship with the Topnaar community—with the present to better inform the future implementation of the proposal. This study concluded with several concrete recommendations for Gobabeb to improve their effectiveness at fulfilling their proposed role as a capacity-building entity in current proposal.

I. Introduction

Gobabeb Research and Training Centre is an internationally recognized center for dry land research and training in Namibia. Situated at the nexus of the Namib Sand Sea (NSS) to the south, the gravel plains to the north, and the ephemeral Kuiseb River, Gobabeb is unique in its location within Namibia's largest natural reserve, *Namib Naukluft Park.* Also residing in the park are the Topnaar (≠Aonin) people, comprised of 300-400 members spread out between small settlements living along the banks of the Kuiseb River. Gobabeb and the Topnaar live in close proximity to one another, and are both considered to be part of the Lower Kuiseb Valley socio-ecological system. As a highly complex and dynamic system, the Lower Kuiseb has been the subject of a number of academic articles and research projects (e.g. Megrue et al. 2013; Ito 2005; Botes et al. 2003). This paper intends to build on this existing body of knowledge and contribute to an enhanced understanding of the system and its many components.

Our interest in this system was sparked by a proposal recently submitted by Gobabeb for funding from the Finnish Fund for Local Cooperation. This proposal, entitled "Benefit-Sharing in the Namib Sand Sea", intends to contribute to the sustainable management of the Namib Sand Sea by engaging local communities and sharing benefits from the NSS's inscription as a World Heritage Site. In order to realize these goals, the proposal outlines a number of components aiming to: 1) Advance and diversify education efforts at Gobabeb through including non-formal community training programs; 2) Capacitate a remote, marginalized community to derive benefit, while optimizing and conserving traditional knowledge and practices in managing the NSS; and 3) To strengthen organizational capacity and obtain strategic clarity for Gobabeb, particularly in light of NSS opportunities. These objectives stem from Gobabeb's current mandate as a training center offering skill building and workshops. Given their existing functions, Gobabeb feels as though it is "well-placed to offer appropriate training interventions to contribute to uplifting its neighboring communities," (FLC Proposal).

The objective of this paper is to investigate and analyze Gobabeb's role as a capacity-building organization for the Topnaar communities surrounding the center. We focus on gauging internal and external perceptions of Gobabeb's capacity-building role in order to improve strategies for capacity building within the Topnaar community and enhance understandings of the relationship between Gobabeb and the Topnaar within the broader socio-ecological system. Questions guiding our research include: *How can Gobabeb more effectively play a capacity-building role in the Topnaar community?; How do perceptions of Gobabeb, both internal and external, affect their ability to serve as an effective capacity-building organization for the Topnaar?;* and *How can Gobabeb incorporate knowledge based on previous capacity-building efforts and case studies to more effectively play this role?* In answering these questions, our goal is to provide a variety of key recommendations to Gobabeb that could enhance their implementation of the components outlined in the proposal in more efficient, effective, and appropriate ways.

In Section One we provide a theoretical overview of what capacity building is, and why it is relevant to our research. We also provide a more comprehensive outline of Gobabeb's proposal for FLC funding, and link specific components within the proposal to particular aspects of our research and findings. The methodology of the research is discussed in

Section Two. Our interview and surveying process is described, as well as the academic methods used to analyze Gobabeb's past capacity-building efforts and a specific case study. Section Three provides background on relations between Gobabeb and the Topnaar, and describes in detail what past efforts Gobabeb has made to engage in capacity-building programs with the Topnaar community. This historical analysis serves to inform Gobabeb's future capacity building efforts by drawing lessons from past mistakes and successes. In Section Four we conduct a thorough case-study analysis of the Kyaramacan Association in Bwabwata National Park, which is identified in the proposal as a potential model of legally recognized self-organization from which comparisons may be drawn for the Topnaar. This case study is assessed for strengths and weaknesses in terms of applicability to the Topnaar community, and the opportunities/limitations for drawing comparisons between the two contexts are evaluated. Section Five presents our qualitative findings from the interviews we conducted with various stakeholders, as well as our quantitative findings from a survey of the current Gobabeb staff. These findings are divided into four crosscutting themes we identified within the data: communication, collaboration, continuity, and commitment. In Section Six we discuss these findings and integrate further findings from the case study and historical analyses in order to establish a comprehensive conceptualization of Gobabeb's role as a capacity-building organization. In Section Seven we discuss the limitations of our research. In Section Eight we incorporate our analysis of these findings into eight key recommendations. The limitations of our research as well general conclusions about the findings are discussed in Section Eight. Finally, in Section Nine we describe potential opportunities for future research.

a. *What is Capacity-Building?*

Capacity building, and specifically the notion of 'community capacity building' (CCB), is increasingly becoming a part of policy and narrative in development and conservation. It is frequently associated with efforts to foster social change, redress disadvantaged communities, promote health initiatives, and regenerate both social and urban capital, and is stitched together with other notions of community competencies, asset based social planning, and community participation (Verity 2007). CCB is linked to a host of particular development activities, from rebuilding an entire nation after traumatic conflict to training an individual, and can be found in countless reports, literature reviews, case studies, toolkits, academic articles, and books, as well as in the strategic plans of a range of international development NGOs. Inevitably, such diverse use of the term can lead to "confusion about what is done in its name and how to evaluate programs which claim to do it," (Hunt 2005).

Because of the near ubiquity of the term within international development rhetoric, there is not consensus on how to best define CCB (Mitchell and Macfie 2004). It is a dynamic, contested, and ill-defined idea, and requires further clarification. In trying to understand and define community capacity building, Goodman et al. (1998) effectively capture the term's highly fraught nature:

> It is a process as well as an outcome; it includes supportive organizational structures and processes; it is multidimensional and ecological in operating at the individual, group, organizational, community, and policy levels; and it is context specific. Also, communities can lose as well as gain capacity. Capacity exists in a dynamic state and develops in stages of readiness that must be taken into account selecting capacity-enhancing interventions

(Goodman et al. 1998).

Taking these definitions into consideration, we consider CCB to be an intentional process aiming to enhance the ability of communities to sustain themselves and their well-being now and in the future.

There is a broad literature on what conditions are most conducive to successful capacity building (e.g. Greenberg 2013; UNESCO 2013; Chinman et al. 2005). Effective implementation of capacity-building programs may entail a number of activities and practices, and may be guided by a range of principles. However, across the literature, we have identified a general consensus on the need for a few key elements in order to achieve truly successful community capacity building. The first requirement is having effective channels for *communication* in place. Communication can be said to exist at the root of all human interaction and development, and is thus inextricably linked to rural capacity building. In exploring the link between community capacity building and communication, Romanow and Bruce (2006) remark that, "…ultimately, the most important thing communities can do to build capacity is to engage in multidirectional dialogue with all community stakeholders. Only then does sustainable development have a chance," (Romanow and Bruce 2006). *Collaboration* between stakeholders is the second prerequisite to effective community capacity building. The development of successful partnerships in capacity building is dependent on the ability of the stakeholders involved to work together (Chaskin 1999). Thus, building capacity within a community must include collaborative processes that link stakeholders to one another in meaningful and mutual partnerships (Foster-Fishman et al. 2001). Third is a need for *commitment* to capacity building efforts from all stakeholders involved in a project or program. In order to achieve a specific development goal, there must be a strong commitment from both the community and the capacity-building organization(s), as well as from other stakeholders involved (Otoo et al. 2009). Foster-Fishman et al. (2001) acknowledge that members of capacity-building programs are "more willing to participate when they hold positive about the proposed project or have a strong commitment to the targeted problem," (Foster-Fishman et al. 2001). Finally, successful capacity building programs require *continuity* to achieve long-term, sustainable outputs within the community. Follow-up and knowledge building both forms an integral part of capacity building, and thus capacity-building organizations should continue to monitor their partnerships and help them succeed (Hemmati and Whitefield 2003). In discussing the principles underlying community capacity building, Atkinson and Willis (2006) write that the process of capacity building "needs to be seen as long-term and organizations working with or setting up programs within communities need to be there for the long haul and work in a context that may not be easy," (Atkinson and Willis 2006).

While there are countless other principles and practices that may contribute to effective capacity building, we feel these four elements (communication, collaboration, commitment, and continuity) are integral to the successful implementation of capacity building programs and strategies. We will incorporate these four elements as a framework for understanding and organizing the results of our stakeholder interviews in section five, as well as to further integrate our overall findings into an analysis of Gobabeb's role as a capacity-building organization in section six.

b. *"Benefit-Sharing in the Namib Sand Sea"*

The Namib Sand Sea was successfully inscribed as a World Heritage Site by UNESCO in 2013, aided in the process by Gobabeb Research and Training Centre. Following the inscription, Gobabeb was designated as a monitoring facility to assist relevant authorities in managing the site. As part of the World Heritage Committee's decision, a number of recommendations to Namibia's national World Heritage Site governing body were offered, including: a) Strengthen further participatory management arrangements with the indigenous peoples with rights related to the property, including to maintain traditional access and sustainable use of natural resources within the property and its buffer zone; and b) Strengthen management capacity in terms of financial and human resources, including the highly effective support provided to the property by the Gobabeb Training and Research Centre (http://whc.unesco.org/en/decisions/5124). Gobabeb recently submitted a proposal for funding from the Finnish Fund for Local Cooperation (FLC) in order to carry out a two-year capacity building project for the Topnaar communities neighboring the center. There are five activities envisaged within the proposal that address its three objectives, each contributing different outputs for the Topnaar people:

1. **Component A**: Training course on the NSS for Topnaar guides

A training course on the NSS will prepare Topnaar guides for employment in the tourism industry by equipping them with relevant, marketable skills like guiding. The course itself will include modules on the WHS inscription, technical information (e.g. NSS ecology, geography, and geology), the tourism sector in Namibia, business skills, and soft skills (e.g. presentation skills, conflict resolution, and minute taking), and will allow Topnaar community members to benefit from the anticipated increases in visitors to the area resulting from the inscription of the NSS as a World Heritage Site.

2. **Component B**: Training course on the NSS for J.P. Brand Primary School Grade 7 learners

The inscription of the NSS presents an opportunity for Gobabeb to assist in the development of a new curriculum component on the heritage of the NSS for grade 7 learners at J.P. Brand Primary School. The training curriculum on the NSS will include explanations of World Heritage Site criteria, the NSS's inscription, and ecology of the NSS. A complimentary display with more hands-on learning materials (e.g. workbooks, banners, etc.) will also accompany the curriculum component, serving as a long-term educational resource that can easily be shared with other schools in the region to promote the NSS.

3. **Component C**: Collective Legal Entity to Represent the Community's Interests in a Protected Area

Due to their location in a protected area, rural Topnaar communities cannot legally organize themselves into a conservancy in order to derive benefits from their natural resources, and are thus unable to capitalize on development opportunities in the area. The creation of an accountable, effective mechanism for the Topnaar to realize benefit-sharing opportunities from the NSS is critical to ensuring sustained livelihood

improvement. This mechanism will draw on lessons learned from communities facing similar challenges to organization, such as the San people residing Bwabwata National Park, in order to aid the Topnaar in being able to benefits from their rich ecological and cultural heritage.

4. **Component D**: Viable Traditional Needlecraft Industry

Gobabeb hopes to support Topnaar women by coordinating and growing needlework skills and marketing their products in order to secure improved income sources and preserve this invaluable cultural practice. Sewing circles, with essential equipment, will be established at Gobabeb and a business model developed to ensure the sustainability of the initiative. Women participating in the circles will receive supplementary training in business skills and marketing, and will have the opportunity to interact with and engage other women in discussions on issues of relevance.

5. **Component E**: Sustainability Strategy Operationalized

A sustainability strategy for capacity building at Gobabeb was developed in 2014 to ensure that Gobabeb remains adaptive and responsive to evolving needs and guarantees quality products and services. The benefits outlined in this strategy are dependent upon the strategy's successful implementation. Fully operationalizing this strategy will require that Gobabeb management revisit the long-term vision for the center, articulate primary and long-term objectives and impacts, and solicit buy-in from all key stakeholders.

Through the multidimensional strategy outlined in the proposal, Gobabeb intends to expand its role a capacity-building organization for the Topnaar communities neighboring the center. In the process, Gobabeb hopes to "facilitate the transfer of new skills and knowledge for the Topnaar to take advantage of biodiversity-based businesses and entrepreneurship opportunities presented by the NSS," (FLC Proposal).

II. Methodology

From November 3rd to November 10th, 2014, we, a group of four Dartmouth College students, conducted a qualitative and quantitative analysis of Gobabeb Research and Training Centre's relationship with the Topnaar people residing in the Lower !Kuiseb Valley, Namibia. We specifically focused on how Gobabeb as a neighboring research center can provide successful capacity building programs through their Benefit Sharing Proposal. We stayed at Gobabab for eight days collecting data and information from various stakeholders in the region. Through the interview process, we hoped to gain a better understanding of the lived experience of the stakeholders to better inform recommendations for future capacity building programs (Seidman, 2006).

Direct Stakeholder Interviews:
We conducted twenty-one semi-structured face-to-face interviews with direct stakeholders, including current Gobabeb employees, Topnaar community members, and the Topnaar Traditional Authority (TTA). The team interviewed nine current Gobabeb employees ranging from management to researchers to housekeeping staff, three key Topnaar community members, and the Topnaar Special Advisor to the Chief. Typically, interviews

lasted 30 minutes to an hour, with some lasting up to two hours. With at least two of us conducting the interview, we suggested to meet at a location convenient and comfortable for the interviewee. Almost all of these interviews were digitally recorded and partially transcribed. We asked a series of open-ended questions to gain insight into the current perceptions of the Gobabeb-Topnaar relationship, as well as to compile input or ideas from various stakeholders about the future capacity building programs. We developed different interviewing methods and protocols depending upon the stakeholder, but there were several questions that were asked in all of the interviews, including: *How has Gobabeb's relationship with the Topnaar changed over time? In your opinion, what role should Gobabeb have for capacity building?*

Internal Gobabeb Survey:
We conducted a paper survey of Gobabeb staff, titled *Gobabeb Internal Survey*: 13 of the 23 employees were able to respond to the survey. Paper surveys were distributed on Thursday, November 6. Respondents were asked to either drop the survey off with the survey team, or were collected by survey team members on Friday. Identifiable information was not collected. The survey had five questions, all of which were closed-ended questions. This survey allowed us to complement our qualitative interview results with quantitative data. The survey also allowed for a broader framework for understanding the Gobabeb-Topnaar dynamic and for more employees to provide input anonymously. The survey also shed light as to whether Gobabeb employees had differing or similar opinions.

Peripheral Stakeholder Interviews:
We also had contact with peripheral stakeholders: Namibia's Ministry of Environment and Tourism (MET), World Wide Fund for Nature- Namibia (WWF), Integrated Rural Development National Council (IRDNC), Namibia's Department of Sport and Recreation, past Gobabeb staff members, and the local primary school J.P Brand. This process included in person meetings, telephone conversations, and email correspondence. Because of the lack of cohesive results regarding the history of the relationship, these informal conversations allowed the team to compile previously undocumented individual information to add to the broader understanding of the Gobabeb-Topnaar dynamic. Moreover, through telephone and email communication, we were able to contact individuals located elsewhere in the country that have done a similar program (Kyaramacan Association) as the one Gobabeb hopes to pursue with the Topnaar through the proposal, and use their knowledge to inform the case study analysis.

Content Analysis:
In addition to gaining insight through interpersonal communication, we reviewed Gobabeb's organizational documents, research studies about previous capacity building programs, specifically those related to Gobabeb programs for the Topnaar community and the Kamarcan Assocation for the Khwe San. We reviewed unpublished documents regarding previous programs. These documents were critical to reveal the weaknesses and strengths of past programs and to further inform recommendations for future programs.

Data Analysis:
We reviewed interview notes and debriefings immediately after the completion of the interview process. To better address and organize their comprehensive data, the team

reviewed interview notes and debriefings to find broad themes and patterns that related to capacity building potential. There were four themes that repeated in almost all interviews: communication, collaboration, continuity and commitment. We then listened to all of the audio recordings and transcribed portions to verify the accuracy of the four themes. Through this thematic analysis, we were better able to organize and present the results and findings of the research.

III. Background

While a comprehensive history of the relationship between Gobabeb and the Topnaar people is beyond the scope of our research, a brief overview of the past outreach efforts provides valuable insights that serve to contextualize the proposal.

Starting in the late 1990s, Gobabeb began to support a series of programs designed to benefit the Topnaar community. The most notable of these programs are summarized below in Table 1. While the majority of Gobabeb's earlier programs focused on environmental studies and educational support, there was a significant shift in the late 2000s towards programs that supported utilization of the tourism concession. Unfortunately, information was not available for more recent programs, so the summary table does not include programs offered after 2009. Qualitative evidence from interviews with Gobabeb suggests that Gobabeb has offered fewer programs since 2009 than it has traditionally.

Table 1: Previous Gobabeb-Funded or Facilitated (or DRFN at Gobabeb) Programs concerning the Relationship between the Topnaar Community and Gobabeb

Date	Event	Aim
1989	English literacy classes given at Gobabeb	To empower the Topnaar people with the new official language of the country
1993	Enviroteach	A DRFN program which works with the Ituseb School to test their materials on Environmental Education
1993	Summer Desertification Programme 2	Addresses water use in the Kuiseb Catchment which also includes the Topnaars
1996	DRFN facilitates the visit of a Topnaar group to the Richtersveld	For the Topnaar to utilize the Richtersveld as a case study to inform their own future planning
1997	Workshop at Gobabeb for Topnaar community	Determine the Topnaar people's perception of their relationship with Gobabeb and expectations from Gobabeb
1997	Workshop at Lauberville on !nara resource management	Inform Topnaar !nara harvesters and processors
1998 onward	Provision of bursaries to Topnaar students	
1998	Fog Information Day at Gobabeb	Education about fog-collection, establishment of fog net for water collection
1998	Workshop at Gobabeb on Topnaar water resource management	
1999	DRFN hosts two Topnaar interns at Gobabeb	Facilitate information transfer and cooperation between the GTRC and the Topnaar community
2000	Gobabeb hosts workshop on alternative livelihoods to combat desertification	
2002-2003	The Kuiseb Basin project ELAK (environmental learning and action along the Kuiseb) focuses on Topnaar development, including monthly workshops for 2 years	Train water point committee members
Dec. 2006 & Jan 2007	Topnaar tourism development workshops to plan tourism concessions for the Topnaar community and for Gobabeb	Prepare for tourism concession
2007	Desert and desertification workshop	
2007-2008	Tourism Guide Training of Topnaars, 6-month regular meetings with community to prepare, followed by several training events	Prepare Topnaar for tourism development in their area
2008	Sustainable Agriculture Workshop	Demonstrate appropriate sustainable ways of gardening in the desert
2009	Topnaar Cultural Exchange Project	Empower the people to be proud of their culture, while preparing for tourism opportunities in the area
2009	Topnaar Identification Project Workshop	To strengthen the relationship between Gobabeb and the Topnaar community
2009	Solar cooking demonstration project	To create awareness of energy efficient stoves and solar cookers

Source: Gobabeb Training and Research Centre. (2009). Gobabeb-Funded or Facilitated Programmes concerning the Relationships between the Topnaar Community and Gobabeb (or DRFN at Gobabeb) after Independence.

From our review of Gobabeb's previous efforts, we identified three that are particularly relevant for the purpose of our research: the Gobabeb-Topnaar community meetings in 1997 and in 2009, as well as the tour guide training program in 2007-2008.

Since Namibian Independence, Gobabeb has hosted two major events to facilitate cooperation and communication between Gobabeb and the Topnaar community. In 1997, Gobabeb hosted the "First Indaba" workshop to determine the Topnaar community's relationship with and expectations of Gobabeb (2009 Program). During this meeting, Topnaar community members requested the following: increased access to the GTRC library, joint educational efforts to benefit the Topnaar youth, the resumption of English literacy classes, projects that established solar power to run water pumps, employment of the Topnaar individuals beyond the laborer level, and greater research on the decline in the !nara harvest ("Notes on DRFN-Topnaar Interaction Project", 1997).

In 2009, Gobabeb hosted the second workshop guided by the following two questions: "What can Gobabeb do for the community?" and "What can the community do for Gobabeb?" ("Minutes and Proceedings from the Topnaar Workshop", 2009). Community members voiced a number of requests similar to those of the meeting in 1997: the provision of additional study bursaries for Topnaar youth, increased job opportunities at Gobabeb itself, and assistance in !nara projects ("Minutes and Proceedings from the Topnaar Workshop", 2009). In addition, during the 2009 meeting, community members specified new areas where Gobabeb could assist them: the building of a clinic, the provision of transportation for school children and elderly people, computer training, the development of chicken projects, and additional assistance with the tourism concession ("Minutes and Proceedings from the Topnaar Workshop", 2009).

In 2007-2008, Gobabeb offered the basic Level 1 and Level 2 tour guide training to the Topnaar community. This program provided broad training on tourism in southern Africa rather than focusing intensively on a particular region.

IV. Case Study: Kyaramacan Association

a. *Purpose*

The following analysis serves to inform Component C: "Collective legal entity to represent the communities interests in a protected area" of the "Benefit-sharing in the Namib Sand Sea" proposal. We chose to dedicate an entire analysis to this component because it is one aspect that Gobabeb identified they wanted the most help with. Gobabeb feels confident in implementing Components A and B (training courses on the NSS for Topnaar guides and J.P. Brand Primary School) because they have past experience in training and have previously worked with the school (Gobabeb employee 2, personal communication, 11/7/14). We studied the Kyaramacan Association (KA), an association that organizes the Khwe San in the Bwabwata National Park, because Gobabeb identified in the proposal the KA as a model example. This case-study analysis will elaborate on the process of creating a residents' association and evaluate whether it is a feasible option for the Topnaar community.

b. *The Situation of National Park Residents in Namibia*

The Bwabwata National Park (BNP) and the Namib Naukluft Park (NNP) are the only two parks in Namibia in which people still live inside the protected area: the Topnaar live in NNP while the Khwe San, the subject of this case study, live and thrive in BNP with help

from the KA. Even though both groups have received concessions from the MET that imply their recognition, their presence and land rights in the national park are not explicitly recognized in any formal documentation (Jones and Dieckmann 2014). This lack of a legal recognition limits development options because communities cannot enter into legal contracts or joint-venture agreements with government or tourism operators nor open a bank account to establish a development fund (Interviewee). Besides not having legal recognition inside the park, restrictions, such as prohibiting cattle, further limit development and livelihood opportunities. The Special Advisor to the Chief lamented on the Topnaar's status:

> *We sit with pain in hearts that we also want to become an actual rural community. We sit in a park but in actual fact, the park sits on us because the park came when we were already residing […] I cannot own land and build traditional hut and use that land as bank guarantee, so I can buy more cattle.* (Topnaar Traditional Authority Representative #1)

c. *Kyaramacan Association*

The Kyaramacan Association (KA) is the most important community institution in the Bwabwata National Park since it is the only overarching organization for all residents in the park (Jones and Dieckmann 2014). The Kyaramacan Association has brought considerable benefits such as trophy-hunting concession, devil's claw harvest organization, continuation and empowerment of traditional knowledge, educational scholarships, and cultivation of management partnerships. Its trophy-hunting concession has brought N$1.9 million, which is used to employ male Community Game Guards and female Community Resource Monitors. It has also helped ensure devil's claw harvesters obtain a fair price by negotiating with buyers and storing the harvested product. Through a program called TEKOA, the KA ensures that traditional knowledge is not lost due to park hunting restrictions by helping old hunters train young generations to hunt. The Khwe San face a large high school dropout rate because students struggle to pay for hostel fees. To fill this education gap, the KA supports 20 students in various training colleges. The KA is also part of a Joint-Management Committee that oversees hunting in the park with MET, and a Technical Committee. The Technical committee is composed of representatives from different ministries, neighboring conservancies and NGOs that advise the MET on general park management issues beyond hunting (Jones and Dieckmann 2014). Currently, the government has the official position that communities may benefit from parks, but the government would prefer communities not to be involved with management. However, the KA demonstrates that communities can successfully and effectively help manage parks (Jones 2012). In sum, the benefits that are accrued from an association are similar to those obtained from a conservancy. The association is another way to allow a marginalized community to have a more legitimate form of representation.

The Kyaramacan Association benefits of harvest organization, continuation of local knowledge, and educational scholarships show that there is potential if the Topnaar do decide to organize themselves as an association. !Nara harvesters would benefit from an association that would defend their interests, as the KA did for devil's claw harvesters. The needlework group presented in the Gobabeb proposal could work as a TEKOA-type project, which ensures traditional knowledge continues to be used by the community. After the creation of a broad association, a sub organization, the Technical Committee, which would

be composed of Gobabeb, MET, the TTA as well as the broader association, could then be created. This committee would help address Topnaar community members' desire for more empowerment and consideration in park management decision-making. Just like the Khwe San, the Topnaar also struggle with students dropping out of school because of educational expenses (personal communication), and an association could attract donor funds that help support students. Overall, an association could also give more legitimacy to the Topnaar community and allow for empowerment and development to start from within the community.

While the KA presents several opportunities as to how the Topnaar could benefit from an association, the KA also has some unique characteristics compared to the Topnaar, such as lacking a Traditional Authority (TA) and having game to hunt. The Khwe San do not have an officially acknowledged TA. Therefore, the KA is the only organization that can speak on their behalf to the government (Jones and Dieckmann 2014). Since the Topnaar already have a TA, they may not think an association is necessary or sufficient to appropriately represent their human and land rights. In fact, because the Topnaar already have a TA, the TTA may not want an association that would circumvent their power as the link between the government and the Topnaar. Moreover, a significant amount of the monetary and in-kind benefits come from the trophy-hunting concessions, which the Topnaar do not have. Therefore, without this significant hunting income, the Topnaar may struggle to support the association itself. Furthermore, the KA relies heavily on IRDNC; it is likely that the association would not be able to continue operations without their assistance (Interviewee). The Topnaar would either have to obtain long term support from Gobabeb or from a partnering NGO.

It should also be noted that based on interviews the Topnaar Traditional Authority is already in the process of evaluating if creating a legal entity would better represent Topnaar interests and rights. The TTA is currently trying to work with the government to rezone the land in order to have their own communal land (Topnaar Traditional Authority Representative #1). Both Gobabeb and the TTA have been separately investigating how to improve land access for the marginalized community, so it would be beneficial if there was more communication and collaboration between both parties.

V. Findings

a. *Previous Community Capacity-Building Efforts*

Our review of previous efforts in conjunction with feedback from interviews with Topnaar community members suggests some opportunities that the proposal could build upon to complement prior programs and events that Gobabeb has hosted.

Since many Topnaar successfully completed the Level 1 and Level 2 guide training, we recommend that the upcoming tour guide training to be narrowly tailored to the World Heritage Site and local area. One community member claimed that there are not enough employment opportunities in the local tourism industry to employ the Topnaar who are already certified in Level 1 and Level 2 tour guide training (Topnaar Community Member #1). This sentiment was echoed in our interviews with two other members of the Topnaar community as well:

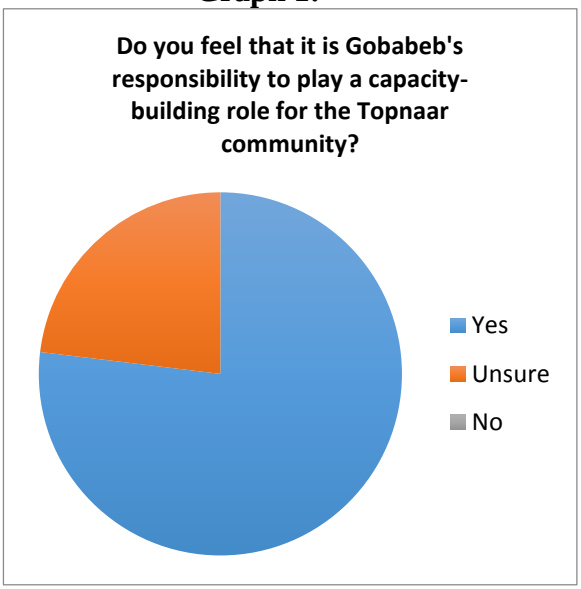
We were 16 candidates when started the training. And in the end, we received the Level 1 and Level 2 training. In the end, only 5 received national guide training, so they are national guides now. But they are not in that field. Only two of the national guides are not working as guides (Community Member #3).

My daughter was here for the tour guide training. My daughter learned to be the tour guide, but she cannot work. The guests who are coming do not want tour guides (Community Member #5).

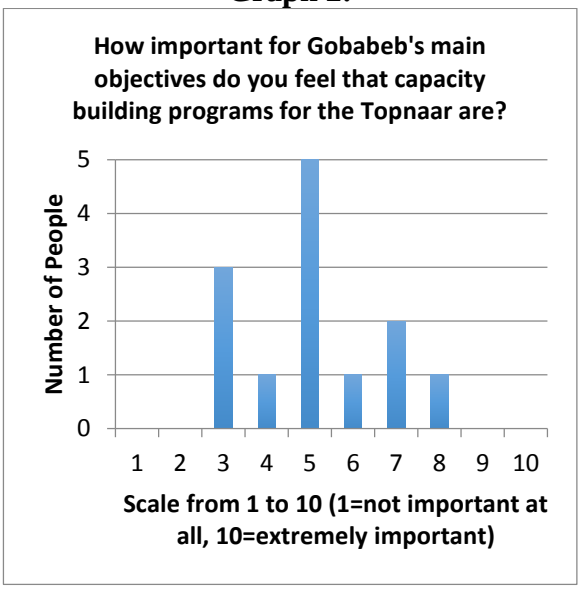
b. *Gobabeb Staff Survey*

Our quantitative survey yielded a number of important results. First, the survey confirmed the short-term nature of employment at Gobabeb. Among the staff surveyed, the average duration of employment was only 1.73 years. As will be discussed shortly, this rapid turnover of staff has significant implications for the formation of institutional memory at Gobabeb. While more than three-quarters of the staff believe that Gobabeb has a responsibility to play a capacity-building role for the Topnaar community, the opinion of the staff with regard to the nature of the relationship between Gobabeb and the Topnaar differed dramatically. When asked to rank the importance of capacity-building programs for Gobabeb's main objectives on a scale from 1 to 10 (1 being not important at all, 10 being extremely important), responses ranged from 3 to 8 (See Graph 2). The majority of the responses were concentrated on the lower end of the range. This result could be explained by the staff responses about the most important and least important reason that Gobabeb should continue to engage with the Topnaar community. The survey asked the staff to rank the following reasons for engaging with the Topnaar community in importance: 'Learning', 'Neighbors', 'Mutual Dependence', and 'Respect'. Almost half of the staff identified 'Neighbors' as the most important reason, and more than half of the staff chose 'Mutual Dependence' as the least important reason (See Graph 4 and Graph 5). Thus, most Gobabeb employees appear to be motivated to engage with the Topnaar community because they feel an obligation due to proximity. Our survey suggests that the majority of Gobabeb staff do not believe that Gobabeb is reliant upon the Topnaar and do not perceive the relationship with the Topnaar to be mutually beneficial. Finally, our survey revealed the discrepancy amongst staff opinions about the quality of Gobabeb's relationship with the Topnaar community. When asked how effective a job Gobabeb has done in reaching out and communicating with the Topnaar community on a scale from 1 to 10 (1 being a very poor job, 10 being an excellent job), the survey responses ranged from 2 to 8 (See Graph 3). Overall, the survey indicated how prevalent internal differences in opinions are among Gobabeb staff about the relationship between Gobabeb and the Topnaar community. These findings provide some insights on why prior outreach efforts may have lost momentum.

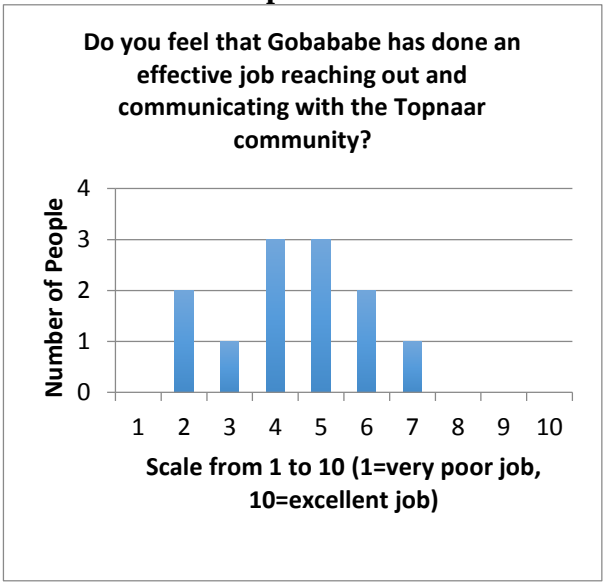
Graph 1:



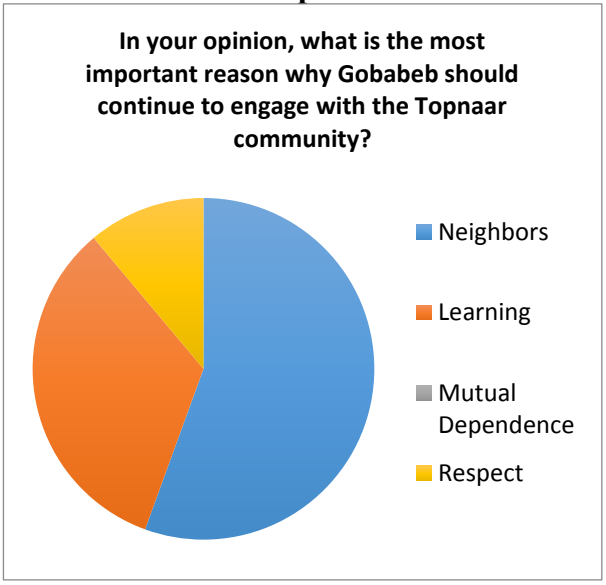
Graph 2:



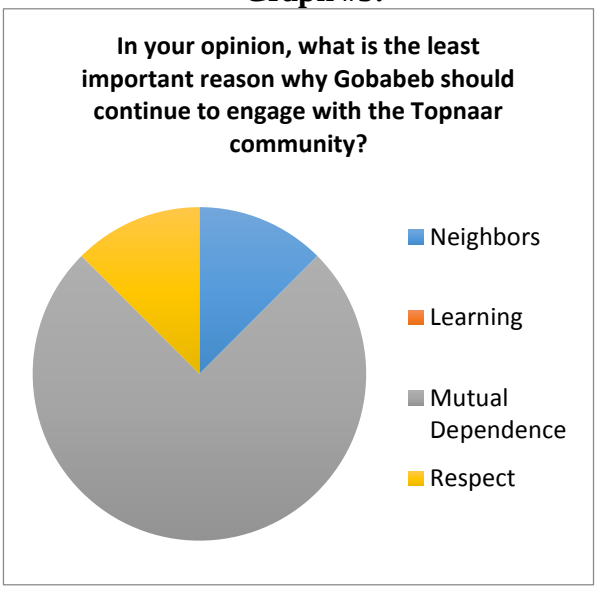
Graph 3:



Graph 4:



Graph #5:



c. *Stakeholder Interviews*

i. Communication

Based on our interviews with key stakeholders, it is clear that communication presents a significant obstacle to Gobabeb's ability to play an effective capacity building role for the Topnaar people. Interviewees from multiple organizations identified two issues impacting communication between Gobabeb and Topnaar communities, including inadequate and infrequent communication and misperceptions about Gobabeb's role in the community.

A common concern throughout many of our interviews was that communication between Gobabeb and the Topnaar community has been inadequate and infrequent. Several staff members acknowledged that the Topnaar are not aware of the research that occurs at Gobabeb, and that a lack of communication impacts their relationship (Gobabeb Staff Member #3). One Gobabeb staff member noted:

> *I think we haven't done a great job in the past of kind of disseminating the knowledge that we've gained or kind of what we're doing, so often times the people don't actually know what's going on at Gobabeb, they just know it's a research and training center.* (Gobabeb Staff Member #4)

Other stakeholders shared similar concerns. Regarding Gobabeb's research, a government official from the Ministry of Youth, National Service, Sport, and Culture asked:

> *What have they done themselves to let the people know what makes it important and ways how the community can benefit?* (Government Representative #1)

Members of the Topnaar community also expressed dissatisfaction with the lack of communication about the Centre's research. One community member remarked that

Gobabeb must "bring the research down to the people" as a way to improve relations (Topnaar Community Member #1). A representative from the TTA similarly noted:

> *We would like to know, for instance, research that is being done at Gobabeb. We don't have access to that. If information comes out from us [Topnaar community members], that information can at least be available for us or released to us.* (Topnaar Traditional Authority Representative #1).

Interview findings also indicate several misperceptions about Gobabeb's role in the community and the scope of their research and training initiatives. For example, members of the community stated that Gobabeb must assist them with problems such as groundwater availability, sanitation and hygiene, and availability of electricity. One community member commented that Gobabeb "must warn people in advance" about floods and other climatic events that might damage crops (Topnaar Community Member #2). Though such requests are not unimportant, they fall beyond Gobabeb's current research capacity and agenda. Several Gobabeb staff members acknowledged this disconnect between what Gobabeb actually does and what community members perceive Gobabeb to be capable of:

> *I think sometimes there are some misunderstandings on the Topnaar end of what we're doing for them and thoughts that maybe we should be doing more for them.* (Gobabeb Staff Member #4)

> *Maybe if they can better articulate their research questions or their needs which would require research to be done, and us to have some means of prioritizing what we can do to help. Rather than expectations put out there and we can't deliver.* (Gobabeb Staff Member #8)

Despite identifying several challenges related to communication between Gobabeb and the Topnaar community, many stakeholders identified increased interaction as a way to improve relations. Several community members expressed a desire to enhance their communication with Gobabeb:

> *We have to meet and we have to express these needs or expectations that we have towards one another.* (Topnaar Community Member #3)

> *We definitely would like to have a closer interaction with Gobabeb.* (Topnaar Traditional Authority Representative #1)

> *We are only 34 kilometers away… let us sit together and plan.* (Topnaar Community Member #4)

Nearly all of the Gobabeb Staff we interviewed also identified communication as an area that, if improved, could enhance relations with the Topnaar community. Staff members noted:

> *But if there was a better understanding on both ends of what they actually want and need and what we're actually capable of giving to them, there would be greater appreciation on both ends of what we are able to give and*

> *it would be more useful to them what we do give.* (Gobabeb Staff Member #4)

> *Maybe just once or twice having a forum where you can just meet and share concerns or new issues coming up or new opportunities, I think would be useful. And this element of distrust, which has been there, hopefully, will be whittled away.* (Gobabeb Staff Member #8)

One Topnaar staff member even identified the sewing circle component of the proposal as a specific opportunity to improve communication and relations between Gobabeb and the Topnaar (Gobabeb Staff Member #5).

ii. Collaboration

Our interview findings revealed results related to collaboration that may impact Gobabeb's ability of achieving their current and future mission, in terms of research, training and community outreach.

From interviews and data analysis of historical documents, it appears that at least some levels of partners' needs are being met: Topnaar have expressed needs in transportation and employment and Gobabeb has provided those. However, in terms of higher-level collaboration where both partners' expertise is recognized and mutual benefit is achieved, interviews indicate there can still be improvements. For example, one Topnaar representative expressed desire for more strategic input on general management decision-making processes at Gobabeb. However, an interview with a leader at Gobabeb indicated that they have already provided the TTA with space for involvement in decision-making by offering the chief with a seat on the Board of Trustees.

Interviews also offered insights on collaboration in terms of research. Gobabeb's mission is strongly focused on research and multiple interviewees perceived a need for collaboration in the research process. For example, one Gobabeb staff member stated:

> *It is important to have better relations, then they would be more willing to assist groups…the better the relationship is, the more willing they will be to help, we have quite a few groups that want to interact with the Topnaar…* (Gobabeb Staff Member #5)

A Topnaar representative indicated interest in collaboration in order to benefit from Gobabeb's research, for example, research on solar energy to provide electricity for elderly community members.

Despite this interest, our findings showed that some participants perceived a lack of equal collaboration. For example, three Gobabeb staff members recognize that collaboration with the Topnaar is not integral to their research mission per se. In addition, Topnaar interviewees indicate a problem with the research process itself. Our presence as Dartmouth students in the socio-ecological system came up several times as an indicator of this problem. There is a perception amongst several Topnaar interviewees that they are research subjects instead of research partners. They indicate a lack of research benefits as a key

problem. They feel as though research benefits are not distributed in a way that recognizes their contribution to the research process. There was a desire that the research that we were doing at Gobabeb, not only benefit us and Gobabeb, but that it also benefit the Topnaar, especially when this research is about them. Two Topnaar community members argued:

> *If Gobabeb is doing research, they bring people to us! … There must be a wedding between us [Gobabeb and Topnaar] first before you guys come, so if we know that what Gobabeb gets from you, we are also benefitting from it.* (Topnaar Traditional Authority Representative #1)

> *Last year there were people asking me the same questions…it is only you benefitting from these things.* (Topnaar Community Member #3)

Even though there were some challenges with collaboration in the research process, past and current training programs came up as examples of productive collaborations. Regarding the 7th grade curriculum currently under development, Gobabeb feels confident about its implementation because they have collaborated well with the school in the past and have already supported a nationwide change in environmental education:

> *The school has a better understanding because it falls directly under our training…we work with schools all the time* (Gobabeb Staff Member #4)

Importantly, there are developments going on in Topnaar villages that present opportunities for collaboration with the activities presented in the proposal. A Topnaar community member suggested the following:

> *Somehow Gobabeb is planning for the future in tourism industry…why not join hands with community because we are also in tourism industry? Already have road concession as well… why can we not link up of the community? We can also help develop community campsite as well…can do joint promotion or management of both center and community.* (Topnaar Community Member #3)

A Gobabeb staff member did see this collaboration with the community as feasible since the community is also at the beginning stages of their projects:

> *They were evaluating the potential of selling some of the crafts they were making to Desert Hills…I think the tribal authority was also looking to create more tourism opportunities and advertise themselves better…but those were all kind of at the beginning stages, so I think we're hoping that by providing this kind of program now, just when they are at the beginning stages of thinking these things too, we can combine our ideas.* (Gobabeb Staff Member #4)

Gobabeb also said that by implementing the proposal, they could act as a liaison for the Topnaar and MET to collaborate. Gobabeb understands that building the Topnaars' capacity to guide tours is not enough; there are already many community members who are tour-guide certified. There is also a need for advertising those skills. By acting as a liaison between the Topnaar and MET, Gobabeb hopes that the MET will advertise for the already qualified tour guides (Gobabeb Staff Member #4).

Nevertheless, there is a misperception from the Topnaar regarding this relationship between Gobabeb and the MET. While Gobabeb see themselves as an effective liaison between the Topnaar and MET, the TTA sees Gobabeb' relationship with the MET somewhat negatively. When talking about their plans to apply for communal land to improve their vulnerable and restricted status as park residents, a TTA representative stated the following:

> *We thought Gobabeb would have assisted in achieving our dreams, but unfortunately now Gobabeb is now a joint venture partner with MET, which is at this moment the enemy.* (Topnaar Traditional Authority Representative #1)

iii. Continuity

While our research confirmed that Gobabeb has offered a variety of workshops, training sessions, and other support programs for the Topnaar community, the data reveals that the programs have been relatively inconsistent. Our interviews indicated that there are two major obstacles to improving the continuity of program offerings: the heavy dependence of the development programs on external funding and the rapid turnover of Gobabeb's staff.

Throughout our interviews, several Gobabeb staff members emphasized that the availability of donor funding was a pivotal factor that drove whether outreach programs were offered and the duration of those programs. One staff member confirmed that Gobabeb does not have a permanent portion of its budget that is allocated towards community development. Thus, Gobabeb must apply to donors to fund specific projects in order to provide programs for the Topnaar community. One Gobabeb staff member noted:

> *I don't know what our capacity to follow through on these things. It's also determined by funding, which can sometimes be difficult as well.* (Gobabeb Staff Member #4)

Another central theme of our interviews was the impact of the quick turnover of Gobabeb staff. Due to Gobabeb's extremely remote location, it struggles to retain long-term employees, especially those with school-aged children. Furthermore, the nature of Gobabeb's training programs often attracts young professionals who are seeking short-term work experience before graduate school. We found that the rapid turnover of staff both hinders the development of long-term person-to-person relationships between Gobabeb staff and the Topnaar community and impedes the continuation of institutional memory. Some Topnaar community members expressed that they were not sure whom to contact at Gobabeb to express concerns and to inquire about programs because of the frequent turnover of staff. This sentiment was echoed in our interviews with Gobabeb staff:

> *I'm hoping these two programs foster a closer relationship with the Topnaar, both at Gobabeb's level and at an individual level… With the turnaround of staff members, one person might leave and then that connection is gone. So it's important to foster more of a connection and communication with them.* (Gobabeb Staff Member #4)

Since Gobabeb's ability to offer outreach programs is somewhat conditional upon its current staff, the changeover of staff impacts both what programs can be offered and the duration

these programs can be offered. When prompted to comment on barriers to increased continuity in program offerings, one Gobabeb staff member remarked:

> *It's very much dependent on what capacity Gobabeb has on the staff at the time… At the moment, we don't have water managers, agricultural specialists, we don't have alternative energy experts.* (Gobabeb Staff Member #8)

The changeover of staff had significant consequences for the formation of institutional memory within Gobabeb. Since institutional memory transcends the individual, it necessitates the continuous communication of experiences, concepts, and know-how between members of the group. The rapid changeover of staff and poor documentation of previous outreach efforts significantly hinders the creation of strong institutional memory at Gobabeb. This lack of institutional memory prevents current Gobabeb staff from effectively building upon previous efforts and improving the design of future programs. As one Gobabeb staff member noted:

> *Well, I think you must know what worked and what didn't work, so that you don't repeat the same mistakes, especially if you're targeting the same beneficiaries with very similar types of interventions… Unfortunately, I think the monitoring and evaluation of previous courses is just not there or wasn't done. So we can't really go back to our paper files for example, because they are not there to see. It's not there.* (Gobabeb Staff Member #8)

While several Gobabeb staff members appeared to be aware that Gobabeb had offered more outreach programs in the past, they were not knowledgeable on the details or outcomes of these programs. Furthermore, many members of the staff claimed that they were not aware of any current development programs that Gobabeb provided to the Topnaar community. A Gobabeb staff member remarked:

> *We've done several projects that have included them in the past… I think this past year, we haven't done much with them. So I think it should be more important than it has been in the recent past.* (Gobabeb Staff Member #4)

iv. *Commitment*

The majority of Gobabeb interviewees identified issues related to commitment to be a barrier to the success of long-term programs. Issues relating to commitment manifested in several ways, including: the continuity of training programs, cultivation of partnerships, and maintaining the Centre's objectives. Gobabeb employees in particular discussed overall dedication to capacity building programs much more than any other stakeholder (they are also the majority of our interviewees), but commitment as an issue was identified in all relevant stakeholders in the region, Topnaar community members, Topnaar Traditional Authority, Gobabeb employees, Gobabeb institutionally, and the government.

Gobabeb employees expressed concerns about commitment on the part of Topnaar community members to program attendance. There is a perception amongst several Gobabeb employees, past and current, that programs ultimately fail because community members drop out:

> *The greatest challenge.... from past experience, when we try to engage with them, they don't commit. You get a small amount of people involved in projects and programs, and as the program goes along, you see more of them drop out until eventually nobody is a part of the program... commitment from their side is a problem...* (Gobabeb Staff Member #5)

While commitment to the program is a problem for program continuation, the employees also recognize there are multiple challenges associated with attendance beyond commitment, such as interest, daily obligations, intracommunity dynamics, trust, and cultural stigma. Some interviewees attribute the decrease in attendance to interest:

> *We had several projects [back in the 1990s], but they didn't want to be a part of it.* (Former Gobabeb Staff Member #1)

Others point out that daily activities and chores can be a barrier for follow through:

> *There is a need and an interest but it is difficult to sustain [the computer education program for the Gobabeb Topnaar staff] they get caught up in their daily activities and household chores.* (Gobabeb Staff Member #8)

Another employee speculated that perhaps it is because of the programs; many of the programs Gobabeb has offered in the past have been about self-improvement, something participants cannot immediately benefit from. This employee wonders if a program that could lead to income generation would have better attendance:

> *With programs in the past, they couldn't see immediate benefits, which is probably why they didn't stick around.* (Gobabeb Staff Member #5)

> *I think they are more interested in capacity programs that would bring in income.* (Gobabeb Staff Member #5)

Others attribute dynamics and tensions community members have with each other, with TTA, and with Gobabeb as barriers:

> *It's a challenge to mobilize them because of intracommunity fighting.* (Gobabeb Staff Member #5)

> *There is a lack of trust amongst them and that makes it difficult for Gobabeb to work with.* (Former Gobabeb Staff Member #1)

Employees perceive that the community members have issues with each other and the center that affects their attendance. Several employees discussed cultural stigma community members may experience for being associated with Gobabeb. One former employee pointed out the long standing tensions between the TTA and community as a problem. Community interest may vary from the TTA's interests, and thus, when TTA forms a contract with Gobabeb, the community is less likely to follow through with this contract Former Gobabeb Staff Member #1, personal communication).

Moreover, Gobabeb employees also expressed that they felt that their partners, the government and TTA, demonstrated lack of commitment to maintaining their end of the relationship:

> *There is a wish that Gobabeb did more... but in some cases, it's not our role, we aren't the government providing services for them, we are a research and training center.* (Gobabeb Staff Member #4)

With regards to the TTA, there are criticisms that, even as a member of Gobabeb's Board of Trustees, the Topnaar chief hardly ever comes to board meetings or makes an effort to come to Gobabeb (Gobabeb Staff Member #8).

However, on the other side of the table, Gobabeb employees also acknowledged that Gobabeb also struggles with commitment individually and institutionally. Individually, short term employees cannot ensure the long term success of certain programs. As a world renowned research institution, Gobabeb attracts many young researchers who are beginning their careers, and these young researchers are often eager to create programs to empower the Topnaar (Personal communication). However, in part because of Gobabeb's isolated location in the Namib Desert, many of these researchers move on after a couple of years at the Centre. Partially because of this high turnover of various experts, programs are not included as part of the long term agenda for the Centre. (Gobabeb Staff Member #9). Long term employees struggle to prioritize time dedicated to the Topnaar focused programs:

> *For me, the biggest challenge, and I know this sounds weak, but prioritizing and finding the time and effort. there are more pressing things... there is some urgency. I must deal with this. that case gets pushed aside because we can talk to Topnaar anytime.... making a firm commitment right now.... translating willingness into action is a challenge.* (Gobabeb Staff Member #8)

For many employees, time can be a barrier, and because of the geographic proximity of the Topnaar, there is a sense that the Topnaar will always be there and may not be a priority compared to temporary visiting researchers.

On an institutional level, many employees pointed out that Gobabeb cannot completely commit to Topnaar capacity building programs because of the current focus of Gobabeb as a scientific research institution. One employee recounted that when he first started working at the center, he was interested in doing a project with the community, but management explicitly told him that Gobabeb was not a social development organization (Gobabeb Staff Member #9). Some employees asserted that Gobabeb cannot commit its own limited resources to the community. Gobabeb is primarily committed to research

> *I'm not sure if a social scientist is something we would recruit because we have so many areas that are more pressing...we would encourage outsiders to do research, but I can't see us doing that; we need a training manager, it's a real need* (Gobabeb Staff Member #8)

> *The research is our core...by doing training, we are giving back to the community...*

it's secondary, but it's still a main component. (Gobabeb Staff Member #8)

Even though in reality both the employees and the institution itself struggles with commitment, the employees also recognize that the Centre theoretically has a responsibility and obligation to the neighboring community:

> *It is important for Gobabeb, but maybe more than corporate social responsibility that we have as an NGO and. they are our neighbors. you know we kind of feel like we should give something to the community that has been recognize as on of the most marginalized in Namibia.... Gobabeb should be assisting somehow in uplifting programs.* (Gobabeb Staff Member #8)

Even after failed efforts, employees still continue to try, because of the recognition that as a neighbor with access to international funding, Gobabeb can do something.

> *There are many things that could be happening under Gobabeb initiative instead of waiting for UNICEF to identify the Topnaar community.* (Former Gobabeb Staff Member #8)

VI. Discussion

a. *Previous Community Capacity-Building Efforts*

The inscription of the Namib Sand Sea as a World Heritage Site along with the development of both the Gobabeb and the Topnaar tourism concession will likely significantly expand the opportunity for employment in the tourism industry in the area. If Gobabeb collaborates with Journeys Namibia and other tourism companies who operate in the area when designing its training program, it could ensure that its program provides the necessary skills that these companies require for employment. Consultation with these tourism companies may improve the likelihood that graduates can secure employment.

Since Gobabeb conducted the two communication forums in 1997 and 2009, it could use the valuable information gathered from these meetings to inform its future program offerings. While Topnaar community members requested assistance on topics that exceed the scope of Gobabeb's mission and capacity, they also identified a series of more appropriate, reasonable issues. We found that the Topnaar community members consistently identified educational outreach programs, increased employment opportunities, and help with !nara research as areas where they would like more assistance from Gobabeb in the 1997 meeting, 2009 meeting, and our interviews. This consistency in responses may indicate that these areas are of the highest priority to the Topnaar community. Additional follow-up in 2015 should be conducted to assess priorities.

b. *Stakeholder Interviews*

i. Communication

Results from our stakeholder interviews indicate that the current state of communication between Gobabeb and the Topnaar community is inadequate to allow the Centre to

effectively play a capacity-building role for the Topnaar. The FLC proposal clearly reflects Gobabeb's interest in expanding their capacity building initiative to aid the Topnaar communities that neighbor the Centre and facilitate "the transfer of new skills and knowledge for the Topnaar," (FLC Proposal). However, as it is, ineffective and infrequent communication between the two parties places a strain on their relationship, and ultimately may threaten Gobabeb's ability to implement the proposal and its components successfully.

Topnaar interviewees frequently expressed frustration with the lack of communication they have with Gobabeb. Despite Gobabeb being physically close, community members spoke of the Centre as being distant and detached. They voiced a desire to know more about the research that takes places at Gobabeb, as well as a desire to know how they can benefit from this research. Gobabeb staff members also acknowledged that they have historically done little to ensure Topnaar community members are informed of the Centre's work, and that the Topnaar are generally unaware of Gobabeb's research and training initiatives. As a result, community members are left to make ill-informed assumptions about how Gobabeb might be able to help them. These assumptions then become expectations, which are frequently left unfulfilled, leading to discontent within the Topnaar community about Gobabeb's role. This also leads to dissatisfaction from Gobabeb staff, as the efforts that are made to assist the Topnaar remain unnoticed or unappreciated. If left unaddressed, these challenges resulting from inadequate communication will severely limit Gobabeb's ability to serve as an effective capacity building organization for the Topnaar. Improvements in both the quantity and quality of interactions between Gobabeb and the Topnaar could significantly enhance their relationship and benefit Gobabeb's implementation of the proposal.

In order to address the concerns expressed by all stakeholders regarding communication, there are a number of potential improvements that can be made to facilitate a stronger relationship between Gobabeb and the Topnaar. Gobabeb and Topnaar members alike identified a lack of awareness within the Topnaar community about the research and training initiatives in place at Gobabeb. Improving community knowledge of Gobabeb's work could involve increasing opportunities for the Topnaar to visit the Centre with "Open House" days, or increasing direct community outreach by Gobabeb to the communities neighboring the center. One suggestion, provided by a Gobabeb staff member, could also be to increase opportunities for Gobabeb staff and Topnaar community members to interact in less formal settings, such as the "Team Topnaar" bicycling program or social gatherings held at the Centre. Interviewees also expressed a desire to engage in more direct, face-to-face communication. Inviting community members to Gobabeb meetings and holding programs within Topnaar villages are both practices that Gobabeb has previously used and could continue to make use of in order to enhance face-to-face communication between the Centre and Topnaar community members. Gobabeb could also communicate with neighboring communities through a staff member working as a "community liaison" to the Topnaar. Though Gobabeb currently employs a Topnaar staff member in this position, increasing the frequency of interaction to include more scheduled, predictable communications and meetings could enhance the Gobabeb's relationship with the Topnaar.

Interviewees clearly expressed a desire and willingness to engage in conversation and improve communication - both the Topnaar and Gobabeb *want* to improve their interactions. Doing so is crucial to improving relations between both parties and establishing the proper conditions for Gobabeb to play an effective capacity building role for the Topnaar. In

increasing the frequency and effectiveness of communication, Gobabeb could improve community understanding of the Centre's research and training initiatives and give the Topnaar a firmer grasp on what research assistance Gobabeb can and cannot provide. Enhancing opportunities for communication may also bridge the disconnect within the Topnaar community regarding misperceptions and unfulfilled expectations with Gobabeb's role, and may allow for more mutual appreciation of what each party is capable of. Engaging in a more effective dialogue will require effort from the Topnaar as well as from Gobabeb; a reciprocal relationship necessitates that all stakeholders contribute and commit to improving communication. In doing so, Gobabeb may be able to more effectively meet the needs of the Topnaar, and the Topnaar may be able to more effectively articulate these needs to Gobabeb. Improving communication between Gobabeb and the Topnaar, in terms of quality and quantity, presents a clear opportunity for both parties to improve relations, and is something that both have identified as being desirable. Such improvements could allow Gobabeb to implement the proposal in the most effective manner possible, and may enhance Gobabeb's interaction with the Topnaar far into the future.

ii. *Collaboration*

Our research detected that collaboration between Gobabeb and the Topnaar is not perceived as equal by some Topnaar interviewees. Gobabeb has met some of the identified needs of the Topnaar, such as transportation and jobs, and provides a space for strategic input from the Topnaar Traditional Authority. However, some Topnaar interviewees have identified that they would like to see more benefits from the research carried out through Gobabeb, especially when the research relates to them. There seems to be a misperception about the benefits of research. Some interviewees felt there was a financial benefit, but in reality Gobabeb does not receive much financial benefit from research, except from donor funding and housing fees. This misperception has also been a source of tension in other community-based participatory research processes. Community partners often perceive that the academic and professional researchers gain the most from research collaborations (Minkler 2004). Although we do not know the entire process of benefit distribution from research, this misperception indicates that there needs to be a clearer understanding of the research partnership.

As identified by Megrue et al. (2013), Gobabeb has been actively trying to shift this mission towards development, while still acting primarily under a structure of scientific research. The FLC proposal is a promising next step in this direction. Gobabeb sees the FLC project as a way to improve collaboration between them and the Topnaar and put the relationship at the forefront. The proposal will aim to ensure that both groups benefit equally from the Namib Sand Sea and its increasing tourism opportunities. If successful, the proposal could ameliorate the TTA's perceptions of Gobabeb's joint-venture agreement with the MET because then all three parties would benefit equally from the national park and the TTA would not feel ostracized. However, only following what the proposal suggests without proper consultation from the community would worsen existing misperceptions expressed by some Topnaar interviewees. Our finding that both Gobabeb and the Topnaar are willing to collaborate and incorporate each other's ideas in these beginning stages is, therefore, an encouraging indicator of the proposal's successful implementation. Furthermore, Gobabeb appropriately recognizes the need to partner with the relevant entities to carry out the proposed activities as successfully as possible. The mentioned partners are the National

Training Authority, NATH, the Namibian Institute for Educational Development (NIED), Journeys Namibia, the Ministry of Youth, National Service, Sport and Culture, the Ministry of Gender Equality, and the National Heritage Committee (FLC Proposal). Gobabeb's previous collaborations with the school and their self-recognized need for partnership with different entities and the community support Gobabeb's capacity to implement their proposed activities.

iii. *Continuity*

Our research demonstrated that the lack of continuity in Gobabeb's outreach efforts has inhibited the establishment of a long-term, positive collaboration and relationship between Gobabeb and the Topnaar community. While reliance upon external funding will continue to pose a challenge to the continuity of Gobabeb's program offerings, we recommend a number of potential strategies to minimize the impact of rapid staff turnover and improve the continuity of its outreach efforts.

As suggested in Activity 4.2 in the FLC proposal, the employment of a Topnaar community member who had the explicit responsibility to serve as a liaison with the community and organize programs would facilitate the cultivation of a long-term relationship between Gobabeb and the Topnaar community, especially at the person-to-person level. While Gobabeb employed an individual in a similar position in the past, it does not currently have any such position on the staff. The establishment of a permanent position for community outreach will give the Topnaar community a consistent person to contact about concerns, suggestions, and program information. Furthermore, it will ensure that momentum to organize and offer programs can be sustained despite the turnover of other Gobabeb staff. When asked about the possibility of employing an individual specifically to focus on community outreach, a former staff member of Gobabeb remarked:

> *I think it would be good to have another person of a similar position [community outreach]. Even if they only came once a week, but had regular contact. I always think that continuity is terribly important.* (Former Gobabeb Staff Member #1)

Another suggestion for Gobabeb to improve the continuity of its outreach efforts is for Gobabeb to engage in long-term monitoring and assessment of its previous programs. In the past, Gobabeb has offered valuable training programs and courses, but it has not performed follow-up assessments with the graduates to evaluate the outcome of these programs. One community member noted:

> *The workshops were taking place a lot of the time, and this is what I'm talking about mentoring and monitoring. You have given us so many workshops on gardening or whatever, but how can we show our interest and see if the skills given have been applied.* (Topnaar Community Member #3).

After Gobabeb provides the tour guide training and establishes the sewing circle, it could implement long-term monitoring and follow-ups with graduates to assess the success of the programs and to gain insight about how to improve these programs in the future. In addition, these follow-ups can serve to increase the continuity of communication and collaboration between Gobabeb and the Topnaar community. While discussing the possibility for

Gobabeb to engage in more long-term monitoring of its programs, one community member suggested:

> *I was thinking more from Gobabeb's point of view… It could act as a kind of interaction to show it's a sustainable relationship. To show, this is not a one-off thing and then we're off, but there is a kind of continuous contact between the community and Gobabeb.* (Topnaar Community Member #3)

One simple, cost-effective strategy Gobabeb could employ to minimize the adverse consequences of staff turnover would be to increase the documentation of the program logistics, outcomes, and lessons learned for the future. Improved documentation will facilitate the formation of institutional memory by providing a concrete source of information that future staff can refer to when they are designing programs. To ensure this information is properly reviewed and utilized, Gobabeb could incorporate a document that details the history of Gobabeb's outreach efforts with the Topnaar community as a piece of its employee orientation program. Similarly, Gobabeb could encourage its staff members to update that document as part of their employee exit program. As Gobabeb tries to improve its institutional memory, one valuable resource could be the Topnaar Central Service staff. Our interviews confirmed that the Central Service staff are Gobabeb's most longstanding employees. Thus, the experience of these employees could serve as a springboard to gather information about Gobabeb's previous outreach efforts to improve institutional memory.

iv. *Commitment*

Interview data reveals that commitment from both sides is perceived to be an issue for long term success of capacity building programs and for the development of a mutually beneficial partnership. Based on Gobabeb employee interviews, the Topnaar community members have struggled to commit to programs beyond the first couple of meetings, and Gobabeb as individuals and as an institution have struggled to continue producing the successful programs. However, moving forward with this proposal, commitment is an important component that needs to be addressed, because the potential funding for this proposal is only for two years. As one participant noted:

> *Project only runs for two years, and that's not enough to really get the ball rolling to be sustainable on its own, that's the problem with funding, so what happens to people after the project funding ends? (*Gobabeb Staff Member #5)

There is not enough data to identify the reason behind program attrition. Despite speculation, one Gobabeb employee noted:

*"We've never looked into why people have dropped out exactly… we have a few theories, but whether or not they are true is another question." (*Gobabeb Staff Member #5)

In order to help retain participants, Gobabeb could periodically check in with the participants to ensure that the program is something the participants would like to continue to commit to.

On the other side, Gobabeb is currently struggling with bridging their desire to help the Topnaar with the practical everyday barriers of lack of in house capacity.

> *"There is funding... it just would take time and effort to get something going.."* (Former Gobabeb Staff Member #1)

Gobabeb may have access to certain funding and may want to help, but in reality, they may not be able to with the current public mission of the center.

Even though it is a center focused on research, there is still a desire to commit to the Topnaar because of the social responsibility of Gobabeb as an institution. Gobabeb employees feel this social responsibility, as neighbors co-living in a very extreme environment. In fact, recently Gobabeb rethought its co-management partner for its tourism concession and switched to a more reputable tourism company that has more experience with community development so that there could be more capacity development for the Topnaar (Gobabeb Staff Member). Now, this social responsibility is even more apparent and contractual: last year Gobabeb was named the monitoring organization for the Namib Sand Sea World Heritage Site. As a World Heritage Site, Gobabeb now has a social responsibility and obligation to ensure local community development.

> *"With the inscription of the Sand Sea, we have to examine that and see to which degree can the local communities benefit more... it's a social responsibility."* (Government Representative #1)

To some extent, Gobabeb now has to answer to the World Heritage organization external rules as well as its own internal responsibility.

Another concern across the interviews is the idea of underappreciation. Gobabeb employees feel that Topnaar community members do not appreciate them, whereas a TTA representative voiced that that Gobabeb take the Topnaar for granted.

> *"Occasionally, there's an underappreciation for what we are doing, so we fall into the idea that maybe there's no use in doing it in the first place..."* (Gobabeb Staff Member #4)

This underappreciation can cause an underlying tension that prevents full commitment from a stakeholder. The TTA representative expressed that the Topnaar-Gobabeb relationship could potentially result in a marriage of sorts. However, because of various issues, especially communication and lack of appreciation, neither side has fully invested in one another:

> *There must be a relationship, there must be a wedding between us...We would like to have that marriage first, or in the near future, so we can benefit from what Gobabeb is benefitting...* (Topnaar Traditional Authority Representative #1)

One community member suggested an official document detailing a contract. If there was a group agreement, especially between Gobabeb and Topnaar, there may be less frustration about differing perceptions of obligations.

> *Whatever it is, there must be a clear memorandum of understanding and clear agreements on what each role player can bring to the table to have a better relationship or better interaction between the community and the Center* (Topnaar Community Member #3)

VII. Limitations of Research

Above all else, we were limited by who we could and could not talk to. In particular, because of cultural, language, and time constraints, we were not able to talk with more Topnaar community members. Moreover, it should be noted that the community members we were able to talk to are all affiliated with Gobabeb, either directly or indirectly. We also contacted previous Gobabeb employees who were closely connected with past capacity building programs. However, given the short timeframe of our research, they did not respond to our emails in time. As a result, we had to minimize our initial intent of conducting an exhaustive, comprehensive historical review of past efforts. A key MET representative was also not available during the time of our research. Of the ten Gobabeb staff members who were not able to respond to the survey, four were off-site, and six were Topnaar community members who could not be reached in time. We understand that this is a significant amount of the Gobabeb demographic and, thus acknowledge that the survey results could have been different.

VIII. Conclusions and Recommendations

Given Gobabeb's position within the Topnaar community, both physically and socially, as well as the Centre's mandate as a research and training facility, we feel that Gobabeb is well positioned to play an effective community capacity building role for the Topnaar. Gobabeb has a long history of working with the Topnaar community in capacity building projects and programs. However, more could be done to learn from these past initiatives or to ensure continuity between previous, current, and future programs. We propose that long term monitoring of capacity building programs be a way to build upon past efforts to enhance future offerings. Further inhibiting Gobabeb from playing an effective capacity building role for the Topnaar is a lack of frequent, quality communication between the Centre and the communities neighboring Gobabeb. Opening up new channels for enhanced face-to-face communication will help to alleviate misperceptions about Gobabeb's role in the community, allow for greater tailoring of programs to meet specific needs, and enhance trust between Gobabeb and the Topnaar. Increasing venues for communication would also improve collaboration between the Topnaar and Gobabeb since it would allow for better clarification of the research process and an interchange of ideas on how both can equally benefit from increasing tourism opportunities. Moreover, to ensure the long-term success of programs, and to allow for communication, collaboration, and continuity, there needs to be a clear and equal commitment from all sides.

Besides long term monitoring, we have several other concrete recommendations that could help improve the implementation of the proposal and enhance the current relationship. These recommendations are targeted to improve the four components of successful capacity building with the ultimate goal to have a more reciprocal, sustainable, and satisfying partnership.

a. *Recommendations to Gobabeb:*

1. Hire a part-time community member to become a liaison

In several interviews, Gobabeb employees acknowledged that having a Community Liaison in the past helped the Centre better understand the Topnaar community. Moreover, word-of-mouth was identified as a more effective means of communication: the community nearest to the research center has a better relationship with Gobabeb, partly because of their close proximity and partly because most Topnaar staff members live here, which allows for more direct word-of-mouth communication. However, Gobabeb currently does not have the funds to hire a full-time Community Liaison, so it is recommended that Gobabeb identify an eager community member to work as a Community liaison part-time. Gobabeb could support this individual to commute to the Centre once a week and throughout the community to spread any information and or knowledge and serve as a facilitator for both sides to share concerns.

2. Appoint a staff member to become the expert at Topnaar relations

While having a Community member act as a Liaison is helpful, it is also important that Gobabeb also contributes to the communicative relationship internally. There have been former Gobabeb employees who were passionate about the community in addition to their daily tasks. Currently, there is no Community Manager at the Centre, but the lack of funds does not have to be a barrier. Instead of hiring a completely new staff member for this role, Gobabeb is encouraged to appoint a staff member to become a community expert. This does not have to detract from that staff member's main job description, but rather add to the job description, at least partially. This staff member would become the expert on Topnaar relations and would continue to work at implementing these capacity programs or at least coordinate shared responsibilities amongst the staff. Ideally, this person would be a permanent staff, but a Grinnell Fellow at Gobabeb would be acceptable as long as he/she trains the next fellow. The duties of the community management would eventually become a part of the employee's contract, clearing up any ambiguity.

3. Organize income-generating programs

While training programs have a great potential, there are some concerns from the community that training is not enough. The Topnaar community could benefit from sustainable income generating programs. Gobabeb could encourage Journeys to hire from the community, as mentioned in the proposal. Moreover, in addition to providing tour guide training about the natural system of the Namib Sand Sea, Gobabeb could provide resources that allow the trained tour guides to advertise themselves as well as help foster connections between the trained tour guides and MET.

4. Create a memorandum of understanding with the Topnaar

When Dr. Charles Koch was executive director, he had a gentleman's agreement with the Topnaar chief that stated that Gobabeb would try to hire from the Topnaar community first before the outside community (Gobabeb documents). This was not an official agreement, but it is reported to have worked effectively at the time. However, because it was not

official, Topnaar community members felt it was not long lasting, especially with changes in Centre management. Therefore, Gobabeb and the Topnaar could work together to create an official document or memorandum of understanding that demonstrates clearly how each side can and will contribute to the mutual relationship.

5. Face-to Face Meetings

Many interviewees mentioned the desire for more face-to-face contact with the other group. Face-to-face meetings can help facilitate communication as well as respect and gratitude. Moreover, misunderstandings are more likely to be addressed in face-to-face meetings.

5. Empower community to create an association

Even though the idea of the Association should come from within the community, Gobabeb can try to empower and provide resources to help the community come to the decision of whether they want to create an association or not. Moreover, Gobabeb is in a position where they can more easily access and then provide legal resources if the Topnaar do choose to create an association.

6. Capitalize on current strengths: education programs

Many Gobabeb employees pointed out that the Centre is already very good at its education programs and, thus, implementing the programs at the school will be the least challenging aspect of the proposal. Moving forward, Gobabeb can identify why exactly school programs have been so successful for the Centre, and use these findings to inform other programs. Through the seventh grade curriculum enhancement, Gobabeb can try to reach out to the Topnaar community through Topnaar children that attend the J.P. Brand School. Beyond the proposal, Gobabeb can expand their school programs to younger kids at JP Brand Primary School. Currently, Gobabeb only offers the programs to grades five and above. Some employees voiced concerns that Topnaar kids are dropping out and suggested that the Centre try and reach them at a younger age to grab their interest.

7. Consolidate historical memory into a hard copy available in the library

Currently, Gobabeb's documentation is neither comprehensive nor readily available. This paper has begun the process of consolidating information from various stakeholders, but this process is nowhere near finished. There are many key stakeholders that the team could not reach. After the consolidation process, there can be a hard copy of all the programs readily available in the library in addition to literature about the general Topnaar community. Moreover, this document would be continually updated detailing strengths and weaknesses of programs, so that there is a more continuous institutional memory.

8. Comprehensive de-brief following capacity building program

One of the best ways to improve capacity building is often by learning from past mistakes and successes, but this is a challenge when there is not enough information about past programs. Moving forward, Gobabeb can better consolidate results from programs through de-briefs with both employees and participants. If a program is a failure and there is little

attendance, Gobabeb could conduct a survey to better understand why participants may drop out. If a program is a success and many individuals continue to attend, Gobabeb could conduct a long-term monitoring program to evaluate the effectiveness of training.

IX. Future Research

Suggestions for future research include:

- Evaluate the capacity programs implemented by the Benefit Sharing Proposal
- Analyze the Joint Venture Agreement between Gobabeb and Ministry of Environment and Tourism
- Assess the role of Journeys Namibia as a tourism operator in this region
- Expand this research to include a more representative sample of the Topnaar community as well as more stakeholders, especially the regional government authority
- Explore the dynamics between the community and the Topnaar Traditional Authority
- Investigate how both Gobabeb and Topnaar can better take advantage of the World Heritage Site

Note: We acknowledge that all stakeholders need to work at improving this relationship and can use the data results and analysis to better inform how this relationship can become more reciprocal. However, please note that the intention of this research project was to better inform the implementation of the proposal. Therefore, our recommendations are mainly directed at Gobabeb since they are the writers of this proposal.

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Appendix I. Stakeholder Interview Questions

Gobabeb Staff:

1. What is your name?
2. What is your position at Gobabeb?
3. How long have you been with Gobabeb?
4. What is your current understanding of Gobabeb's relationship with the Topnaar?
5. How important/relevant is Gobabeb's relationship with the Topnaar community?
6. How do you feel Gobabeb's relationship with the Topnaar has changed over time?
7. What is the greatest challenge to Gobabeb's relationship with the Topnaar?
8. Can you tell us a little bit about Gobabeb's work in capacity-building with the Topnaar?
9. Do you know of anything that Gobabeb is currently doing to assist in the capacity-building of the Topnaar people?
10. Can you tell us a little bit about the programs that Gobabeb has offered in the past?
11. Are there any other kinds of programs that Gobabeb could offer to benefit the Topnaar?
12. What do see as being Gobabeb's role in capacity-building for the Topnaar people?
13. What role will Gobabeb play in the future of the Topnaar community in terms of capacity-building?

Past Gobabeb Staff

1. What is your name?
2. What was your position at Gobabeb?
3. How long were you with Gobabeb?
4. How has Gobabeb's relationship with the Topnaar changed over time?
5. What were some examples of successful capacity-building programs offered by Gobabeb for the Topnaar people?
6. What made those examples of capacity-building programs offered by Gobabeb for the Topnaar people successful?
7. In your opinion, is Gobabeb's relationship with the Topnaar community important/relevant?
8. In your opinion, why has there been a decrease in the workshop Gobabeb offers to the Topnaar?
9. What is your general opinion of the capacity-building initiative at Gobabeb?
10. What do see as being Gobabeb's role in capacity-building for the Topnaar people?
11. What role should Gobabeb play in capacity-building for the Topnaar people?
12. Can you describe some of Gobabeb's previous capacity-building programs for the Topnaar people?
13. In your opinion, should Gobabeb play a role in the capacity-building of the Topnaar community?
14. What were the major problems with past capacity-building programs that Gobabeb offered?
15. What do you know about Gobabeb's current capacity-building initiatives for the Topnaar people?
16. Based on your experience, what can Gobabeb do to improve its relationship with the Topnaar people?

17. In your opinion, how can Gobabeb play a more effective role in capacity-building for the Topnaar people?

Community Members

1. What's Your Name?
2. How long have you lived here?
3. Is your family from this area?
4. Are you familiar with Gobabeb?
5. Will you tell me about the kind of interactions you've had with Gobabeb in the past?
6. Do you personally work with/interact with Gobabeb?
7. Will you tell us a bit about the Topnaar's relationship with Gobabeb?
8. How has Gobabeb's relationship with the Topnaar changed over time, if at all?
9. Will you tell us about the kinds of programs that Gobabeb has offered for your community? How about the Topnaar communities broadly?
10. Have you or do you know anyone who has completed training programs through Gobabeb?
11. Will you share with us how the programs have benefitted you?
12. Are there things you think may improve the programs?
13. What kind of training programs would be best for the Topnaar?
14. Is tourism a big industry in this area?
15. In what ways, if any, have the Topnaar people benefitted from tourism?
16. Do you have concerns about tourism in the area?
17. If tourism expands in the area, is something that will benefit the community?
18. Do you think Gobab1eb can help enhance tourism opportunities for the Topnaar?
19. What do you think is the best way that Gobabeb can communicate with the community?
20. Are there any issues that you feel Gobabeb can assist the community with?

MET Representatives

1. What do you think Gobabeb's role is in enhancing opportunities for tourism in the Namib Sand Sea?
2. What has MET's relationship been with Gobabeb?
3. What role does MET play in capacity-building for the Topnaar people?
4. What role has MET played in capacity-building for the Topnaar people in the past?
5. What is MET's relationship with the Topnaar people?
6. What are some examples of successful implementation of MET's Parks and Neighbors Policy?
7. How can the Topnaar most effectively derive benefits from the Namib Sand Sea?
8. Do the Topnaar people currently benefit from the Namib Sand Sea? How?
9. Do you know about the Karamacan Association located in Bwa-bwata National Park? Could something like this work for the Topnaar?
10. What are some of the challenges that the Topnaar face in being able to derive benefits from the Namib Sand Sea?
11. Can Gobabeb play a role in increasing benefit-sharing opportunities for the Topnaar people?
12. How can Gobabeb most effectively enhance opportunities for benefit-sharing from ecotourism for the Topnaar people?

13. What would the legal process entail for the Topnaar if they wanted to self-organize?
14. How accessible are training programs for the Topnaar people?

Tourism Operators

1. What is your relationship with Gobabeb?
2. In what ways, if applicable, has your organization supported Gobabeb's capacity-building programs for the Topnaar people?
3. What opportunities are there to increase tourism for the Topnaar people?
4. How can the Topnaar people derive benefits from
5. In your opinion, have capacity-building programs affected tourism?
6. Has the tourism industry benefited from capacity-building programs for local communities?
7. Can the tourism industry benefit from capacity-building programs for local communities? How?
8. How do you envision the Topnaar people benefiting from the development of tourism in the area?
9. What role will the Topnaar people play in the development of tourism in the area?
10. What do role do you envision Gobabeb playing in enhancing opportunities for tourism in the area?
11. How can Gobabeb most effectively enhance opportunities for benefit sharing form ecotourism in the area?
12. Would you recruit from the Topnaar community for employment?
13. What skills are most needed from tourism operators?
14. Do you normally partner with local communities in the areas that you operate?

Chief

1. How long have you been chief of the Topnaar people?
2. What are the most rewarding aspects of being advisor to the chief? What are the most challenging?
3. We've seen the flow chart, but we were wondering if you could offer us additional information about the structure of the organization and how you work with urban and rural Topnaar communities.
4. Will you tell us about your process for communicating with the individual Topnaar communities? Are there challenges you experience with that communication/are there any strategies that you feel work particularly well?
5. In terms of new developments within the TTA, can you tell us about the process for sharing this information with the community?
6. Are there any organizations (government, NGO) that the TTA currently works with or hopes to work with? What role will these organizations play?
7. In what ways, if any, is the tribal authority working to enhance opportunities for tourism in the area? Are you working with Gobabeb and/or MET to do so? What are the impacts of increased tourism on Topnaar people?
8. With the new concession on the Khuiseb Delta, have community members been able to share in the benefits from tourism? In what ways? Which benefits?
9. What are the options available to the Topnaar for self-organization and legal recognition as a group? Have you already pursued this in the past?

10. What are the Topnaar community's greatest needs? What are some of the strategies the TTA is using to address these needs?
11. Will you tell us about your relationship with Gobabeb? How has your relationship with Gobabeb changed over time?
12. Approximately, how often do the TTA and Gobabeb communicate with each other? Are there any regularly scheduled meetings with each other?
13. Do you feel the TTA has a voice in the programs that Gobabeb runs with the Topnaar? Does the TTA feel like they are consulted in Gobabeb's decisions?
14. What do you think is Gobabeb's role within the Topnaar communities neighboring Gobabeb? What should it be?
15. In what ways does Gobabeb benefit from their relationship with the Topnaar?
16. In what ways do the Topnaar benefit from their relationship with Gobabeb?
17. What are some assets of the community that you feel Gobabeb should capitalize on/will help Gobabeb?
18. What has Gobabeb's role been in capacity-building for the Topnaar? Have Gobabeb's programs been effective? Do people use the skills that they learn?
19. How can Gobabeb most effectively play a capacity-building role for the Topnaar people? What kind of programs would be most effective for the Topnaar people?
20. Is Gobabeb's role within the community explicit or clear? Do people understand what this role is? How can Gobabeb be clearer about their role within the community?
21. How can Gobabeb more effectively interact with and engage the community? Is it important that Gobabeb consult the community?

Appendix II. Gobabeb Internal Staff Survey

1. How long have you worked at Gobabeb?
2. Do you feel that is it Gobabeb's responsibility to play a capacity-building role for the Topnaar community (i.e. providing workshops, skills training, etc.)?
3. How important for Gobabeb's main objectives do you feel that capacity building programs for the Topnaar people are? Please rank on a scale from 1 to 10 (1=not important at all, 10=extremely important).
4. In your opinion, why should Gobabeb continue to engage with the Topnaar community? Please rank the following reasons from 1 to 4 (1=most important, 4=least important).
    a. Neighbors—Gobabeb and Topnaar are neighbors, and both utilize the resources in the area.
    b. Learning—A relationship with the Topnaar provides mutual benefit for learning about culture, traditional knowledge, and history of the Namib desert.
    c. Mutual Dependence—Gobabeb and the Topnaar are interdependent, and both would benefit from enhanced cooperation.
    d. Respect—Gobabeb should respect the Topnaar because it is located in the traditional Topnaar area where they have lived for centuries.

5. Do you feel that Gobabeb has done an effective job reaching out and communicating with the Topnaar community? Please rank on a scale from 1 to 10 (1=very poor job, 10=excellent job).

Long Term Study of the !Nara Plant, Year II: A New Look at !Nara Pollination

November 15, 2013

Prepared By:

Elinore Beitler
Alex St. Romaine
Caitlin Zellers
Alex Greer
Ari Koeppel

I. Introduction

The !nara plant's role as a key cultural and economic component of the Topnaar community is dependent on its population and reproductive health and resiliency. As demonstrated by the Dartmouth student research group in 2013, a long term monitoring study is an ideal method of gathering baseline data on the health and population of !nara and monitoring trends for the purpose of advising future management protocols (McLaughlin 2013). The purpose of this project is to continue the long term monitoring process initiated last year and to refine its methods in such a way that the study is likely to be continued in future years. Herbivory and pollination were two key areas that we identified as important factors involved in the population trends of !nara that were in need of additional research and monitoring.

Long Term Monitoring

Long term monitoring is an important and effective exercise for tracking the population trends of the !nara plant and monitoring the natural rates of change among key ecological factors (McLaughlin 2013). Currently, aside from the protocol established last year by the Dartmouth student group, there is no official !nara monitoring program. Thus, long term anthropogenic impacts on plant biomass and fruit yields are unknown. In order to make decisions about the management of !nara population health, there first needs to be an established biological knowledge base of the environment in which the plant is living and how it changes naturally and because of human disturbance. The data acquired through our protocol is useful in assessing the pollinator and herbivory dynamics of !nara and their relationship to changes in key ecological markers. These are aspects of the plant that have yet to be comprehensively researched over a long period of time.

Herbivory

Herbivory has been identified as one of the key threats to the !nara plant's ability to produce fruit (Henschel et al., 2004). Literature reports that the !nara cricket, blister beetles, and donkeys are the main herbivores of the !nara plant, although a comprehensive study on !nara herbivory has not yet been completed (Henschel et al., 2004). A long term study in the Naukluft mountains showed that grazers influence the floristic composition of vegetation. The high water content of the vegetation in this region attracts livestock to utilize it as a main source of fodder (Burke 1997). The Topnaar community relies on both donkeys and cattle for livelihood, and allows both species to forage freely during the day. Thus, cattle and donkeys pose a threat to the health of the !nara since it is a significant source of moisture in the arid environment of the Namib. Additionally, livestock tend to feed closer to water sources, in the case of this study the Kuiseb river bed, and can cause significant damage to riparian vegetative zones (Moser-Nørgaard 2011). A preliminary study on !nara herbivory showed that plants without donkey herbivory produced around 5 to 10 times more fruit than those that were herbivorized (Henschel et al., 2004). The rate of herbivory at which !nara fruit productively is significantly decreased is unknown. Furthermore, the plant’s response to herbivory has not been studied. Insect herbivory can also affect a plant's productivity due to damage to the flower, although can also serve as pollinators (florivory), which may balance out the flower damage (McCall and Irwin 2006). For example, gall midges were found to consume the nectar of Asian *Schisandra henryi* and spread pollen (Luo 2010).

Herbivory dynamics are complex and interwoven with plant health and reproduction.
Pollination

The pollination of the !nara plant is an important area of study because it affects the plant's reproduction and survival rates (Irwin). Anthropogenic impacts are likely to change plant pollinator interactions since changes to the plant phenology affect foraging behavior of pollinators (Irwin). For instance, rising temperatures due to global climate change are linearly correlated with earlier flowering dates, which can negatively impact pollination (Hegland 2009). For this reason, insect-pollinated plants such as !nara are more sensitive to changes in temperature than wind-pollinated plants (Hegland 2009). Changing rainfall patterns could also play a significant role in altering !nara flowering cycles and pollinator behavior. The reactions specific to the !nara plant are unknown because of a lack of long term monitoring data.

Additionally, the number of flowers affect pollinator foraging behavior and competition amongst plants for pollinator interactions, which is an aspect of !nara ecology included in our long term monitoring protocol. Higher plant and flower densities are more favorable to pollinators because of a high resource abundance and reduced travel time between feedings (Bernhardt 2008). Any significant changes in plant density could affect the pollinator species abundance and behavior, which in turn could alter the plant's reproductive success. Insufficient pollen distribution is linked to decreased reproductive success in plants (Knight 2005).

Pollinator networks tend to be composed of a generalized mix of species instead of operating with a singular pollinator (Hegland 2009). Shorter studies completed during a specialized season could potentially miss or omit important pollinators. A long term monitoring study assessing the pollinator species inter-annually will capture the breadth of species associated with specific plants (Hegland 2009). Using observations, Henschel (2004) identified the blister beetle *M. zigzaga* and anthophorine bees as the main pollinators for !nara.

Our study of !nara pollination incorporated water traps and flower dye as well as observations. The initial findings of our pollination review identified the midge as another likely pollinator of !nara. *Megommata* gall midges have been shown to be the primary pollinators of the Asian *Schisandra henryi* and *Kadsura longipedunculata* (Luo 2010). Midge eggs were observed on stigmas and pollen grains after midges visited a flower (Luo 2010). All captured midges also carried some amount of pollen grains on their bodies when examined under a high-powered microscope (Luo 2010). Many other species of midge have been shown to feed on flower nectar and, in turn, collect pollen (Larson). These studies demonstrate the pollination capability of midges, prompting further research on the role of midges in !nara pollination.

II. Methods

The purpose of this project was to continue the long-term population study of the !nara plant. We returned to the Kuiseb Delta in Namib-Naukluft National Park and again partnered with Gobabeb Training and Research Centre to conduct research from November 3-9, 2014. This year we expanded the population study to 33 distinct hummocks, returning

to the 16 sites in !Nara Valley and adding 17 new sites in the valley south of the Gobabeb campus (Gobabeb Valley). Although methods from last year were altered, the first data set collected is still significant and useful for a longitudinal study.

Site Selection

We selected 17 new sites in Gobabeb Valley based on accessibility by foot and four wheelers, with varying distances from the Kuiseb riverbed, and male-female proximity. Two of the new hummocks were not fully formed but had new growth. By adding juvenile plants, we hoped to add population demographics not previously captured in last year's study.

Biomass Cover

Last year, McLaughlin 2013 used "the wagon wheel" method to measure biomass coverage of !nara hummocks. In brief, this method divides a hummock into eight triangular transects, measuring from the base of the hummock to the center. The perimeter is then measured between the base of each line transect. These data points are used to calculate surface area. To calculate percent live biomass, the fraction of transect lines intersecting live !nara plants is multiplied by average height of individual !nara clusters and total surface area of the hummock. For further detail on "the wagon wheel" method, see McLaughlin 2013. For the juvenile plants located in Gobabeb Valley, the eight individual transects proved to be unnecessary, since a direct measurement of surface area was possible by measuring length, width, and circumference.

Herbivory

One of the aspects of last year's study was to assess herbivory and its relation to biomass. When reexamining their methods, we determined that the wagon wheel was a sufficient and repeatable method for calculating plant coverage. However, we decided to alter their method for measuring herbivory to better capture herbivory trends. McLaughlin (2013) chose to assess herbivory in relation to the length and period of stem spines, using the *acacia* species as a basis for this comparison. Because there is little evidence that the !nara plant behaves like the *acacia* species, we opted to observe traces of herbivory directly through possible detection of tracks and scat surrounding a hummock and, empirically, by a system of arbitrarily looking at stems and tips. We tested multiple techniques of herbivory assessment before selecting our preferred method. Table 1 lists the different iterations of herbivory methods we tested and the limitations and benefits of each technique.

Table 1. Herbivory Measurement Techniques

Method	Description	Limitations & Benefits
Spine Length & Period	Choose a stem and count 10cm towards the base. The next five spines are measured for length individually and between the first and the fifth. Lastly, the tip is checked for herbivory.	- acacia not a good proxy - labor intensive - doesn't differentiate herbivory type
5-Stem Pointing	Arbitrarily select 5 stem tips on each live plant on the transect line. Identify damaged or undamaged	- selection bias - doesn't differentiate + quick
10-Stem (Damaged/Undamaged)	Arbitrarily select 10 stems at root on each live plant on the transect line. Follow to tip and identify damaged or undamaged	- doesn't differentiate + larger sample + less selection bias + quick
10-Stem (MLO)	Arbitrarily select 10 stems at root on each live plant on the transect line. Follow to tip and identify mammal damage, live, or other damage	+ more differentiation but still broad + larger sample
Bolger Method	Divide hummock into four quadrants (North, South, East, West). Select three plants along each cardinal direction (lower, middle upper). Divide each live plant into upper and lower sections. Within section, follow one stem root to tip and identify all signs of herbivory according to the key*. Estimate length of stem. Then select five tips and identify all signs of herbivory.	+ differentiation among herbivory types + comprehensive guide + accounts for location on hummock + includes stem size - smaller sample - labor intensive
MLO/Bolger Hybrid	Do MLO method for each live plant on the transect line. Arbitrarily select one stem on each plant and do Bolger method.	+ differentiation among herbivory types + quicker + larger sample

donkey herbivory photo: 58 and insect herbivory photo: 165

Fruit Size

Another change to last year's study involves characterizing plant fruit and flower growth. Previously, the study had only counted and measured fruit and flowers within a half-meter distance of the transect line. We felt the total number of fruit and flowers was more indicative of plant health than fruit size and, thus, we continued to count fruit and flowers on the transect line *and* the entire hummock. We ceased to measure fruit circumference because

it was not indicative of plant health.

Pollination

Our major addition to the population study, and a highlight of this paper, was our identification and analysis of potential pollinators of the !nara plant. Henschel (2004), the first and only pollination study on !nara, was based on a methodology of observation and net capture. We replicated this methodology in our initial assessment and incorporated water traps to identify any further species not observed. We developed a specific methodology for using water traps and fluorescent powder on flowers. Water traps are water-filled bowls that imitate flowers and attract a variety of pollinators. We used a solution of 60% water, 40% *propylene glycol* (anti-freeze), and a drop of dish soap in our water traps, to prevent evaporation and increase capture success (Kearnes and Inouye 1993). We set up water traps of four different colors (blue, green, yellow, and white) at 12 distinct plants in Gobabeb Valley, staggered at three general distances from the river (100 meters, 1 kilometer, and 3.5 kilometers). In addition to our own initial observations of flower visitors, we enlisted eight unbiased observers to confirm any discrepancies between the water trap method and pure observations. Additionally, green powder was painted on all open female flowers, while orange powder was painted on the male flowers, except at site 12-17 where the colors were mistakenly reversed. The powder is meant to mark potential pollinators that come in contact with the flower. Samples were collected from each water trap at three different times (morning, afternoon, and night) to account for insect variability. Captured insects were then observed in the Gobabeb laboratory using an ultraviolet blacklight to highlight any powder grains that adhered to the insect. A 10x magnification microscope was used for closer analysis of powder adhesion and invertebrate identification. From each sample, we recorded the types of insects present, the number of each type, and any traces of color.

Data Analysis

After compiling the data digitally in Excel, we utilized the statistical analysis program JUMP to conduct t-test analyses and regression models. Our main goals when analyzing the data that we collected were to a) compare our data collected in !Nara Valley to the data collected in the same location last year, and b) set the new herbivory measurements and pollination data within the larger !nara population monitoring framework.

III. Data and Results

Long Term Monitoring

Within !Nara Valley, several factors demonstrated statistically significant differences from 2013 data. Between November, 2013 and November, 2014, live biomass in the !Nara Valley decreased ($t=1.77451$, $df=22.59929$, $p=.0422$), with the average plant biomass decreasing by 56% (Figure 1). Total number of fruit in !Nara Valley also decreased ($t=2.303$, $df=19.45209$, $p=.0324$), with average number of fruit per female plant decreasing by 82% (Figure 2). Lastly, the percentage of herbivorized biomass increased ($t=6.110249$, $df=23.99968$, $p=<.0001$) (Figure 3). The average percentage of herbivorized biomass in 2013 (11%) was 38 percentage points lower than the average percentage of herbivorized biomass in 2014 (49%).

Figure 1.

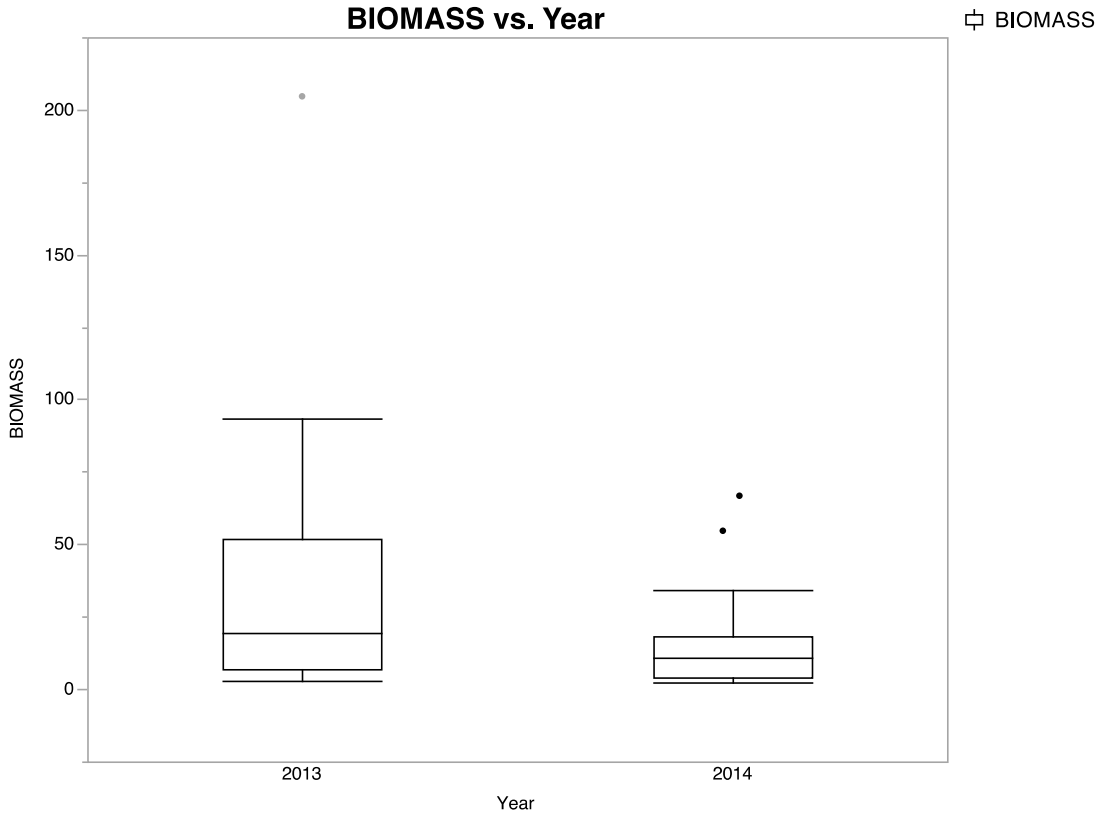


Figure 2.

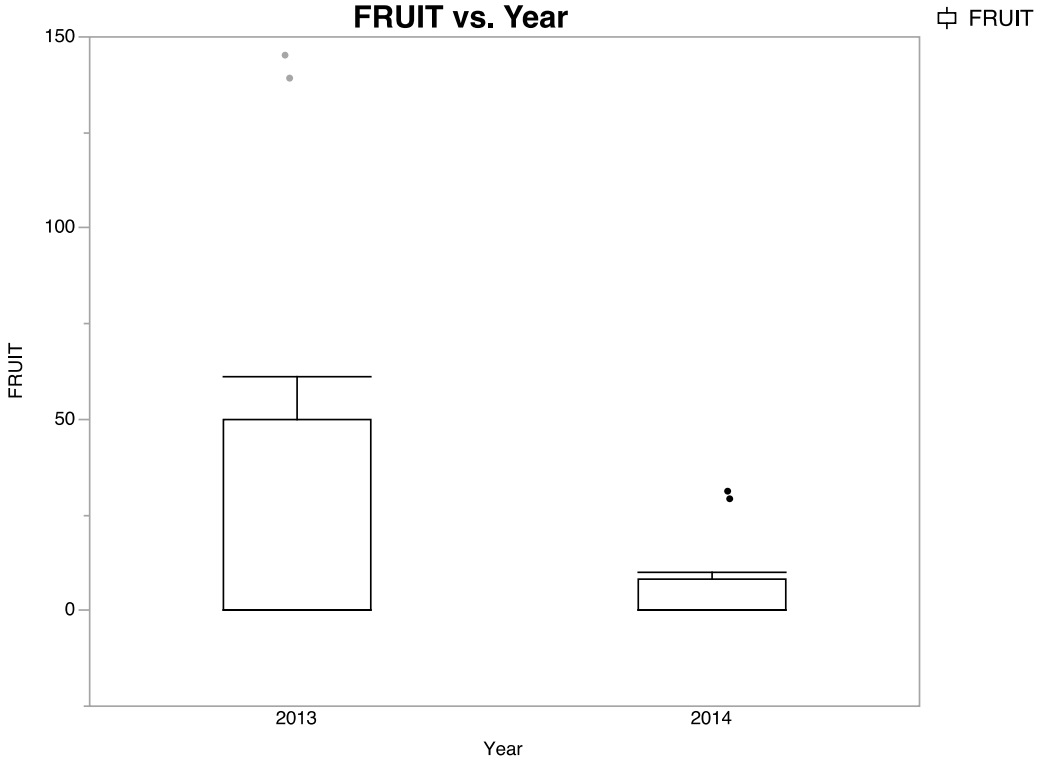
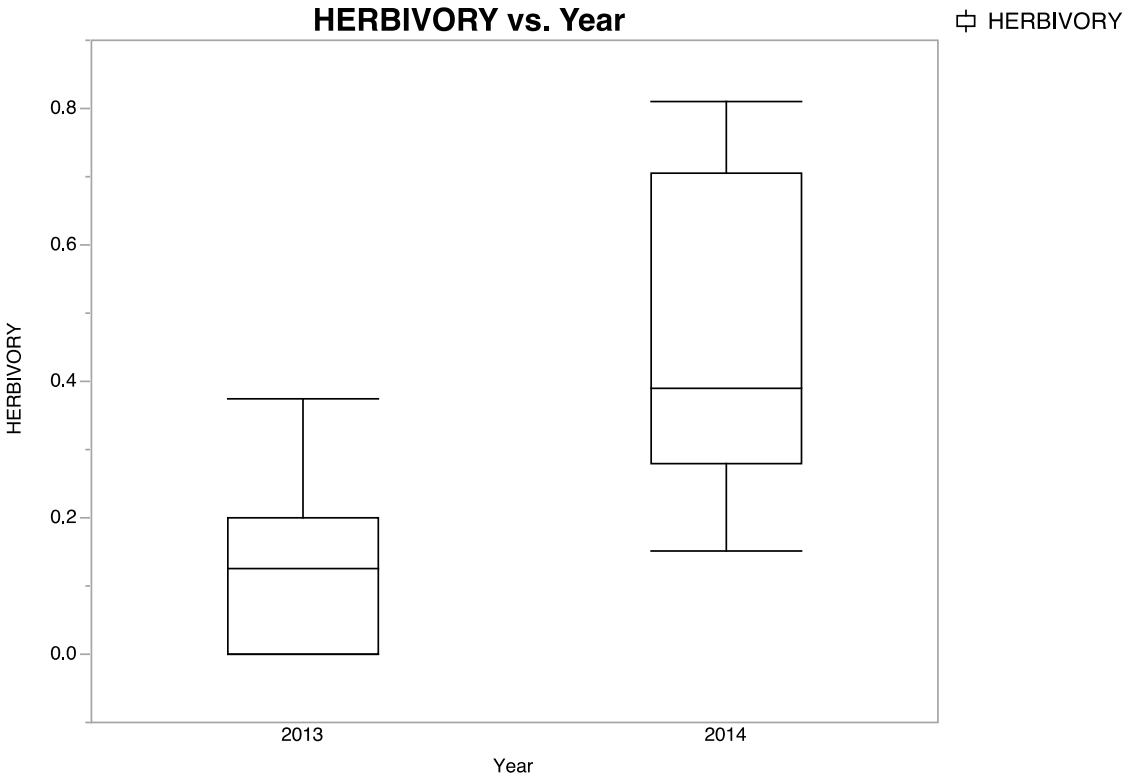
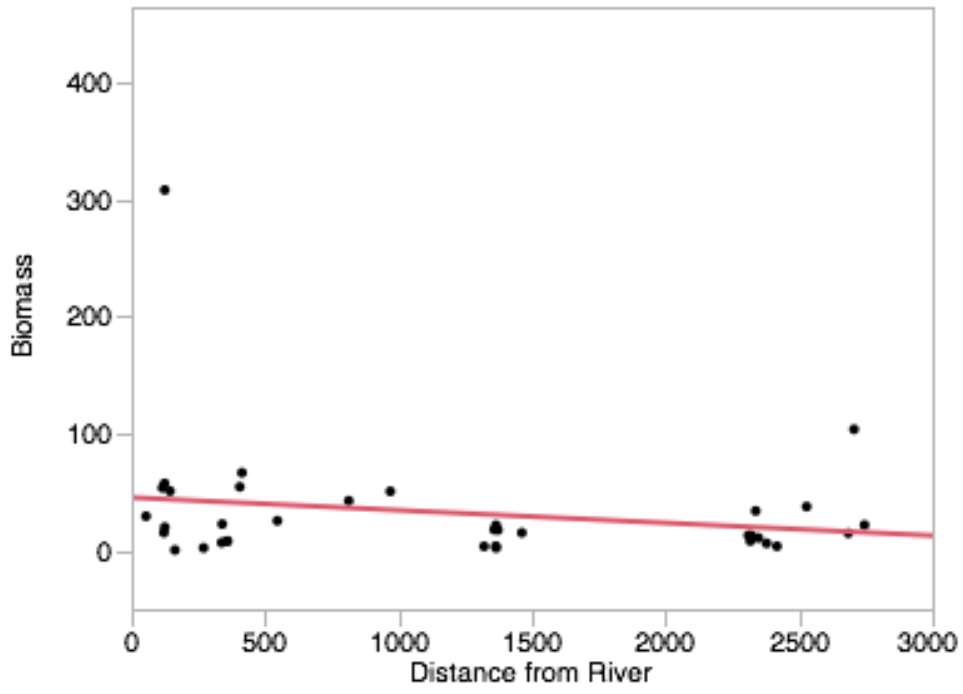


Figure 3.



Total live biomass does not have a statistically significant relationship with distance from the river (R^2=.040337, p=.2402; Figure 4).

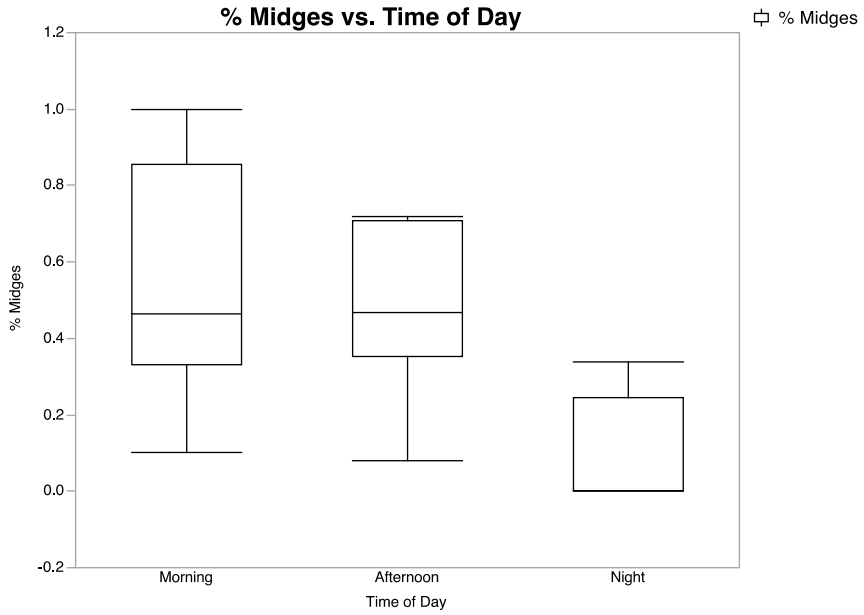
Figure 4.



Pollination

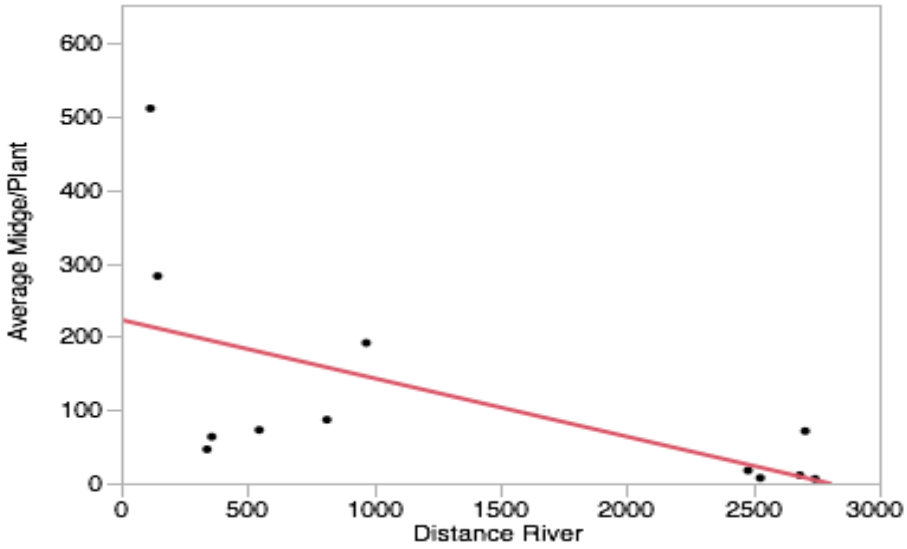
Time of day influenced the number of midges collected at each site (F=10.9138, df=2, 30, p=.0003; Figure 5). Within time of day, the night interval was significantly different from both the morning (p=.0001) and afternoon (p=.001); morning and afternoon were not significantly different from each other (p=.561). On average, 9.4% of total midges were captured during the night interval. For the morning and afternoon intervals, the average percentages are 54.9% and 49% respectively.

Figure 5.



In Gobabeb Valley, distance from the river negatively influenced the average number of midges collected at each plant (R^2=.269533, p=.01; Figure 6). As the distance from the river increases by 1 meter, the number of midges collected decreases by 0.204 midges. No significant relationship was found between average number of midges and sex of plant (p=.4519), percent of plant herbivorized (p=.0711), or number of flowers/buds (p=.1232). Average number of midges per plant was used instead of total number of midges per plant to account for the unequal number of samples taken at each plant.

Figure 6. Average Midge/Plant vs. Distance from River



Midges of each gender color were in found in water traps at both male and female plants (Table 1). On average, 15.3% of the midges with color in the female water traps had male-colored dye. In the male water traps, 21.8% of the midges with color had female-colored dye.

Table 1. Midge Coloration Patterns

Species	**Male Bowl**		**Female Bowl**	
	Male Color	Female Color	Male Color	Female Color
Unidentified Midge	97	27	68	375

In total, 10 different insect species were found with colored dust, indicating that they visited at least one male or female flower with several species visiting flowers of both sex (Table 2).

Table 2. Insects with Flower Color

Insect	**Male Color**	**Female Color**
Midge	165	402
!Nara Fly	3	16
Blister Beetle (*Mylabris Zig Zaga)*	9	2
Blowfly (*Diptera, Colliphoridae)*	1	7
Anthrophora Aure	3	0
Small Moth	1	1
Small Beetle (*Chrysomelidae)*	0	1
Wasp (*Hylaeus*)	0	1
Flying Ant	0	1
Carpenter Bee (*Anthrophoridae Hymenoptera*)	1	0

A total of 8 unbiased participants observed insect interactions with !Nara flowers (Table 3). None of the observers described midges in their findings. Furthermore, two biased observers who knew about the midges took observations at different locations. Again, no midges were observed visually during the observation period.

Table 3. Field Observations

Observer	**Time Period**	**Observations**
Amanda Toporek	9:05am-9:20am	Tiny black ants near ovary, grey fly on flower
Dee Kahuure	10:20am-10:35am	Grey/blue flies on flower, small black ants on stem, big black ants near flower
Jonathan Chipman	10:20am-10:35am	Small ants on buds, green flies on stem, blister beetles near flowers, white butterfly, bees in and out of flower, large ants on stems
Karen Bieluch	11:00am-11:15am	Ant on flower and stem, two large beetles, small ants on new bud, honey bee on flower
Robert Logan	6:35pm-7:05pm	Two flies on flower, ten small gnats at his feet but ignore the plant, one fly lands on spine .5 meters from flower
Taylor Chicoine	6:35pm-7:05pm	Small black ants on flower petal, inside of flower and stem, one small black bee on inside of flower eating and being coated by powder, small green bug flying 8mm from flower
Thorsten Machauer	6:35pm-7:05pm	Ants in and around flower
Nelly Black	6:35pm-7:05pm	!Nara flies around flower and stems, !Nara cricket feeding on stem and flower, two beetles on stem far from flower, one small black ant near bud
Caitlin Zellers (Biased)	5:34pm-6:04pm	Small ants on flower petals and buds, aphids inside and outside flower with ants moving around, medium-sized brown fly on flower touching pollen, no observed midges
Alex Greer (Biased)	8:30am-10am	Three !nara flies, three blowflies and 2 bees in flower, !nara flies, bigger fly, ants, yellow and black beetle, small and pale fly, and moth flying around flower

Herbivory

Percent of herbivorized biomass is negatively correlated to distance from river (R^2=.269533, p=.0037; Figure 7). No significant relation was found between herbivory percentage and sex of plant. However, on average, male plants had higher levels of both mammalian and "other" herbivory (Figure 8). The "other" category serves as a proxy for both insect herbivory and unidentified plant damage. On average, the percent of plant with mammal herbivory was 3 percentage points higher in males than females, while the percent of plant with other herbivory was 11 percentage points higher in males.

Figure 7. Percent of Plant Herbivorized vs. Distance from River

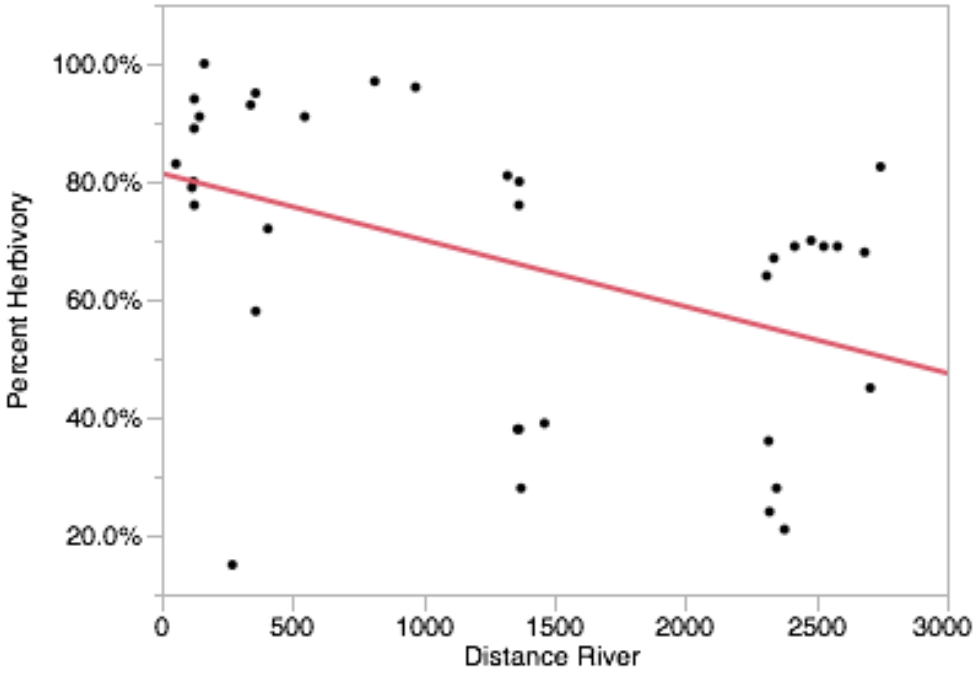
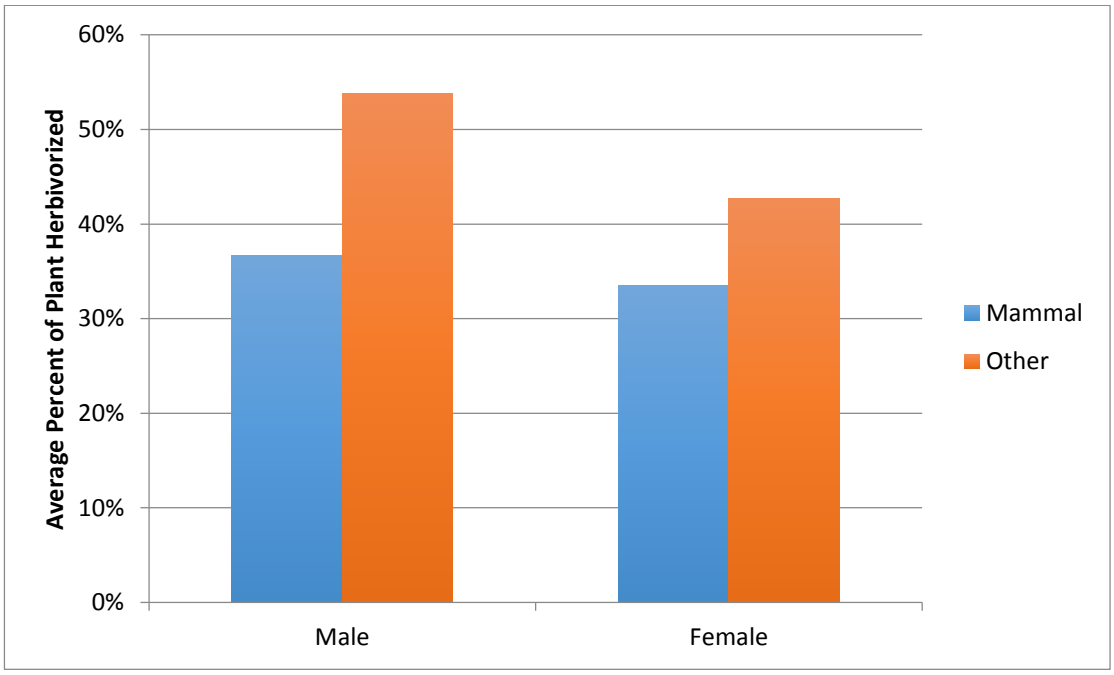


Figure 8. Types of Herbivory by Sex



IV. Discussion

Long Term Monitoring

The purpose of this study was to continue the long term monitoring study initiated by the 2013 Dartmouth student research team and to refine and enhance its methodology. Our goal was to make comparisons between each year's data sets in order to begin assessing trends in ecological markers. Measurements in 2013 differed significantly from 2014 in total live biomass, fruit count, and herbivory rates.

Both fruit count and biomass decreased from measurements taken in 2013. Mclaughlin (2013) documented a positive correlation between biomass and fruit count, which could explain why both have decreased. Although the 2014 research team began measurement during the same week as the 2013 team, it is possible that the research periods aligned with different points of the !nara reproductive cycle. Two years of data are not enough to ascertain whether this is a trend and the factors, such as changing weather or temperature patterns, that may be influencing plant behavior. A reduction in fruit yields can be attributed to a general reduction in biomass, but it can also be a result of early or late flowering, lack of pollination, or harvesting by humans. The fruit reduction could also be related to the increase in herbivory found in 2014.

It is worth noting that the herbivory methodologies of this year and last were markedly distinct. Thus, the observed differences in herbivory could be a result of different measurement techniques. Moving forward, we believe that our improved herbivory technique will provide more reliable data throughout the long-term monitoring process.

Our sample sets in both !Nara Valley and Gobabeb Valley are positioned in clumps at varying distances from the Kuiseb River. We hypothesized that plant biomass would decrease with increasing distance from the river, but no significant relation was found. Instead, live biomass was fairly consistent along each valley. This result could suggest that the !nara plant does not directly rely on water from the main Kuiseb ephemeral river system but instead relies on other water sources, such as fog or deep ground water reservoirs (Henschel 2004).

From the data that we collected and the initial statistically significant comparisons, we determined that the long term monitoring study is an effective and important method of assessing the key ecological markers of the !nara plant. In future years of monitoring, these comparisons can be used to determine long term trends and the affects of anthropogenic or natural changes in environmental conditions on !nara productivity.

Herbivory

An important result of the herbivory aspect of our study was the negative relationship between total herbivory and distance to the river. From observation, one prominent mammalian herbivore of the !nara are the donkeys, which are owned by the neighboring Topnaar communities. These donkeys are more likely to forage close to water sources, a trend documented among western Namibian cattle (Moser-Nøgaard, 2011). Moreover, our result indicate that certain insects are also water constrained. The increased herbivory rates among male plants could be attributed to the fact that males tend to have more flowers than females. Generally insect herbivores are attracted to flowers more than the fruits of a plant (Irwin), which could explain our results. Furthermore, because the !nara tend to drop their fruit within the plant's spiny branches, mammals might prefer eating the stems and flowers.

Pollination

Perhaps the most novel result from this study was the discovery of a large number of small midge species (Order: *Diptera)* with traces of dye from both male and female flowers in the water traps. Until now, this species has been undocumented in the context of the !nara plant, with no mention in the one pollination study (Mayer, 2004). While our findings are not entirely indicative of the midge being a main pollinator, the quantity of dyed midges and the frequent presence of male flower colored midges in water traps on female plants strongly suggests these midges are a pollinator of !nara. The absence of midges from any of our human observations of !nara flowers explains the discrepancy between our study and the previous research, which did not use water traps.

From previous studies it has been found that such small *Diptera* species breed in flower buds, and consume pollen and nectar as the staples of their diets. This prior research aligns with our observations. Once aware of the midge presence, we were able to discover recently bloomed flowers with a number of midges deep in the flower and on the anther.

In addition to the discovery of the midge-!nara interaction, our results from the water traps are also indicative of a number of spatial and temporal dynamics in this relationship. The observations of midge prevalence changing with time of day may be connected to the

phenology of the !nara plant and to temperature. Male and female flowers typically open between 8:00am and 11:00am before being eaten or losing pollen by the end of the day. The highest levels of midge activity coincided with this timeframe. Previous studies suggest that this could be a function of midge breeding behavior in flowers (Luo, 2010).

Our finding that midge density is also correlated to distance from river might be explained by a reliance on additional moisture sources. Wind may also influence this result, since wind speeds are higher farther up the valley, away from the river. Considering the short life span and weak flying ability of such small Diptera species, wind could be a significant determinant to the spatial distribution of midges. Although the scope of this study did not take these factors into account, further studies might reveal their significance.

V. Conclusions and Recommendations

Last year, recommendations were made to improve the capabilities of the long term monitoring study that included methods for analyzing herbivory and an inclusion of a study of pollinators of the !nara plant. We too have gained a series of insights from our work and propose a number of recommendations for future study.

Transecting

By adding another research location, we hope to improve the quality and longevity of the study. If access and resources prevent monitoring at a variety of locations, we recommend that the Gobabeb location continue to be researched, if studying both the !Nara and Gobabeb Valley are too difficult to survey. If enough resources are available to ensure a complete study of both, we further recommend that Gobabeb Valley be accomplished first as a means of ensuring logistical ease. Once location has been established, we recommend that every person conducting field work understand the methods and protocol created. Transecting, we believe, is best done with three people: one at the top of the hummock recording data, one at the base walking up along the transect line and one counting flowers, buds and fruit. These recommendations will help to facilitate a thorough and standardized methodology for conducting transect measurements. To preserve the integrity of the sand covering the hummocks and the !nara plants growing upon it, we strongly suggest that field workers traverse along the predetermined routes created by large mammals and limit their movement when walking around the hummock.

Herbivory

In the section above, we mention the necessity of standardizing the methodology to assure consistent data collection. This recommendation extends to herbivory identification and classification. We recommend a clear and concise definition of healthy versus herbivorized flower and fruits and the ability to distinguish between different types of invertebrate and vertebrate damage. All of this collection protocol should be decided early and consistently used throughout the study. We recommend creating a photographic guide to facilitate the classification of herbivory damage (see Appendix I for the herbivory classification guide).

Pollination

We recommend a continuation of the long term pollination study using water traps and fluorescent powder with the ultraviolet blacklights. Additionally, we advocate for a more extensive study of !nara plant pollination. A comprehensive study on the habits and behaviors of midges is needed to understand their role in pollincation. Intra-seasonal or intra-year collection would be a good starting point that would hopefully lead to a more comprehensive review of the complex !nara pollination network. In order to better understand the midge species' spatial dynamics, we recommend evaluating !nara patches at farther distances from the Kuiseb River than conducted in this study.

For the long term monitoring study we also recommend recording humidity, temperature, and wind speed at regimented times throughout each day, since these factors may influence pollinator presence. From observing the phenology of male and female !nara plants, we know that plants flower later in the morning (8am -11am roughly). Therefore, we recommend that the most intensive aspects of the pollination study occur at this time of day onwards until early afternoon (8am-1pm) (ie: setting up water traps and painting flowers). To more definitively describe the pollination processes, identifying pollen grains on the captured invertebrates and matching them to pollen grains found in flowers would enhance the empirical evidence. Additionally, examination of collected flowers under a high-powered microscope could reveal information about midge reproduction and success of pollination. Further analysis of the multiple types of midges and DNA sequencing of each individual species would serve to improve knowledge of !nara pollination and population.

Despite its ecological, cultural, and economic importance for the Topnaar community, the !nara is a vastly understudied plant. The development of a database of !nara ecological information will be instrumental in monitoring the health of the plant in conjunction with changing environmental and anthropogenic factors. This information is vital for informing future management strategies to ensure the sustainability of !nara. Additionally, it is key to fully understand the pollination network within the !nara phenology as it can drastically affect plant reproduction and fruit productivity. With the proposition of future changing global temperatures and rainfall patterns, it is likely that pollinator networks will be affected. The continuation of this pollination study is indispensable for the conservation of the !nara. We believe the discovery of the midges is significant for this purpose and should be further examined in detail. The existence of midges is an example of a contribution researchers continuing this long term monitoring study could make. As this longitudinal study is replicated in the future, it will continue to shape the foundational knowledge of !nara and, in our opinion, is essential to !nara's prolonged survival.

VI. ACKNOWLEDGEMENTS

Thank you to Eugene Marias, Flora Krivat-Tetley, Doug Bolger, and Nelly Black for their support and guidance throughout our project. Thank you also to Ruusa Gottlieb, Robert Logan, Elna Irish, Rosalia Lileka, Tayler Chicoine, Annelise Sauter-Ortiz, Kripa Dongol, Jonathan Chipman, and all of our participant observers.

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VI. APPENDICES

Appendix I: Protocol

This is meant to be a clear and concise amendment to the original protocol of conducting the long-term !nara population study from Mclaughlin 2013, with a more in depth explanation of added methods. This section includes our recommendations for most efficient use of time, as well as necessary descriptions to ensure data continues to be collected using consistent methods.

Hummock Transecting:
This work is best done in groups of 3-4 where one person, atop the hummock, records data, another holding the tape measure at the bottom of the hummock reads off locations of sand, live !nara, dead !nara and other. After finding the study hummock via GPS coordinates, find a position as close to the top and center of the hummock where the data collector may stand comfortably without disturbing live !nara plants (it is very important to disturb the hummock and !nara plants as little as possible as to not effect the study and future plant growth). The data collector at the top of the hummock must hold the end of the measuring tape for the duration of the "wagon wheel" transecting procedure. The rest of the measuring tape reel is to be held at the bottom of the hummock by another person. The bottom of the hummock is defined as a place where the sand evens out with the mean slope of the nearby area (i.e. where the sand becomes flat if the landscape is flat). In cases where irregularly large hummocks have been divided, the end of the transect line should be taken by rough estimate of a divider line between the adjacent sub-hummocks.

While the person holding the tape measure walks up the hummock reading off radial start and end points of natural material from base to top (zero being the center point, where the recorder is standing), another person carrying a meter stick may calculate the height of each live plant along the transect. Height should be calculated from plant root to the nebulous cloud that is the main dense part of the plant, disregarding any solitary stems and shoots. Another way to think about height is how far off the ground a large tray placed on the plant would sit.

While the tape measurer counts flowers, buds and fruit of plants along the transect line, the third (and fourth) person may take herbivory counts of live plants along the transect (see next section), or count flowers, buds and fruit of plants skipped over in the 45 degrees between transect lines to contribute to the total hummock count. While flowers and fruit can always be counted fairly precisely, buds in male plants are often prolific and estimation methods are useful.

Herbivory:

If interested, see Table 1 in "Methods" section for an in-depth look into the different methods used to arrive at this preferred method. Additionally, Appendix II ("Herbivory Cheat Sheet") is comprised of visuals and descriptions of different types of herbivory and terminology that we used to describe what we saw. These different visuals and descriptions should help to differentiate between invertebrate and vertebrate herbivory in case the decision is made to continue to look at these types of herbivory separately.

Herbivory will be measured on every live !nara plant that crosses each transect line when doing your "wagon wheel transects." Two different methods of measurement are needed to measure herbivory as accurately as possible. First, divide the live plants into an upper and lower segment. For each segment, select a stem from the root of the plant, estimate the entire length of the stem and record all herbivory damage that you notice along the stem. Include damage on spines off the stem but not sub-stems that break off from the original. This first measurement will enable you to accurately determine invertebrate (insect) herbivory.

After examining a stem from both the "lower" and "upper" portions of the live !nara, proceed to the MLO method. MLO stands for Mammal Live Other and is a way to quickly examine tips of !nara stems to determine if there is damage and what kind of damage exists. To perform the MLO method, arbitrarily pick 10 stems from the entire plant by following a root to its end, look at the tips of each of the 10 stems, and categorize the stems as either mammal (clear signs of mammalian herbivory), live (healthy and growing tip), or other (insect herbivory or natural dieback). When arbitrarily selecting stems, it might be helpful to chose a stem from the root and follow it up from the tip so that you are avoiding any biases that may exist (ex. choosing tips of stems that you notice have more or less herbivory). We decided to combine insect herbivory and dieback because often times on the tip of the stem, the two look very similar and we did not feel as if we had the expertise to separate the two categories. In the future, research could be done to split this category into two as more is known about herbivory of !nara. This method is the best way that we could think of to determine herbivory, mammalian in particular, quickly and thoroughly.

If one plant crosses more than one transect, it is only necessary to gather herbivory data for that plant one time.

Pollination:

Much of this section includes recommendations for the bee bowl-flower dusting procedure as per the flowering conditions that we experienced. It is feasable that the flowering times might be variable and thus it is important to note current observations of flower appearance times.

Prior to heading into the field mix the 40% antifreeze (propylene glycol), water solution in a large > 1 L container to ensure you do not run out of solution. Take at least 100 mL of dish soap. Once in the field take a preliminary measurment of humidity, temperature, wind speed and direction and cloud cover. Around 08:30 hr begin placing and filling bee-bowls in locations within a few meters of open or near-open flowers. Place bee bowls in the !nara plant at least 10 cm above the ground. Fill bowls about three quarters of the way so as to avoid having the surface come into contact with the bowl edge which allows insects to climb out once caught. Add a dollop of soap and mix.

At around 09:30 hr begin painting open flowers, consistently using one color for males and one for females, but make sure to wait to paint the ones still unopened. Paint flowers on the female plants first as they will be open earlier. By 11:00 hr most, if not all, male flowers

should be open for the day. At 13:00 hr collect the contents of the bee bowls in fully sealable containers labeled with date, time, bowl color, and hummock ID. Use tweezers to carefully transfer any insects not moved in the liquid. Refill the bee bowls, then, if possible, quickly count and record the insects just collected noting any with the flourescent dust. Return to collect the contents of the refilled bee bowls at 17:00 hr.

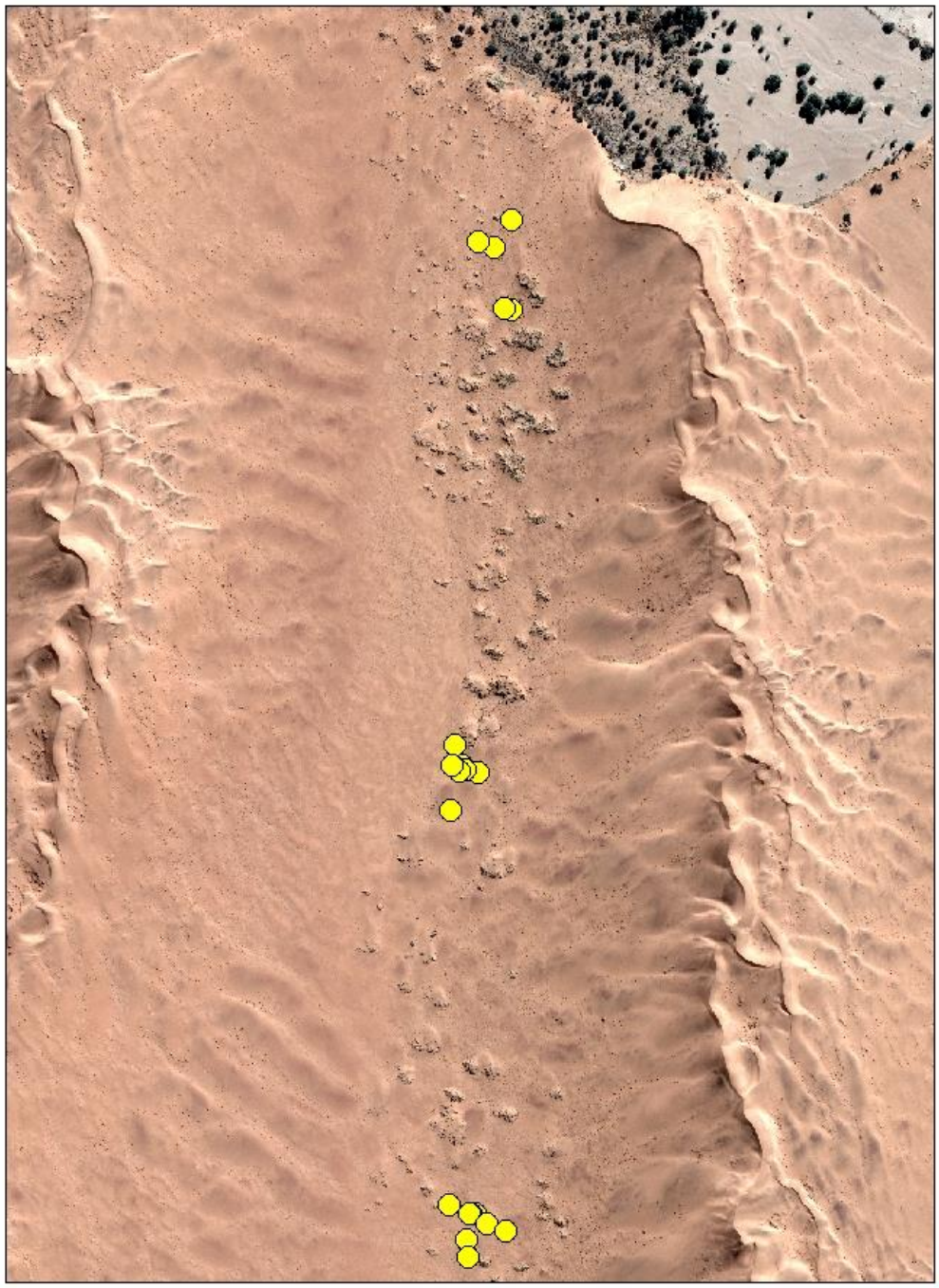
Bring all samples immediately to a refrigerator or directly to the lab for analysis. In the lab pour individual bowl contents into Petri dishes and precisely count the insects recovered. Make sure the Petri dishes are also labelled. After counting total insects, use a UV blacklight, and micrscope if necessary, to count the number of each species with the male and female colors on them in each sample.

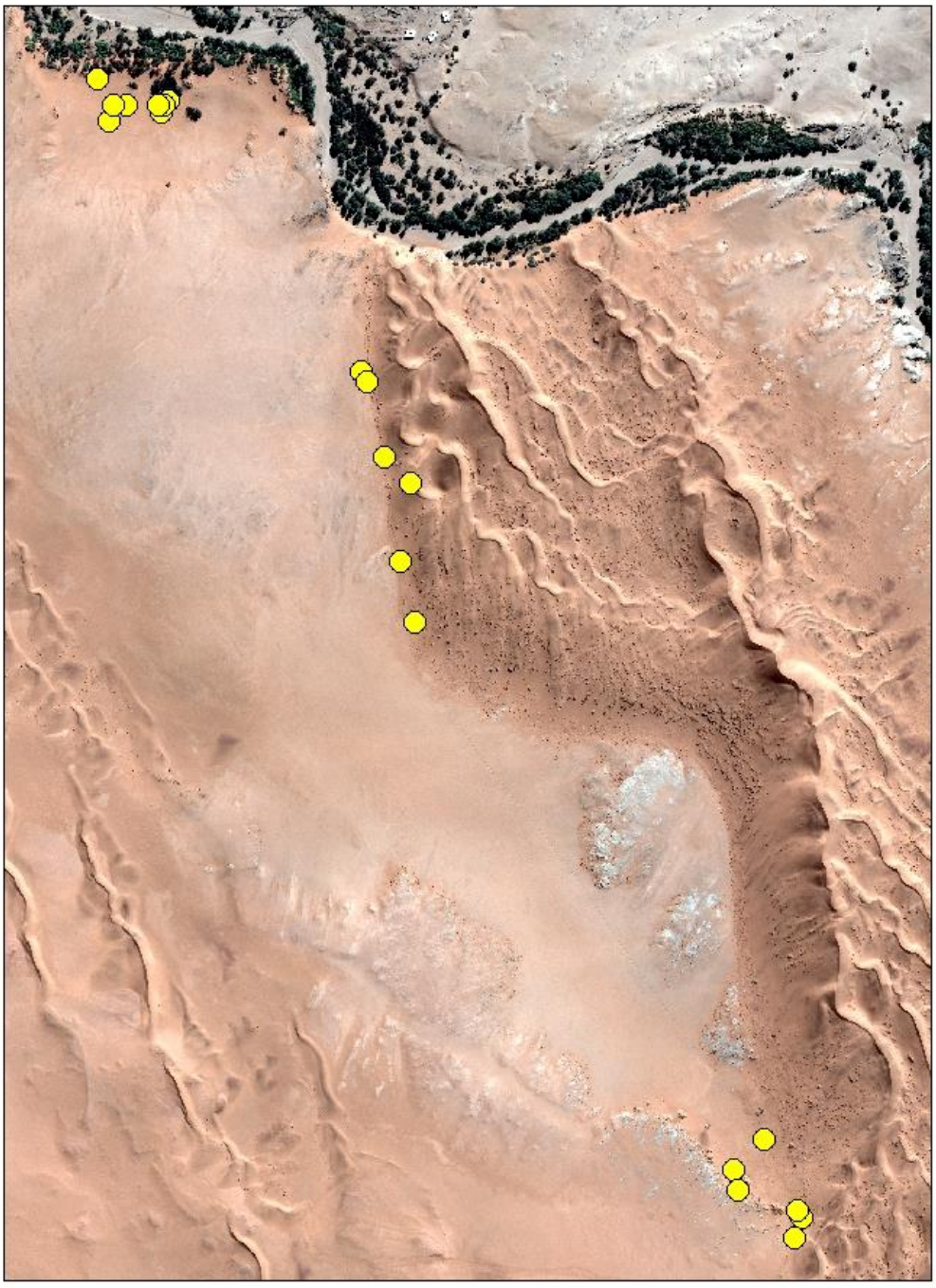
Appendix II: Water Trap Findings

Species	**Description**
Unidentified Midge #1	Most prolific species, white with black head and back plate. Iridescent green-black eyes.
Unidentified Midge #2	Brown body with striped hind section. Black hairs on back. Red eyes.
Unidentified Midge #3	Half the size of Midges 1 and 2. Imperceptible to naked eye. Tiny black eyes.
Unidentified Midge #4	All black. Hunched back.

Other Partly Identified Species
Blow Fly (Order: Diptera, Fam: Calliphoridae)
!Nara Fly (Order: Diptera, Fam: Uliidae)
Blister Beetle (*Mylabris zigzaga)*
Small Bee (*Anthrophora aune)*
Small Beetle (Fam: Carabidea)
(Order: Hymenoptera, Fam: Vespoidea, Subfam: Masaridae)
Carpenter Bee (Order: Hymenoptera, Fam:Anthrophoridae)
Five Species of *Hylaeus* (Small wasps)
Chrysomelidae Beetle (Order: Coleoptera)

Appendix III: Study Sites





Sex and Size Distribution of the !Nara in Relation to Water Resources

November 15, 2013

Prepared By:

Kripa Dongol
Noah Jennis
Melissa Li
Katie Rowe

Abstract

This study explores sex and size distribution of the !nara plant in relation to the water resources it depends upon. It also examines spatial mapping of !nara in relation to palaeochannels, and investigates potential sexual segregation within the population. Results indicate an increase in the average aboveground live vegetation cover per plant moving from upstream to downstream along the !Khuiseb River. Sex and size distributions in relation to the distance from the river directly or along the valley between dunes were not significant. However, we observed a general two-patched trend in distribution reflecting the geography of the palaeochannels flowing beneath the valleys. This suggests that the plant's relationship with water resources examined are more complex than previously understood and supports existing hypotheses that !nara plants cluster around palaeochannels (Muller, 2004). Additional analysis suggested differences in clustering between sexes where females exhibit greater tendency to cluster than males. Sex ratios appear to be 1:1 within distinct patches and across the population. Further research is needed to explore sex and size distributions in relation to a more nuanced understanding of resource gradients across !nara habitats.

Background

The !nara plant of the Namib Desert is one of the oldest cucurbits known, at least 40 million years old, with an impressive ability to survive in the harshest of environments (Berry, 2003). !Nara plants grow on hummocks, which are mounds that form over time as sand collects in the root system. !Nara has many adaptations that allow it to thrive with minimal water. These include spines rather than leaves, a photosynthesizing stem, and a taproot to access groundwater up to 50m below the surface (Muller, 2004). Still, little research has been done on the relationship between the nuances of !nara distribution and the water resource gradient.

Sexual dimorphism in longlived plants in resource limited habitats is typically associated with differing costs of reproduction. Female plants typically show higher costs because of fruit production. As a result, male plants often surpass females in growth rate, shoot size, and propagation capacity (Barrett, 2012). Due to different spatial availability of resources in the !Kuiseb River catchment, it follows that !nara might exhibit spatial segregation of the sexes. Thus, we infer that female populations may exhibit greater vulnerability to changes in resource availability, such as access to surface and groundwater. This is supported by the negative relationship between reproductive investment and stress tolerance typically observed in dioecious plants (Case and Barrett, 2001).

The ecology of !nara is such that it is dependent upon different water sources during different times of its life. Surface water is critical in the early phases because roots have yet to reach groundwater aquifers and the seed requires specific germination conditions. Sand must contain moisture for at least 4 days before seed germination can occur (Moser, 2001). One study compared the survival of two plants in the interdune area and one in the riverbed, only watering one plant in the interdune region. Only the watered plant survived; this again points to the key role that surface water plays in the initial establishment of a !nara plant (Moser, 2001). The water availability and storage capacity of a recently flooded riverbed likely serves as a great advantage for !nara seedling establishment and development (Moser, 2001).

Rainwater flows down the dune lines (the path between the ridges of two parallel dunes (see Appendix I for map) following elevation gradients to the river, flooding the river and recharging the aquifers beneath the sand. If this flow were interrupted, it would be detrimental to the !nara plants, beginning with those furthest from the river along the dune line that get the least flow. The !Kuiseb River has experienced large scale flooding 16 times in the last 160 years but only once in the last 50 years (Ito, 2005). This provides empirical support for recent changes in surface water availability.

Another key piece of the water use of !nara is its dependence upon groundwater. In order to survive, a !nara plant requires that its taproot reach the water table before surface water resources run out and the flood season ends. Although the seed root growth rate of most desert plants exceeds 2mm/day, the !nara plant has a growth rate of 0.61.3mm/day (Ito, 2005). This could imply a greater sensitivity to changes in water table depth. The subterranean water beneath and around the !Kuiseb River is the primary source of water for the growth of the !nara plant, once its taproot is able to access groundwater anywhere between 160m below the surface (Vissner, n.d.; Muller, 2005). In general, the water table is lower moving away from the river, which is the location of the primary aquifer; this is shown in the ephemeral rivers of the Orangefish River Basin and can be extrapolated to !Kuiseb (Tordiffe, 2010). Therefore, direct distance to the river can be used as a proxy for groundwater level, which dictates how far the taproot must grow to reach water.

Subterranean river flows have been blocked by the damming of the river down to the granite bedrock for flood control; simultaneous pumping from the river to supply water to the large, coastal cities has similarly reduced groundwater resources and flow (Shilomboleni, 1998). Dams have also been built upstream. Estimates made by the Desert Research Foundation of Namibia have put the decrease in the groundwater levels beneath the !Kuiseb River at half a meter per year (Vissner, n.d.). Anecdotal evidence suggests that the pumping of groundwater out of the !Kuiseb catchment might be decreasing the size of the !nara fruits and seeds (Botelle & Kowalski, 1995). This has been echoed by the !nara market data; the quantity of pips sold by !nara harvesters significantly declined in the years following the construction of the !Kuiseb Dam (Shilomboleni, 1998). This indicates a threat of reduced groundwater that might affect the plant's ability to reach the water resources it needs to grow beyond a seedling and to continue growing as an adult plant.

The final water resource dynamic that has potential to affect the growth and survival of the !nara plant in specific regions along the river is water flow. Since the Topnaar people and much of the !nara population are located in the middle and lower !Kuiseb, the amount of water that flows to those areas must be sufficient to supply the plant. The Topnaar themselves do not have a great effect on the upstream versus downstream dynamic. Because they use a very small amount of water – less than 0.1% of the water abstracted from the lower Kuiseb – they have no significant effect on the river levels (Amoomo *et al*., 2000). Farming, mining, and pumping for municipal purposes threaten the river. If the water table continues to drop in the middle and lower !Kuiseb, it may have negative ramifications for the !nara population in this region. Plants can be mapped in relation to one another and designated as upstream or downstream so that they can be compared in relation to river location.

Most importantly, perhaps, is that many of the Topnaar people depend heavily upon the !nara plant for their livelihoods. Though it is rarely the only source of income due to its seasonal nature, !nara provides a significant source of both food and money for many Topnaar people (Werner, 2003). If the resource base of melons and their seeds were to decrease, it would be detrimental to the Topnaar people. Therefore, It is important to know where the melons are, specifically, in relation to the areas that are most vulnerable to water resource decreases. We hypothesize that these specific areas are those farthest from the river along the dune, those with a direct distance from the river that is greatest, and those upstream (although the delta region requires special consideration). If the melon resource base is located in vulnerable areas, it suggests a lower resilience of the plant in the face of potential changes in water resources. As melons only grow on female plants, females are the heart of the resource base for human consumption. Within female plants, a measure of aboveground live vegetation is one of the closest proxies available for plant productivity and, thus, melon production, as live biomass has a strong correlation to fruit production (McLaughlin et al., 2013). Larger plants should be expected to have more fruit production. Therefore, both sex and size can be measured and mapped out in relation to the three water variables mentioned above in order to look at the vulnerability of the melon resource base.

We took GPS points along with sex data for all plants in !Nara Valley to supplement prior GPS points and sex data collected in Gobabeb and Reed Valleys (see Appendix I). We also took advantage of an opportunity to sample points in the delta region. A sample of plant size, via aboveground live vegetation cover, was measured at 1km increments away from the riverbed. Statistical analysis was used to examine spatial patterns of collected data. Water resources are looked at from three different angles, encompassing the surface water, groundwater, and upstream versus downstream dynamics that might affect the growth of the plant. The proxies used for these three dynamics were distance from the river along the interdune region between the dune lines, direct distance from the river, and location upstream versus downstream, respectively. Our research also studies the link between !nara presence and palaeochannels and explores the dynamics of sexual segregation or clustering of the plant. We hypothesize females and larger plants to be clustered in more resource rich, less vulnerable areas, and that the same relationship is not present in the male population. Gaining a better understanding of how !nara depends on water resources provides insight into how vulnerable the plant population may be to changes in water resources.

Methods

Sex and GPS Point Collection

Using !nara sites determined by Jonathan Chipman, Dartmouth College, via GIS satellite images and confirmed by Wommack et al. in 2013, we chose to map three interdune valleys that stretched 4km from the entrance of the valley at the river. An additional site in the !Kuiseb River delta downstream was also examined. For each !nara plant within a valley, we recorded the GPS coordinates, the sex of the plant, and, if applicable, its unique shape or multiple plants in one hummock. Sex was determined by the presence of male or female flowers. If there were no indications of sex, the plant was marked as unknown. At the delta site, an arbitrary sample of 50 points was taken inside the riverbed and 128 points outside. Sex was again recorded for each plant at which a GPS point was taken.

Size Estimation (via Live Above Ground Vegetation Measurement)

Size data was also collected for an arbitrary sample of five plants every km from the river in the interdune valleys from a distance of 4km. At the delta site, a sample of five plants was measured inside and outside the riverbed. Size data was collected using a combination of total hummock surface area measurements and percentages of live and dead vegetation cover.

Live and Dead Vegetation Cover Measurements

Using a 38x38cm piece of cardboard, we created a grid to estimate percent surface cover of live and dead vegetation on each measured plant. The grid was divided into 36 equal sized squares where a square cutout was made in the center for the eye to look through. With arms outstretched, the grid was held up to each plant on 4 different faces that maximized the coverage of the plant within the grid. One researcher looked through each square at a time and determined whether the square was predominantly live vegetation, dead vegetation, or sand. Squares that captured an area not encompassed by the plant were not counted. Using recorded tallies, percent live coverage was calculated as the number of live squares divided by the total number of squares and where the aggregate percent cover was calculated as the average of the four faces. The same method was applied to percent dead vegetation cover.

Hummock Surface Area Approximations

The closest geometric representation of most hummocks was half an ellipsoid. In order to perform this calculation, we measured the long and short diameter of each hummock using a Sonin Pro measuring device. For an illustration of the shape used, see Appendix II. The approximate surface area for half of an ellipsoid can be calculated with Knud Thomsen's formula,

$$S \approx 2\pi\left(\frac{a^p b^p + a^p c^p + b^p c^p}{3}\right)^{1/p}$$

where a = the short radius, b = the long radius, and c = the height and p = 1.6075. This approximation formula yields a relative error of at most ±1.061%. In situations where the base shape was roughly circular, one radius was measured and the same value substituted for a and b within the formula.

For plants growing at ground level (without hummocks), the surface area was approximated using the formula for an ellipse,

$S = \pi ab$

where a = the short radius and b = the long radius.

In a few situations, surface area was more appropriately approximated using a triangular prism with three rectangular sides and a triangle top (see Appendix III for figure). The following formula was used in those situations:

$$S = \sqrt{p(p-a)(p-b)(p-c)} + (a + b + c)\,h$$

where a, b, and c = the three sides of the triangle base, h = height, and $p = \frac{!!!!!!}{!}$.

Data Analysis

The software ArcGIS was used to map GPS points. Different shapefiles were created for each valley, the river sections at the start of each valley, and the entire river. The distance to the river was calculated for all measured plants, both along the axis of the valley between the dune lines and directly. This was done by creating a near table within ArcGIS for each point in relation to the section of the river at the mouth of the dune valley and in relation to the entire river.

Statistical analysis was carried out using a combination of Microsoft Excel, JMP, and an online software called GraphPad. For the distance to the river relationships with aboveground live vegetation cover, linear regressions were run on the average cover values at each km from the river. To look at differences in average aboveground live vegetation cover between the valleys, an ANOVA test and a subsequent TukeyKramer HSD analysis were calculated on square root normalized data. These allowed for a comparison between the valleys from upstream to downstream. Aboveground live vegetation cover and the ratio between dead and live cover were also both compared to hummock surface area using a linear regression of all measured points.

To determine the differences in sex ratios along the dune, we calculated sex ratios for different patches in the valleys. While Reed Valley and Gobabeb Valley had clear patches of !nara plants, !Nara Valley had a more continuous distribution. Thus, to better quantify the patches, we used Sanchez Meador et al.'s method of using Ripley's K to calculate patches of pine forests in Arizona (2009).

Ripley's K compares the distribution of the given valley to Complete Spatial Randomness (CSR), giving an expected K and observed K value. The data is considered to be clustered when observed K is greater than expected K while the reverse is true for dispersed distributions. When a confidence interval is calculated, a clustered distribution above the higher confidence interval and a dispersed distribution below the lower confidence interval are considered to be statistically significant. For our analysis, we ran Ripley's K

analysis for every valley with a 99 permutation confidence interval. Then, the peak clustering distance, where the difference between expected K and observed K was highest, was recorded as patch size. The patch sizes found using the Ripley's K analysis was then used to create patches within each valley so that a linear regression could be carried out on sex ratio along the distance to the river within the dune lines.

Analysis was also carried out on clustering of male and female plants in the three valleys. We calculated the distance to the nearest neighbor for female to male, female to female, male to female and male to male plants. We then normalized the data by calculating the square root of all distances and again conducted an ANOVA and TukeyKramer HSD test.

Results

AboveGround Live Vegetation Cover in Relation to Water Resources

Across all three valleys, no statistically significant correlation was observed between distance to river a long the dune line (measured in meters) and average aboveground live vegetation cover at each km distance away from the river (measured in square meters).

Similarly, there was no relationship observed between the variables shortest distance to river and aboveground live vegetation cover in any of the three valleys. Given the geography of Reed Valley, points could only be collected up to a 2km direct distance from the river and therefore a sample of 2 points was insufficient to run a regression (Table 1).

Distance to river along dune line (m) v. average aboveground live vegetation cover (m^2)		
Valley	**R^2 Value**	**P Value**
Gobabeb	0.0097	0.87
!Nara	0.62845	0.11
Reed	0.0081	0.89
Shortest distance to river (m) v. average aboveground live vegetation cover (m^2)		
Valley	**R^2 Value**	**P Value**
Gobabeb	0.92942	0.17
!Nara	0.65272	0.19
Reed	N/A	N/A

Table 1. Relationship between distance to river along dune line and shortest distance to river vs. average aboveground live vegetation cover in all three valleys. Note a lack of statistical significance for all regressions (see Appendix IV for a sample regression).

A oneway ANOVA test demonstrated a statistically significant difference between square root transformed average aboveground live vegetation cover in the three valleys ($F_{(2,73)}=10.9715$, $p<0.0001$). Figure 3 shows those average values for each valley.

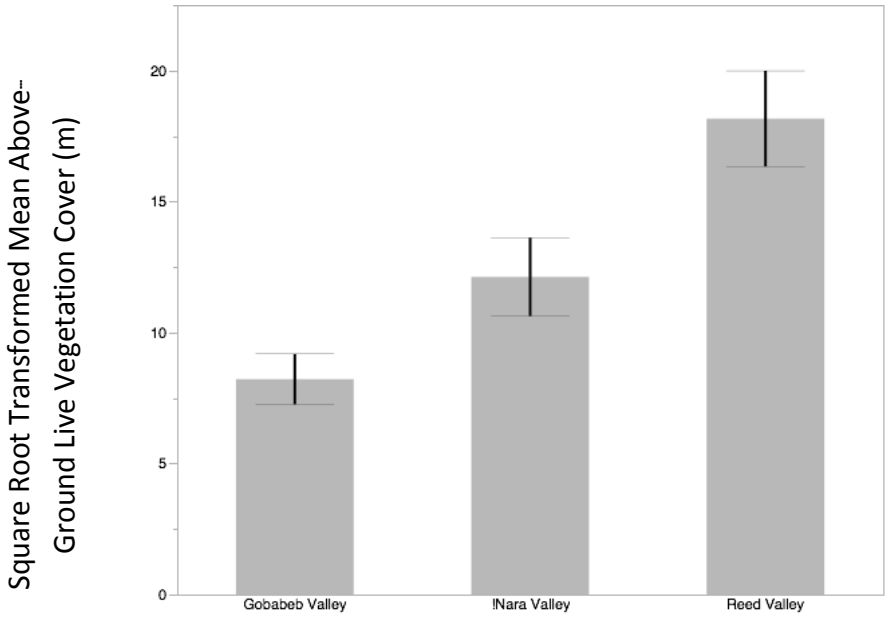


Figure 3. Square root transformed average aboveground live vegetation per plant of each valley listed in order of furthest upstream to furthest downstream. Each error bar is constructed using one standard error from the mean. (Gobabeb Valley mean = 8.22, SD = 4.62; !Nara Valley mean = 12.12, SD = 7.62; Reed Valley mean = 18.16, SD = 9.13)

A TukeyKramer HSD test shows a statically significant difference between the square root transformed average aboveground live vegetation cover in Reed Valley and Gobabeb Valley ($p<0.0001$) as well as between Reed Valley and !Nara Valley ($p=0.0135$). However, no significant difference was found between !Nara Valley and Gobabeb Valley ($p=0.1656$).

Further Vegetation Cover Analysis:

A statistically significant positive correlation was observed between total hummock surface area and live vegetation cover for measured points across all three valleys (see Figure 4). However, no relationship was observed between hummock surface area and the ratio between live and dead vegetation cover ($p= 0.2520$).

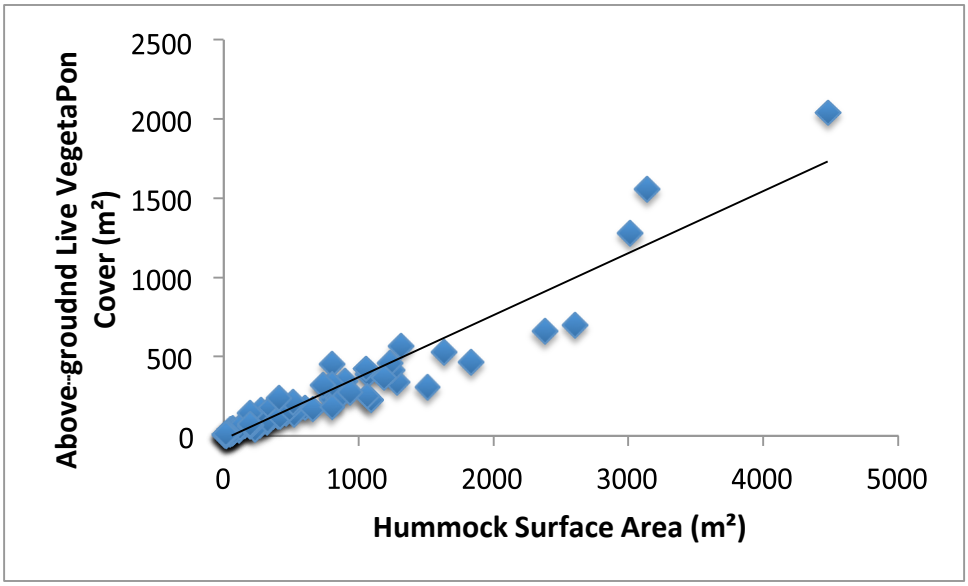


Figure 4. Relationship between total hummock surface area and aboveground live vegetation cover on that hummock for all measured plants (R^2=0.91373, p < 0.001).

Sex Distribution and Clustering

Ripley's K analysis on Nara, Reed, and Gobabeb Valleys shows clustering up to 500, 620, and 590 meters and peak clustering distances of 313, 361, and 340 meters, respectively. Based on the number of plants in each valley, a weighted average of 0.7, 0.23, and 0.07 is applied to the three valleys to get an average patch length estimate of 326.43 meters. Figure 5 shows a sample Ripley's K result for Gobabeb Valley, and additional figures for !Nara and Reed Valleys can be found in the Appendices 56.

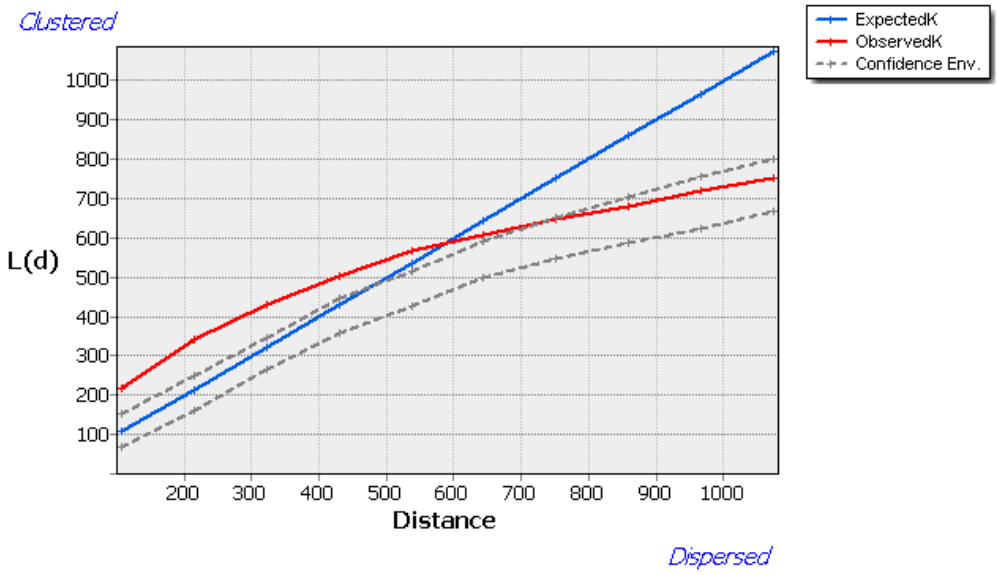


Figure 5. Ripley's K analysis of Gobabeb Valley. Observed K at highest clustering is 340 meters, clustering until 590 meters.

The sex ratio of each valley was also examined to observe differences in percentages of each sex between upstream and downstream valleys, including the delta (points were an arbitrary but representative sample of the entire region). While a decreasing trend in percent female from upstream to downstream is seen, this is not statistically significant for any of the valleys. A binomial test shows that sex ratios do not vary enough from the expected value of 50% to meet the 95% confidence interval. Table 2 shows the sex ratios per valley and p values.

Valley	% Male	% Female	Sample Size	P value
Gobabeb	44.4%	55.6%	45	0.5515
!Nara	47.7%	52.3%	432	0.3607
Reed	49.3%	50.7%	140	0.9327
Delta	50.0%	50.0%	188	N/A

Table 2. Sex ratio and total sample size by valley (No pvalue reported in the delta because expected and observed female sex ratios were equivalent)

We hypothesized that sex ratios would differ with distance to the river along the axis between dune lines. Our initial hypothesis was informed by an analysis of the existing mapping of Reed Valley where patches furthest from the river exhibited a lower percentage of female plants. However, after running a regression on distance to the river by patch (patch length = 326.43m) versus percent female plants per patch, no relationship was found for either Reed or !Nara Valleys (Gobabeb Valley could not be modeled with the patch method given an insufficient sample size). Figure 67 shows the lack of relationship between patch distance from the river along the dune valley axis and sex.

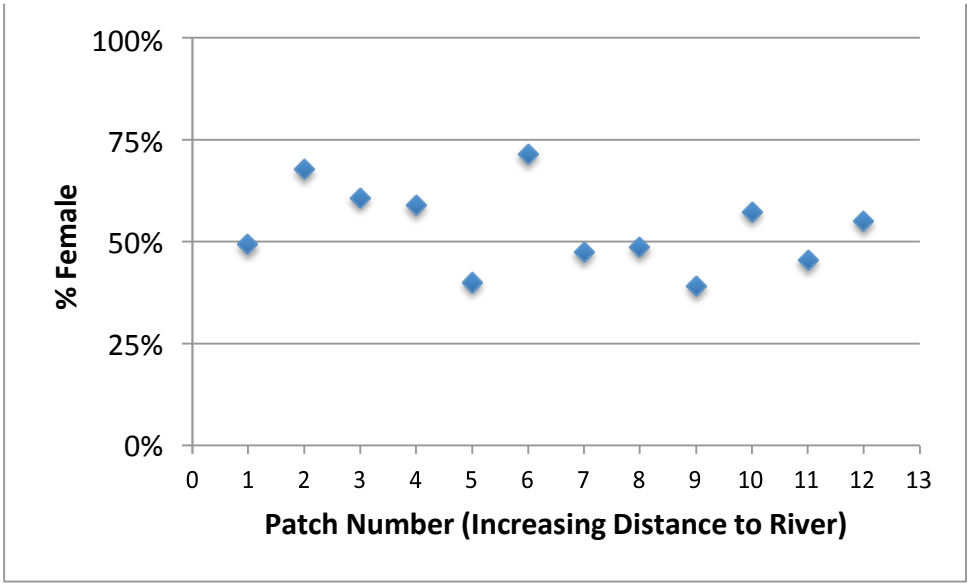


Figure 6. Relationship between patch number (with increasing distance from the river) and percent female in the patch for !Nara Valley. No observed statistical significance ($R^2 = 0.10094$, $p = 0.3142$).

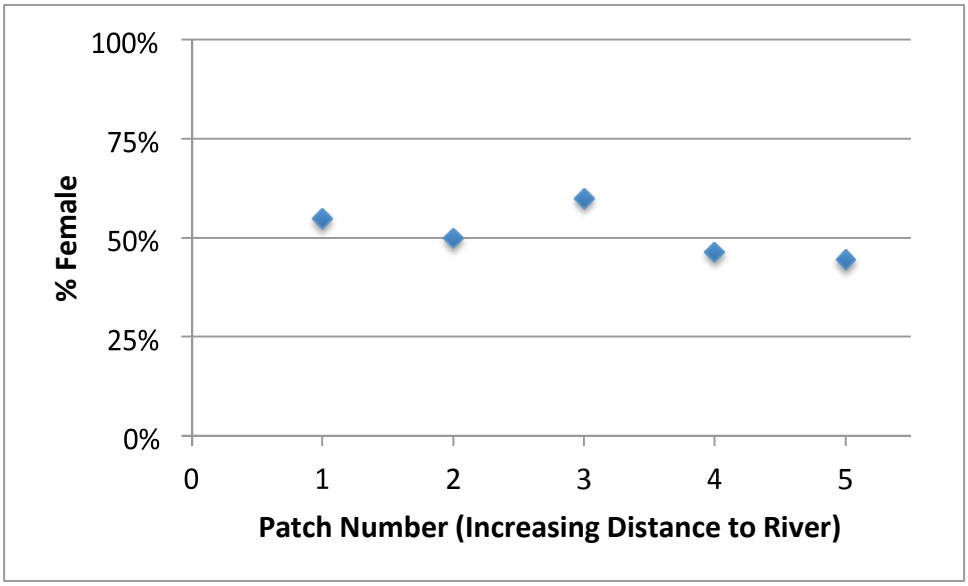


Figure 7. Relationship between patch number (with increasing distance from the river) and percent female in the patch for Reed Valley. No observed statistical significance ($R^2 = 0.36634$, $p = 0.2794$).

The differences in sex clustering between male and female !nara plants was also examined. A oneway ANOVA indicated a statistically significant difference between nearest neighbor distances of females to females, females to males, males to males, and males to females ($F(3,863)=4.8272, p=0.0024$). Figure 8 shows this analysis.

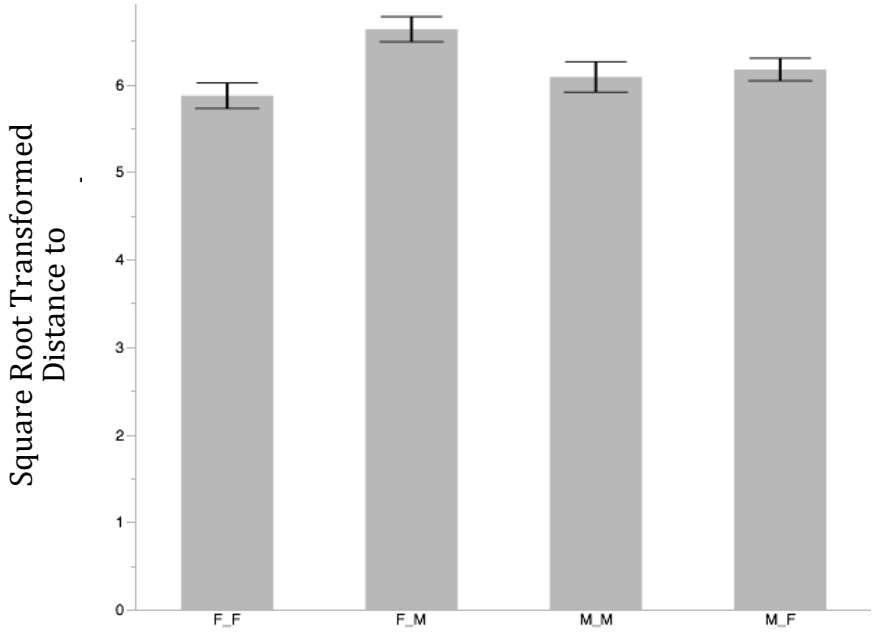


Figure 8. Square root transformed distance to nearest neighbor. Data is for females to females, females to males, males to males, and males to females, left to right. Each error bar is constructed using one standard error from the mean. (FF mean = 5.87, SD = 0.15; FM mean = 6.63, SD = 0.15; MM mean = 6.09, SD = 0.15; MF mean = 6.17, SD = 0.15)

A TukeyKramer HSD test shows that the distance from a female plant to the nearest female neighbor is statistically significantly shorter than that to the nearest male neighbor (p=0.0013). The test also shows that the distance from a male plant to the nearest male plant is statistically significantly shorter than that of the nearest female plant to the nearest male plant (p=0.0477). All other relationships were insignificant.

Delta Region: Inside versus Outside of the Riverbed

The average aboveground live vegetation cover outside of the riverbed was 232.43 m^2 and inside of the riverbed was 94.97 m^2. An unpaired two-sample t-test was run on this data once it was normalized, and the results showed that the difference was not significant (p=0.2666). Still, it is important to note that all of the plants within the riverbed had 100% live vegetation cover, with no visible dead matter.

In examining the sex distribution between three patches within the delta, the data was divided into points within the riverbed, points outside of the riverbed but South of the road, and points outside of the riverbed and North of the road. A slightly higher percent of females was found in the midsection, but nowhere else. In the riverbed, 50% of the plants are female; outside of the riverbed and south of the road, 59.5% of the plants are female; and 48.8% of the plants are female north of the road. However, using a binomial test, none of the female sex ratios show any statistical significance from an expected value or null hypothesis of 50% (not applicable in the river because the observed matched the expected, p=0.2800 south of the road outside of the riverbed, and p = 0.9142 north of the road).

The PalaeoChannel Hypothesis

In examining the distribution of aboveground live vegetation cover and sex in relation to water resources, we also looked at general distribution of the plants in relation to the river. Figures 910 below show the distribution of all plants in relation to distance from the river along dune lines. With the use of Muller's palaeochannel map shown in Figure 11, the distribution of plants in relation to the palaeo channels can be examined. Superimposed on Muller's map are measurements of both the distance to the palaeochannel from the riverbed (shown in red) and the width of the palaeochannel (shown in blue). The palaeochannel is also represented over the distribution in Figures 910 to show the comparison. Unfortunately, we did not obtain a palaeochannel map of Reed Valley and therefore could not make an inference about plant distribution in relation to the palaeochannel (see Appendix for a chart of Reed Valley's plant distribution).

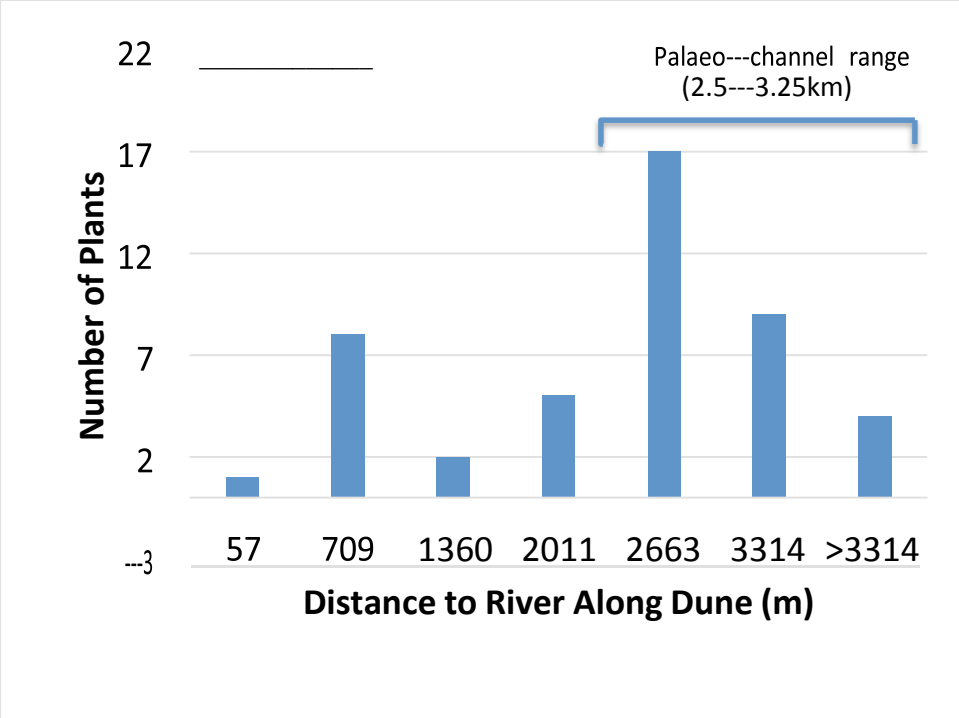


Figure 9. Distribution of all plants in relation to distance to the river along the dune lines in Gobabeb Valley. Palaeochannel range is shown above distribution.

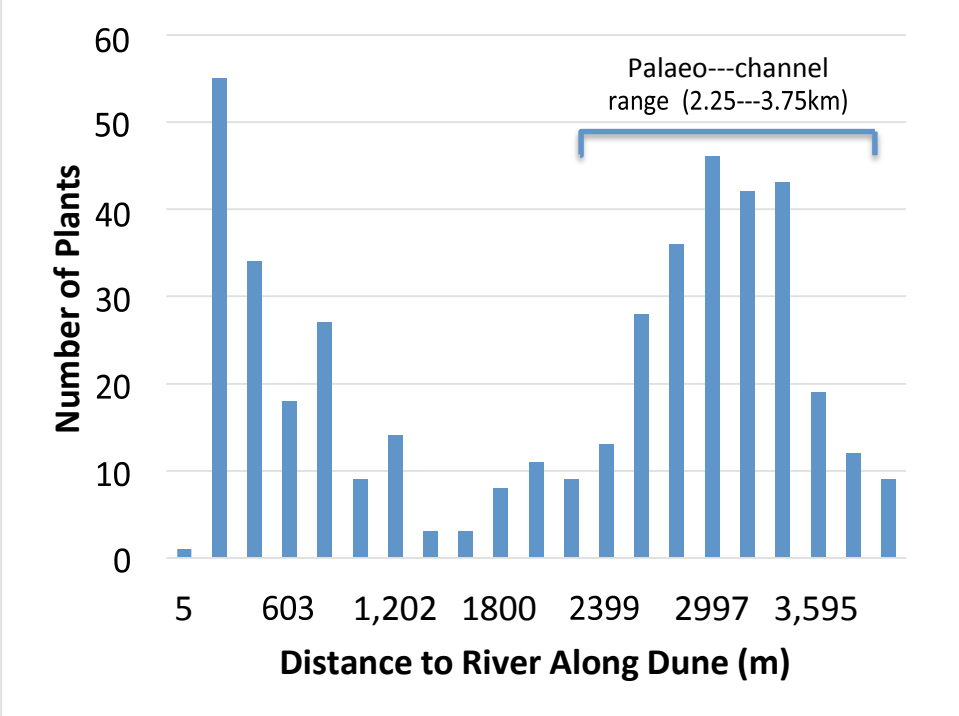


Figure 10. Distribution of all plants in relation to distance to the river along the dune lines in !Nara Valley. Palaeochannel range is shown above distribution.

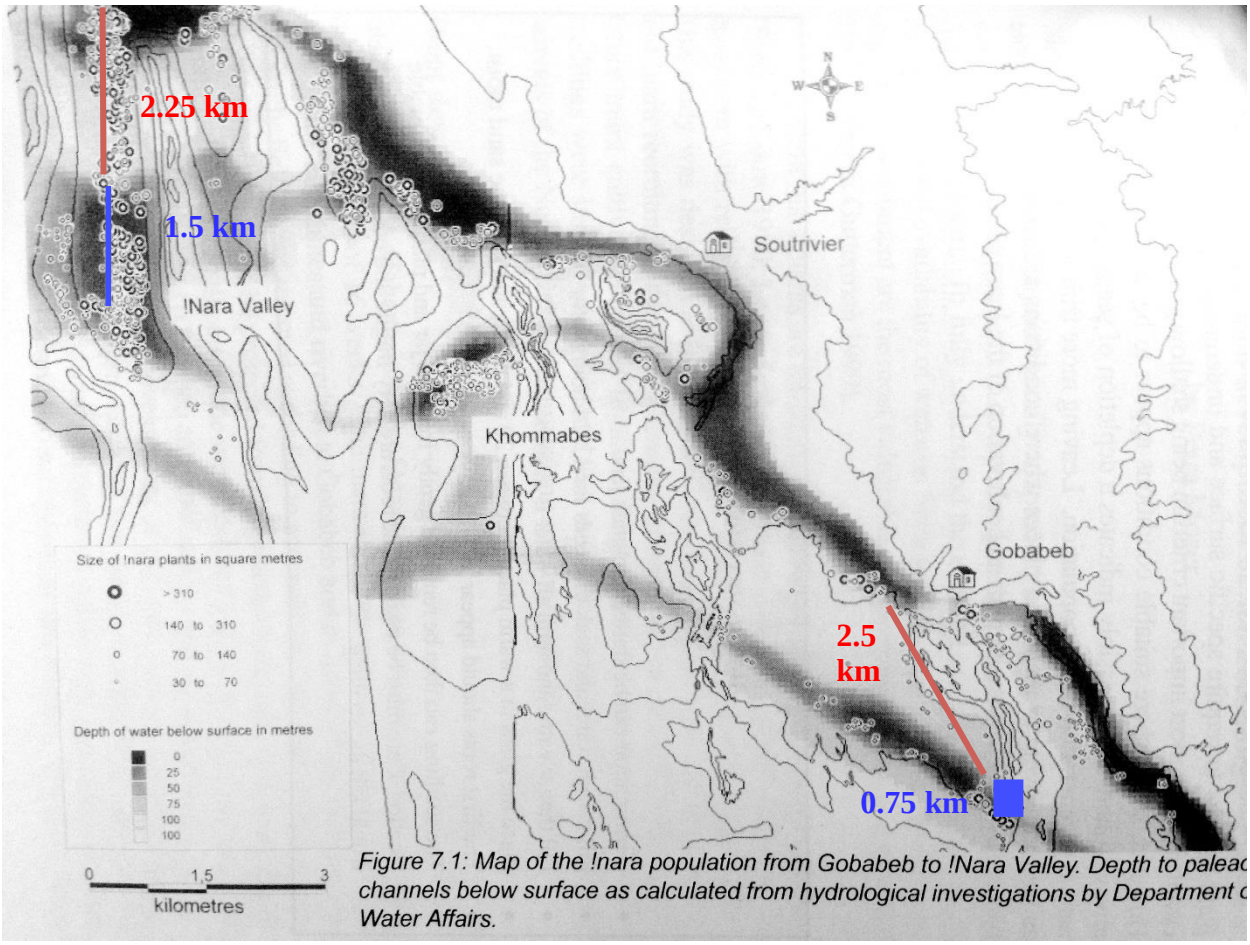


Figure 11. Palaeochannels in relation to the !nara plants mapped for !Nara Valley and Gobabeb Valley. Image taken from *!NARA: Fruit for development of the !Khuiseb Topnaar*.

Discussion

AboveGround Live Vegetation Cover Distribution in Relation to Water Resources

No significant difference in aboveground live vegetation cover was found in relation to the distance from the river, either along the dune line or directly. This may be due to an oversimplification of water resources. While the river is one source of water for the !nara plants growing in each valley, there are additional water sources in palaeochannels underneath the ground that also affect distance to groundwater (see below).

A comparison of average plant aboveground live vegetation cover per valley demonstrated a significant increase in size going further downstream. When these values were normalized and ANOVA and Tukey Kramer HSD analyses were run, a significant trend was observed. The average vegetation cover increased from Gobabeb Valley to Reed Valley, indicating that plants further downstream have more cover were more productive. One potential hypothesis is that the river flow should increase as it approaches the ocean and the catchment funnels into it. More water would allow the downstream plants to grow larger than the upstream

plants. Other potential influences on production are lower elevation approaching the ocean and increased fog, both of which might be more favorable for !nara growth. This also suggests that the melon resources are concentrated further downstream, placing them at less risk to decreases in river flow. Upstream areas would likely be first affected, as they are at higher elevation and further from the water table.

Further Vegetation Cover Analysis

The statistically significant relationship between total hummock surface area and live vegetation cover suggests that it may not be necessary to measure percent live coverage across all plants. A measurement of total hummock surface area alone may be sufficient as a proxy for live vegetative cover given the strong correlation between the two variables. This implies that total hummock surface area may be an appropriate proxy for !nara productivity since it exhibits a strong correlation to live coverage and, thus productivity, than previously assumed. While no significant relationship was found between live to dead cover ratio and hummock surface area, this relationship is still important. The lack of relationship may indicate that the ratio remains relatively stable; as live coverage increases with the surface area of a hummock, so does dead coverage.

Sex Distribution and Clustering

There was no significant distribution of the sexes in relation to distance to the river along dune lines, direct distance to the river, or upstream versus downstream. This was surprising, considering the well documented dispersion of the sexes in relation to resource availability in other plants (Case & Barrett, 2001). There are two potential explanations for the observed lack of correlation. One is that the resource gradient across the valley may not be as stark as we predicted. The presence of palaeo channels might allow the entire valley to access enough groundwater to support the plant. The other possibility is that the female !nara plants are not as susceptible to changes in water resources as we predicted, and that males and females exhibit relatively homogenous resource needs despite sex differences, though other findings about sex clustering might contradict that hypothesis.

Early analysis had indicated some potential difference in the percentage of females per patch moving away from the river in Reed Valley. Analysis of this data using patches created with Ripley's K analysis, however, indicated no significant changes along the river. Regressions for both !Nara and Reed Valleys were not statistically significant, suggesting that there is relatively even distribution of the sexes between patches. The observed sex ratio in every patch was not significantly different from 1:1. This indicates an unexpectedly even distribution of the sexes across patches. Within patches, however, the pattern may be more complex, as indicated by examination of clumping.

There was evidence of greater clumping among female plants than among males. This was statistically significant in !Nara Valley but not in the other two valleys; this could be due to the much smaller sample sizes of the other two valleys. However, the general trend was present in all three valleys: females tend to be closer to their nearest female neighbor than their nearest male neighbor, and the same is not true for male plants and their nearest male neighbor versus female neighbor. This suggests that females might cluster more than males.

Males showed relatively even dispersion and no evidence of sexual clustering. For predominantly insect-pollinated species such as !nara, close proximity of males and females is important. This might explain why males did not also display clustering. Females, since they are more sensitive to resource levels due to their greater resource needs, might cluster around high resource hotspots, although that resource may not necessarily relate to water availability. Further research is needed to understand what resources might induce female clustering and why.

Delta Region: Inside versus Outside of the Riverbed

While no significant sex or aboveground live vegetation cover differences could be detected between the riverbed and dunes, there is still important information to be gleaned from the visit to the delta. All of the plants measured within the riverbed had 100% above ground live vegetation indicating a younger population inside the riverbed. The lack of difference in sex distribution shows similar results to the other examined valleys, which would be expected.

The Palaeochannel Hypothesis

In examining the distribution of aboveground live vegetation cover and sex in relation to water resources, we also looked at general distribution of the plants in relation to the river. The general distribution showed two distinct clumps in each valley, one around the riverbed and the other at the palaeochannel. A comparison of the palaeochannel map with plant distribution for both !Nara and Gobabeb Valley demonstrate a clear link between palaeochannel location and higher density !nara regions. For !Nara Valley, the palaeochannel begins 2.25km from the riverbed and extends another 1.5km. This aligns with the observed second high density patch of !nara (the first being at the riverbed). Similarly, in Gobabeb Valley, the palaeochannel begins 2.5km from the riverbed and extends another 0.75km, again aligning with the second high density patch observed.

This supports Muller's hypothesis that !nara plant density increases around palaeochannels (Muller, 2004). This also suggests that looking at water resources only in the context of the river is misleading. Water resources vary due to many factors besides just the river, and those all need to be taken into account with examinations of sex and size distributions. Better groundwater and surface water flow maps used in future studies may help elucidate a concrete link between !nara sex and size and water resources.

Implications for !Nara Resource Base Vulnerability

We are not in a position to make any sweeping conclusions about the vulnerability of the resource base of the !nara plant. Based on the water resources that we examined, there are no indications that the plant distributes itself by sex. However, it is possible that the clustering of female plants in !nara valley that was not seen in male plants is due to microconcentrations of resources that are more hospitable to females. More research is necessary to explore what those resources are. The difference in aboveground live vegetation cover from upstream to downstream also indicates a potential sensitivity to water levels. Plants downstream are larger and thus are likely more productive, which could be due to

greater access to water. This indicates that water has a potential influence on productivity, but also that the most vulnerable upstream areas, where water resources would first begin to wane as more water is extracted from the aquifer, contain the smallest, least productive plants. This suggests that the resource base is more resilient to changes in the flow of the river, as the melons are concentrated in areas that are less likely to be affected by reduced river flow. Other indicators of potential vulnerability were inconclusive.

Ethics

Our main ethical concern in carrying out this study is similar to that of past researchers in the area. The Topnaars are a disadvantaged people with their unique position living within the National Park, and it is important that any findings that might benefit them, such as the vulnerability of the !nara resources that they rely upon, be shared with them. While many of our findings were inconclusive, we still believe that it is important that this information be somehow made available to them. This might be via booklets distributed next year or with some sort of database at Gobabeb that the Topnaar people are given access to. We suggest that further research be done with the Topnaar people as partners to decide if and how they would like to receive information gleaned in these experiments.

Limitations

!Nara plants are notoriously challenging to tell from one another. Conventional wisdom assumes that each hummock has one plant, but our study often found female and male plants inhabiting the same hummock, indicating that two distinct plants are capable of sharing the same hummock (Henschel & Moser, 2004). The total number of observed paired male and female plants on the same hummock divided by the total number of hummocks observed (doubled to account for same-sex, two-plant hummocks) indicates that 4.6% of the hummocks are multi-plant. This accounts for some of the variation observed, but indicates that there are further variables that are not yet accounted for. While we found 432 !nara plants in Nara Valley, literature suggests only approximately 250 plants exist in the valley (Berry, 2003). This suggests a discrepancy between how a single plant is delineated from the plants around it. A better understanding of the structure of !nara would aid in reducing this limitation.

Given the seasonality of the !nara plant and other climatic changes, it is difficult for us to directly measure !nara productivity. McLaughlin et al. (2013) demonstrated a correlation between the number of melons and surface area of live vegetation. Therefore, we determined surface area of live vegetation to be the most appropriate proxy for !nara productivity, although we acknowledge this is a limitation of the study as the relationship is not strongly established.

Although high density regions such as !Nara Valley contained !nara plants dispersed throughout the valley, the two other valley's contained a patchier distribution. As a result, it was difficult to guarantee at least 5 !nara plants to sample at each kilometer mark we measured away from the river. In Reed Valley, we took one plant sample at a distance of 1.5km and another 2 at a distance of 0.5km from the river because we could only discern 2 plants at the 1km mark. We recognize this is a limitation of establishing discrete cutoffs to distinguish between patches.

Moreover, both !Nara and Gobabeb Valleys ran parallel to the river and, therefore, plants were not distributed at a wide range of direct distances from the river (irrespective of the dune line). Thus, we did not have many clusters to establish a relationship from as Reed Valley only contained plants up to a 2km direct distance from the river. Future research could identify wider dunes with population of !nara at a greater range of direct distances from the river.

As we were limited by sample size, and since the logistics of the program dictated which valleys we could collect data on, we were unable to look at the effects of fog on development of !nara plants. Observations regarding changes in sex and size distribution along an east to west gradient to look at effects of surface water availability could provide interesting results. Since !nara and many other species in the region depend on fog for surface water, the transect could help identify changes that may occur in areas closer to the coast line.

Further Studies

1. *Relationship to Palaeochannels:*

   While our project focused on the availability of groundwater in relation to distance from the !Kuiseb river, there is evidence that this is complicated by the presence of underground palaeochannels that may also still carry water. Past studies have correlated the location of !nara plants with the location of palaeochannels, which are posited to have water between 10 and 80 meters below ground, some of which would be accessible to the taproots of the plants (Muller, 2004). However, sex and size distribution were not measured in this study. Further research might look at sex and size in relation to palaeochannels, nuancing the relationship between !nara and water resources. We recommend that Gobabeb locate detailed palaeochannel maps for the area and that size and sex of plants be analyzed in relation to these maps.

2. *Comparison of plants inside the riverbed vs. outside (in the interdunes):*

   Although we were able to collect data from inside the riverbed during our one visit to the !Kuiseb delta region, more work could be done in identifying potential differences between riverbed and interdune !nara. We noticed riverbed plants did not have hummocks, were much smaller, and had denser live vegetation cover. Our conjecture is that these are young plants that emerged in the water-rich environment that followed recent flooding of the river. Further research might conduct a more detailed analysis into reasons underlying this observed difference, particularly in relationship to !nara seedling development.
3. *Historical Comparison of !nara population*

   Using previous satellite imagery and further mapping of the resource base, high stress areas for the !nara plant, especially areas where productivity might be declining should be identified and brought to the notice of the Topnaar community. This could prompt measures for further protection or improved measured for sustainable harvesting of the plant.

4. *Further Exploration of !Nara Ecology*

   As mentioned in our limitations, there is sometimes more than one plant on a single hummock. Either excavation of a plant or imaging of the hummock might help elucidate the relationship between plant and hummock. This would inform all !nara research.

5. *Studies along an East to West Transect as a proxy for fog*

   As mentioned in our limitations, fog could have implications for the development of !nara seedlings and possibly adult plants. An east to west transect could prove interesting and the maps provided by Jonathan Chipman, Dartmouth College, may be used to identify such a transect. Ground truthing on his maps from last year and this year's data have proved that !nara hummocks are identifiable by satellite images so this could be a manageable way to pre-identify the hummocks.

6. *Further large scale mapping of the resource base with the help of Topnaar harvesters*

   While the analysis of the !nara plants along various transects can provide interesting data and results indicating vulnerabilities and strength of the resource base, it is equally important to have a comprehensive mapping of all the plants in the area. We think that a training of !nara harvesters in the use of GPS could result in collaborative mapping of the resource base. Harvesters could then potentially record the points along with sex, size and particularly interesting herbivory or health comments for the plants while on their harvesting excursions. This way the harvesters can be involved in the research of the resource that primarily affects them. After further consultation with other stakeholders, the mapped points and accompanying comments should also be made available to harvesters and community members.

Acknowledgements

We would like to thank Jonathan Chipman for supporting us throughout our ArcGIS and field Endeavour, Julian Fennessy for field and moral support, Flora KrivakTetley and Doug Bolger for support with methods and logistics and to everyone who came out to help us in the field: Reyk, Rosie, Nelly, Thorston, Taylor, Patti, Ndeheya, Gabriel, Karen and everyone at Gobabeb who supported our research.

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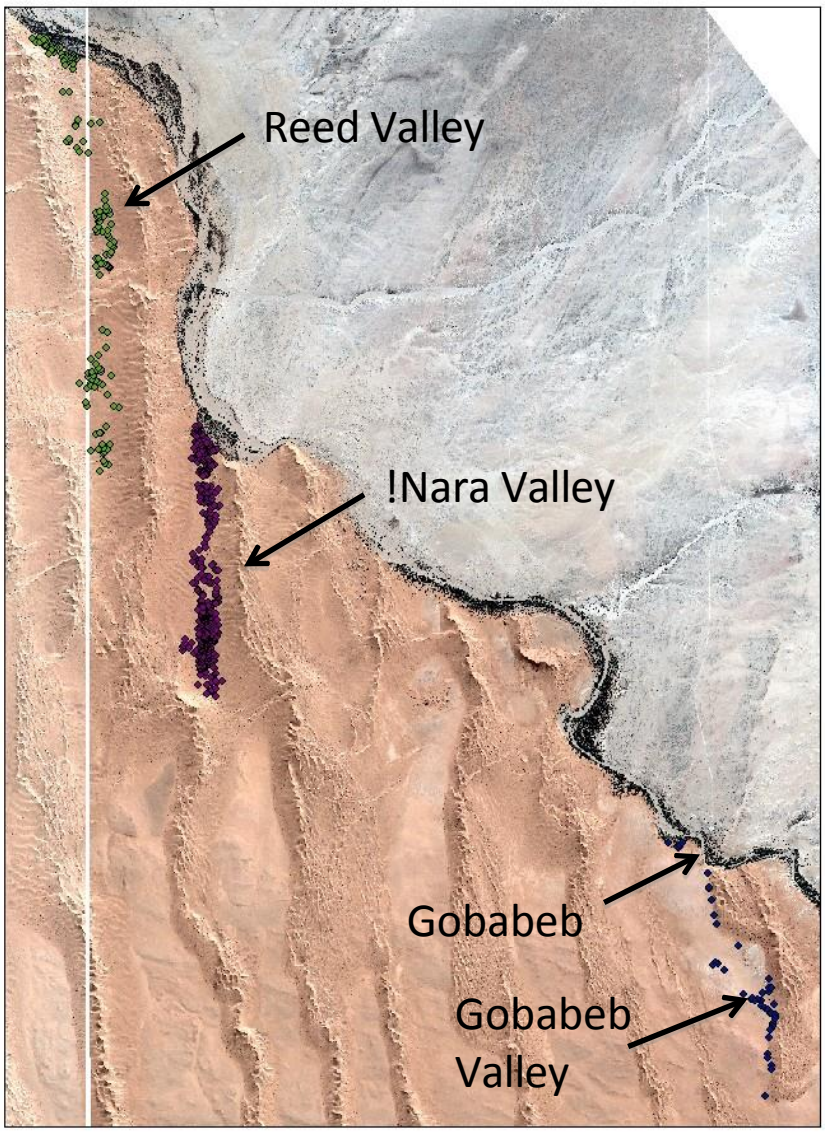
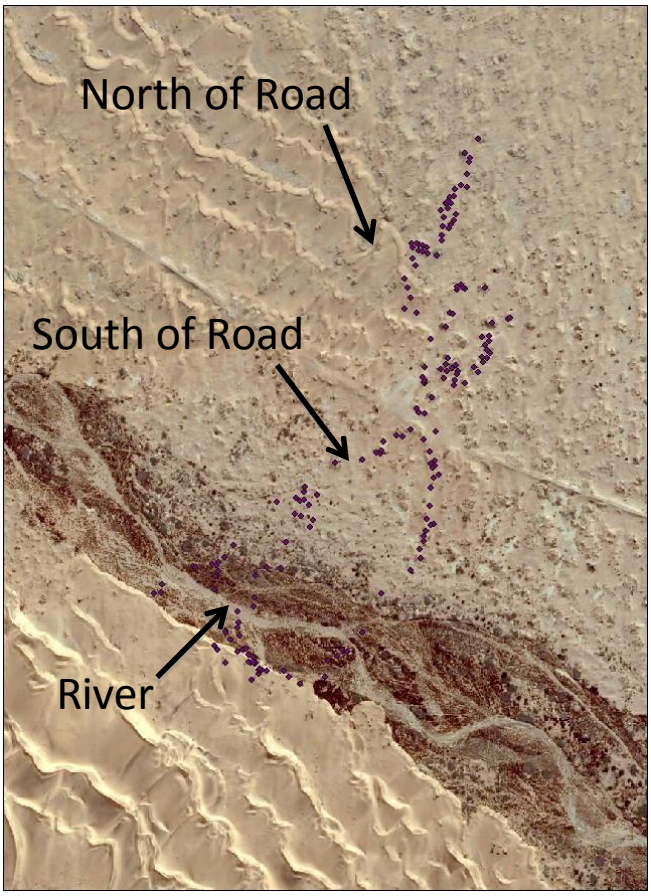
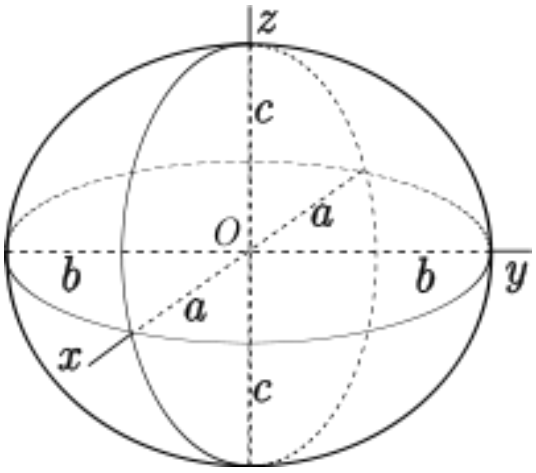
Appendices



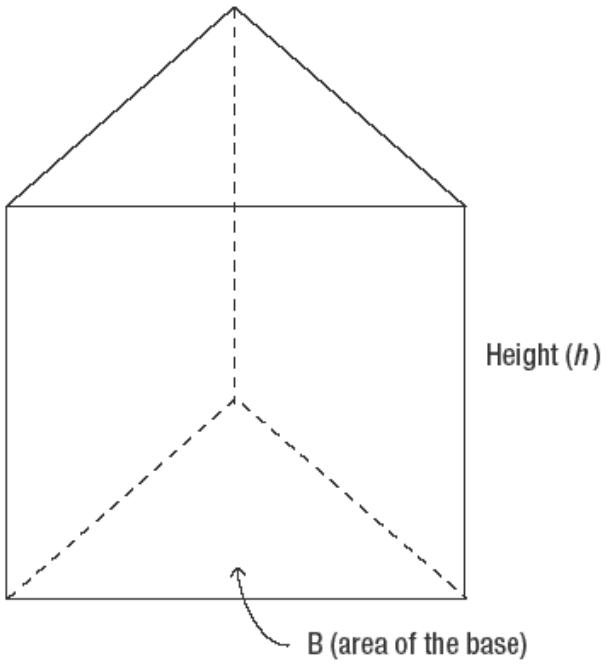
Appendix Ia. Map of the valleys analyzed.



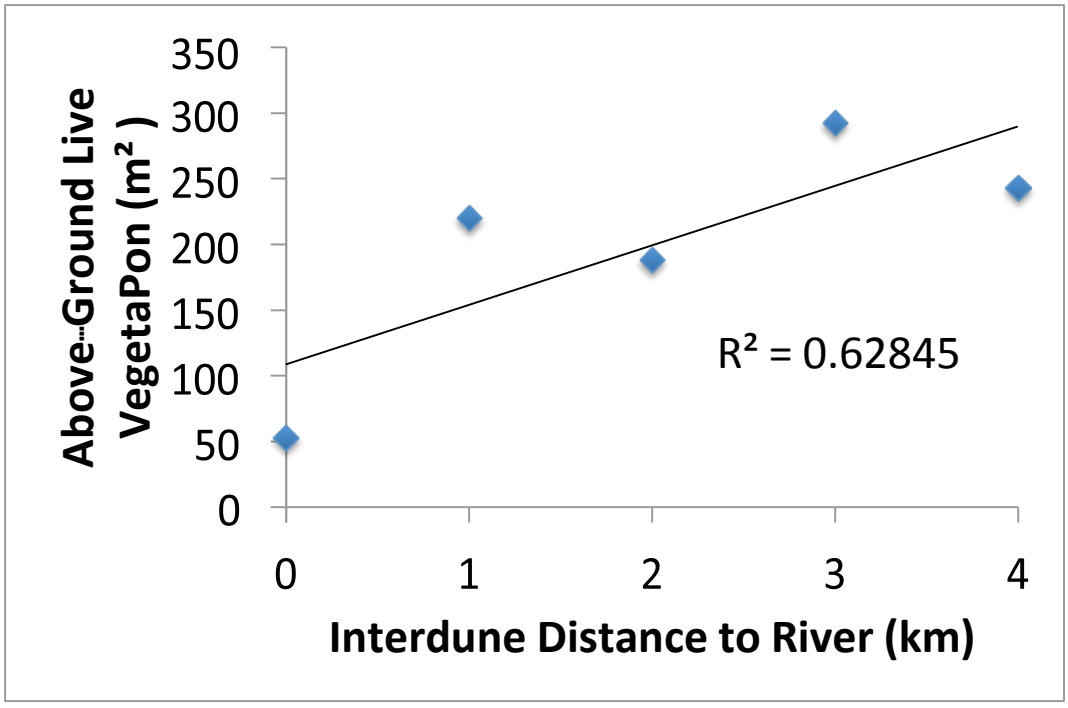
Appendix Ib. Map of delta region analyzed.



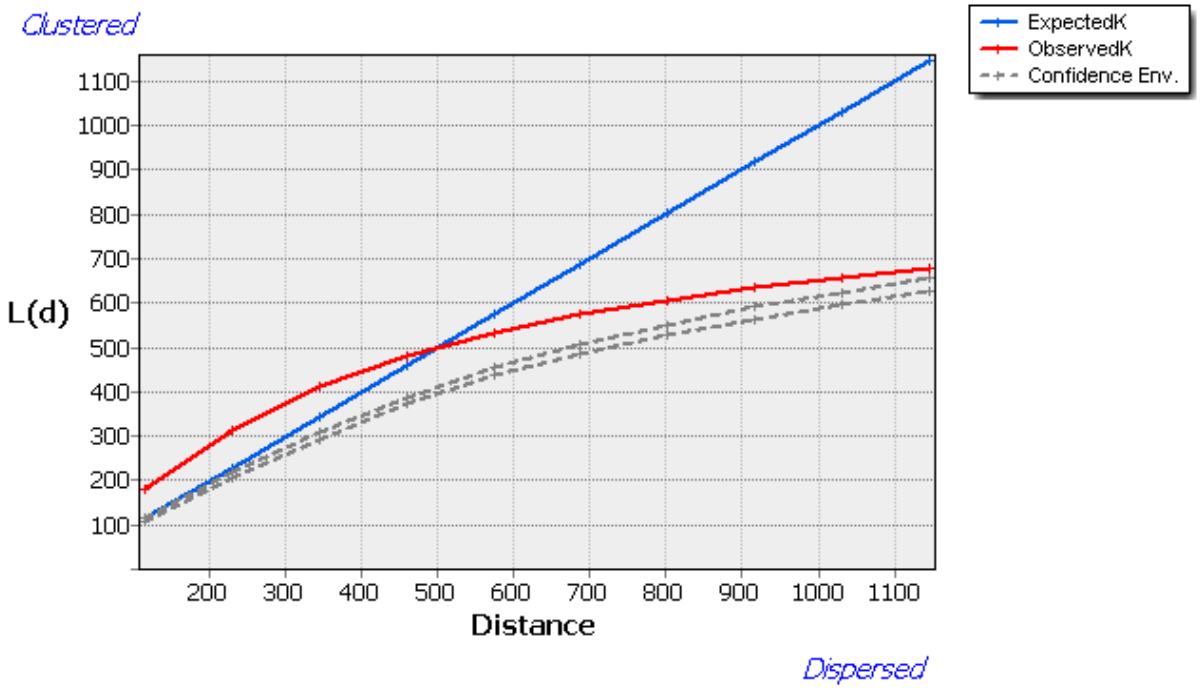
Appendix II. Ellipsoid model used for hummock surface area. Only one half was calculated. Image taken from http://en.wikipedia.org/wiki/Ellipsoid#mediaviewer/File:Ellipsoid_triaxial_abc.svg



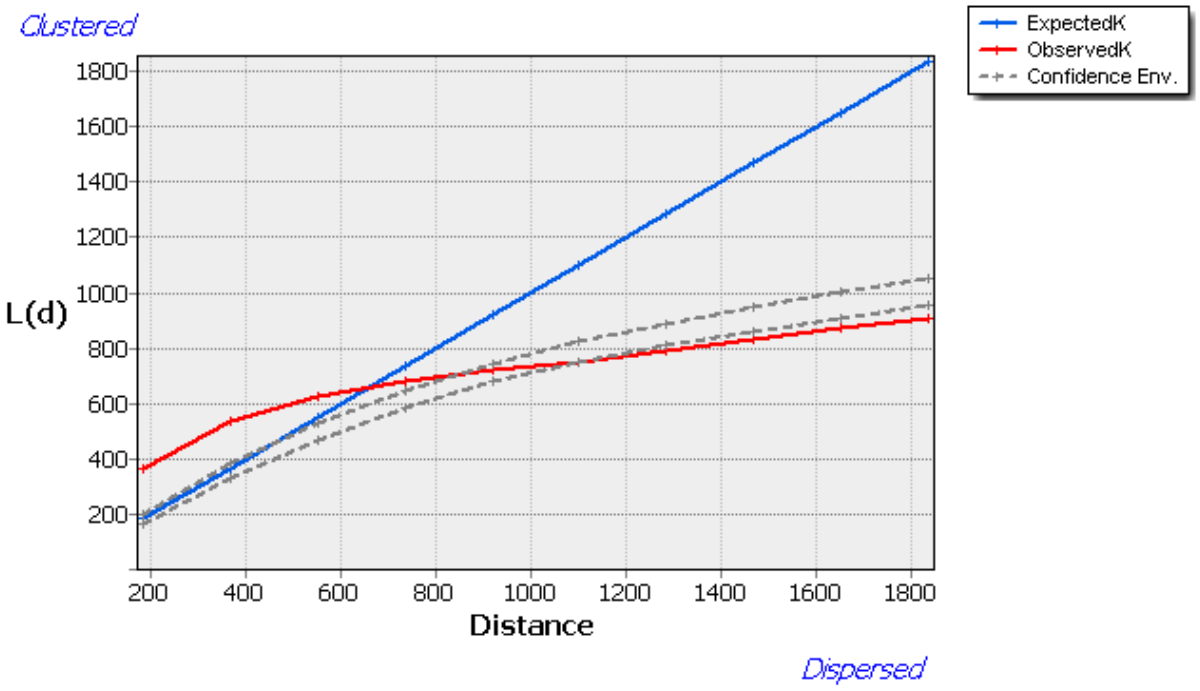
Appendix III. Triangular prism model used for hummock surface area. Bottom face was not included in calculation of total surface area. Image taken from http://00.edu cdn.com/files/static/learningexpressllc/9781576856918/VOLUME_WORD_PROBLEMS_01.GIF



Appendix IV. Relationship between interdune distance to the river and aboveground live vegetation for !Nara Valley (no statistical significance was found between these two variables in any of the valleys)



Appendix V. Ripley's K analysis of!Nara Valley



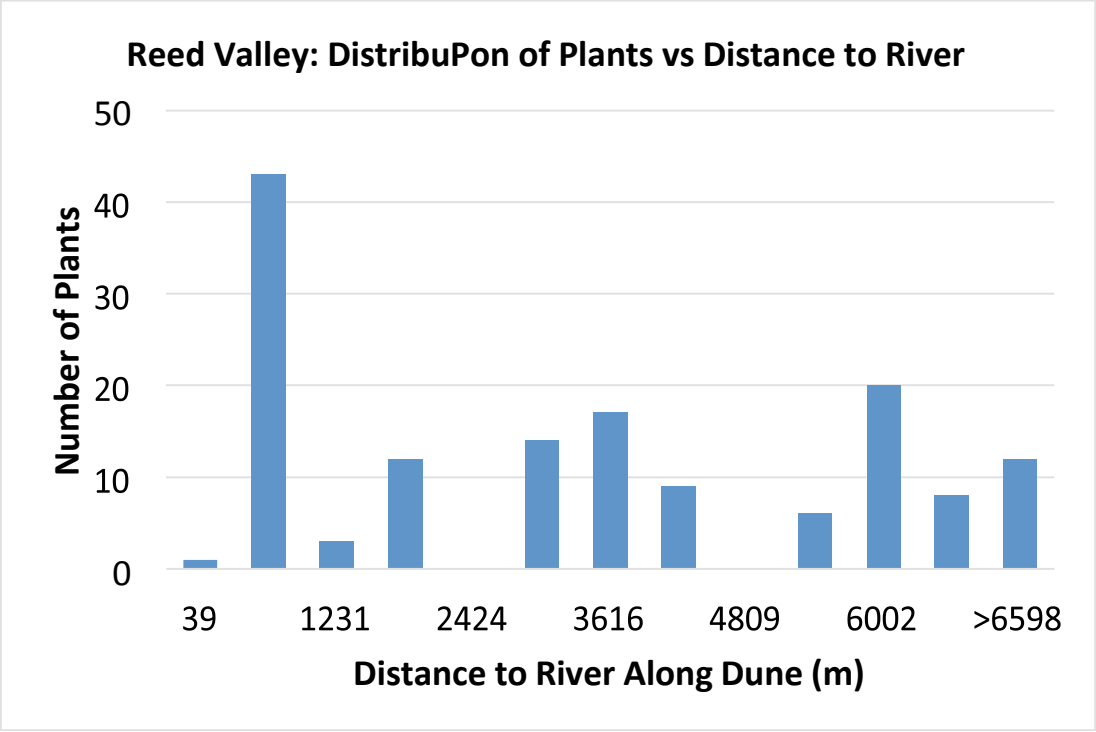
Appendix VI. Ripley's K analysis of Reed Valley.

Nearest Neighbor	Femaleto Female	Femaleto Male	MaletoMale	Maleto Female
Mean	8.766485	8.945837	9.74714	9.03929
SD	4.211755	3.172002	3.74044	3.24325
N	71	71	69	69

Appendix VII. Normalized nearest neighbor between females and females, females and males, males and males, and males and females for Reed Valley. Values are root transformed.

Nearest Neighbor	Femaleto Female	FemaletoMale	MaletoMale	MaletoFemale
Mean	9.95	12.83	11.11	9.77
SD	3.80	7.19	6.25	5.18
N	25	25	20	20

Appendix VIII. Normalized nearest neighbor between females and females, females and males, males and males, and males and females for Gobabeb Valley. Values are root transformed.



Appendix IX. Distribution of all plants in relation to distance to the river along the dune lines in Reed Valley

A Holistic Approach to Mapping the !Nara

November 15, 2014

Prepared By:

Emma Waugh
Vickie Pan
Amanda Toporek

Introduction

This paper integrates indigenous knowledge into a localized community mapping structure, using Geographic Information Systems (GIS), that equally weighs existing science and indigenous knowledge of the !nara system in the Kuiseb River. Our goals are to produce a useful map for all partners in this large socio-political system, encourage further localized community mapping, and contribute our methods and suggestions to the developing field of community mapping. Our research was a holistic study of the !nara plant in relation to !nara researchers, harvesters, salespeople, and Gobabeb Research and Training Centre.

This paper first positions our study within existing literature on both indigenous knowledge and community mapping. Our methods are then outlined in detail, a particularly important process in this area of research. We then present our results, the themes that emerged from empirical data collection, and our finalized map. We discuss the themes in detail, incorporating each partner's knowledge. Finally, we discuss the ethics and limitations of the study and provide suggestions for further research.

Indigenous knowledge v. scientific knowledge

In attempts to value the disadvantaged and the rise of "neo-indigenistas," or those who advocate the value of indigenous knowledge, during the 1990s, there came a false theoretical dichotomy between indigenous and scientific knowledge (Agrawal, 1995; Tripathi and Bhattarya, 2004). The work of these "neo-indigenista" scholars relied on there being a difference between these two knowledge bases, and they sought to raise indigenous knowledge to the sphere of scientific knowledge. However, in reality these two forms of knowledge have more similarities than differences, specifically in substance, methodology, and contextualization. For example, substantively, indigenous knowledge not only applies to daily activities, it also contains non-technical wisdoms. Western science not only contains abstract centralized theories, it also informs daily life. In addition, both types of knowledge are on a methodological spectrum of closed and open systems of input and alteration depending on substance. For example, some science, like the law of gravity, is closed, at this point. Other science is disputed and tested by many. Some open systems of indigenous knowledge contain conflicting or symbiotic stories from many, whereas other theories are accepted as fact, or closed. Finally, in both
categories new knowledge must be scrutinized through peer validation. Scientists submit to peer reviewed journals, and peers must confirm indigenous knowledge for it to be repeated and considered fact. As is evident in these similarities, knowledge may be viewed on a spectrum. (Agrawal, 1995; Tripathi and Bhattarya, 2004)

Despite fluidities in substance, methodology, and contextualization of these two perhaps arbitrary categories, a dichotomy does exist in the way these spheres are regarded. Western science is perceived as centralized, of high prestige, documented, and disseminated. Indigenous knowledge is perceived as decentralized, often undocumented, and of low prestige, often even by those who possess it (Agrawal, 1995). Our work seeks to contribute to literature that values both sets of knowledge. We follow Agrawal's advice and consider these forms of knowledge as classified in multiple fields for multiple uses or generative processes. As a result, we cite both indigenous knowledge and scientific knowledge as important data, falling into the same spectrum of a field of equal importance.

We are aware that society still maintains these lables, but we hope to begin a productive dialogue that will "safeguard the interests of the disadvantaged" (Agrawal, 1995). Ultimately, as students of a Western university using the resources of a Western scientific institution, we did have to compromise this goal in some ways[2].

Community Mapping

Specifically, we collected Traditional Ecological Knowledge (TEK) and placed it into a community mapping framework. Huntington (2000) defines TEK as fitting into scientific research, impact assessment, and ecological understanding.
While it fits into these categories, biologists and ecologists often struggle with TEK collection, perhaps a partial explanation for the stagnation of indigenous knowledge incorporation in the literature. We also sought to play an interdisciplinary role as scholars, collecting data as social scientists and integrating it with data collected by natural scientists (Huntington, 2000).

Community mapping is a relatively new tool used practically and studied in academia. Perhaps intentionally, it lacks a uniform methodology (Parker, 2006; Edberg et al., 2009; Fahy and Cinneide, 2008). As such, all community mapping literature, including this paper, should contain critical reflections on processes and uses so as to help fully hone community mapping as an effective tool (Fahy and Cinnéide, 2008). Despite lacking a common methodology, many scholars agree on principles of community mapping. Parker (2006) defines community mapping as: 1) a "collective endeavor" to "represent a range of community members within a localized geographic scale," 2) the process is often of equal value to the product, and 3) inclusivity, empowerment, and transparency are fully integrated in the project. Using her framework as a guide, we incorporated these principles, whether in concurrence or dissent, throughout our methods. We turned to other community mapping projects of varying scales and settings for methodological inspiration as well.

The application of GIS to TEK is a newer subsection of the community mapping field that remains "underexplored" (Tripathi and Bhattarya, 2004). The up-and-coming processes and products of community mapping, when done within a participatory framework, fit well within the goals of the dismantled divide of indigenous and scientific knowledge because the process seeks to empower the disadvantaged, or locally less powerful, to be experts of their own locations, seeking outside help for technicalities (Tripathi and Bhattarya, 2004; Parker, 2006; Fahy and Cinneide, 2008). This democratized process yields results that geographers view on equal footing as other maps (Tripathi and Bhattarya, 2004). This geography niche seems to have accepted Agrawal's dismantled divide of value in a way that much of academia still has not.

University Partnerships in Community Mapping

In community mapping, different partnerships with communities can have different implications. Scholars caution against the creation of a new elite class of specialized indigenous data collectors (Agrawal, 1995). As university students, we understood our project in terms of a community-university partnership. According to Fahy and Cinnéide (2008), the advantages to this relationship in mapping are that the community has access to expertise and resources (specifically GIS), and the map can be made to meet the standards

typical in the academic sphere. This is crucial in making TEK viewed as a valuable resource. However, if the university agenda runs the project, this partnership also has the danger of community marginalization, causing a loss of capacity building and community ownership (Fahy and Cinnéide, 2008). The goal of the partnership, in long-term projects in particular, is often to teach the community to use the technology so they are empowered with the tools to map their own resources, with the university serving as a consultant when questions come up (Fahy and Cinneide, 2008).

Our Unique Position

As three students taking part in an academic class and not receiving university funding for this project, we propose that much of the danger of university agenda is eliminated from our project. We sought to take advantage of our role as students in fieldwork and interviews. Specifically, we thought this role would help us avoid detracting community ownership or capacity building in this process. Additionally, we sought to take advantage of all of our resources as university students in our unique position to create a high quality final map to serve the community in its entirety.

Students from our university have been coming to Gobabeb Research and Training Centre annually for twelve years. The students started doing individual research projects during a week-long stay at the Centre one year before us. Given the standing relationship with Gobabeb, we had access to their staff, library, and relationships with other members of the community at large. We also aimed to be an objective party throughout this project given our position. In this unique position, we spent our time studying !nara, a plant unique to this region.

The !Nara Plant

The !Nara (Acanthosicyos horridus) is an endemic plant of the Namib Desert, presumed to have existed 40 million years ago, as documented through fossil evidence (Moser, 2006). Populations occur along the entire length of the Namib from Port Nolloth in South Africa to Namibe in Angola (Henschel et al, 2004). Growing in a variety of geographic areas, including sand dunes, river beds and coastal regions, the largest population can be found in the Kuiseb delta (Moser, 2006). Overall, there are hundreds of !nara plants. However, a steady decrease in number and fruit-size has been reported (Shilomboleni, 1998). Some researchers believe that the decline in floods has led to a decrease in the population, while local harvesters attribute the decline to the effects of flooding and wasteful harvesting techniques (Mizuno, 2005; Field day interviews).

A member of the cucumber family,!Nara is a plant that has adapted to the dry, desert environment. Its multiple greenish branches, covered by thorns that are about 2- 3 cm long, conduct photosynthesis in lieu of leaves. The body of the plant is referred to as a "hummock" because it accumulates sand around the stems during its growth, forming a raised dune (Ito, 2005). Its long tap roots facilitate water uptake from underground reserves and are estimated to reach over 50m deep (Henschel et al, 2004). In addition, its transpiration level is high, water use efficiency is low, and not much water is stored in the branches.

!Nara is a dioecious plant, meaning that there are separate male and female plants distinguished by their flowers or when the female plants bear fruit (Moser, 2006). The male plants bloom throughout the year while the female flowers mostly appear from September to December, allowing for an early harvest of the fruit in October and November. The majority of fruits ripen starting in December.

The Topnaar people live along the Kuiseb River and are dependent on this plant in many ways and have used it for some 8000 years (Gardiner et al, 2006). Not only does it serve as a vital source of income, nutrition and traditional culture, but it is viewed by the Topnaar as the foundation for their livelihoods (Interviews 11/6, Field Day 11/7, Henschel et al 2004; Pfeifer 1979).

Methods

Method Selection

We sought to merge case studies of community mapping (Edberg et al., 2009; Fahy and Cinnéide, 2008) with larger frameworks (Parker, 2006; Tripathi and Bhattarya, 2004) to contribute to this newer academic field. All the while, of course, keeping in mind the perhaps cardinal rule of community mapping: each project is unique. Parker (2006) first defines the community as a group of people who share geographic space, but do not necessarily have a set of shared values. We incorporate this definition as well. We define our community as one which shares the space of the !nara harvesting fields we mapped. Most literally, the Topnaar people (from the village and the city) harvest !nara here for personal use or for sale. When the !nara is sold, Desert Hills is the major consumer, perhaps more abstractly sharing the geographic space. Finally, !nara researchers may also come into the field and collect !nara samples. While we only had Topnaar village residents with us as geographic guides, this paper tries to extract information from the other two spheres as well, valuing their knowledge on the same plain as TEK to create a holistic view of these localized areas.

Consequently, we have created a series of maps that layer this information. Our map of solely Topnaar information documents and disseminates TEK in an accessible way within its own valuable sphere. This pilot program will hopefully be one of many TEK maps of !nara made throughout the Namib Sand Sea, if for no other reason than the decentralized and centralized dissemination of this valuable material.

Some scholars might find varying values within different components of our map. We propose that our most holistic map is indeed a community map as it brings in all users of the geographic area equally. We see the dissemination of these maps as a way to create transparency between stakeholders in localized geographies and a step towards decentralizing the arbitrary field of scientific knowledge by increasing accessibility.

Participant and Location Choice

Our research included interviews in and out of the field. In the field we conducted three interviews with Topnaar harvesters. Aside from our work with field participants, as a pilot program we conducted interviews with seventeen Gobabeb scientists, two !nara researchers,

one Desert Hills staff, and four Topnaar harvesters. We interviewed a majority of Gobabeb scientists, and selection was based on who had time in their schedule for an interview during our time at Gobabeb. Selection of !nara researchers to interview was based on knowledge Gobabeb employees had on current projects. Our interview with Desert Hills was with one of two managers, based on availability. Our !nara researcher interviews were via email and phone. Finally, our Topnaar !nara harvester interviewees were selected by Gobabeb employees because they helped facilitate communication with those community members, whereas we did not have a means for communicating with Topnaar in other communities. These interviewee selections were largely a result of our previously discussed unique position in this larger community.

In selecting field participants for our project, we sought to employ a peer selection process given that we did not know our pool of harvesters (Huntington, 2000). In one of our three field participants, we succeeded in finding a peer selected participant that peers referred to as !nara or harvesting experts. Challenges of participant recruitment are discussed in the limitations section.

We chose our mapping location after meeting our participants. The goal was to map a harvesting area with which they were familiar. Consequently, we asked our field participants to guide us to a !nara field, the first step the empowerment and ownership pieces of our project.

Group Size in the Field

Consulting the Parker (2006) principles on community mapping, we disagreed with her emphasis on participants working together to negotiate issues (Parker, 2006) as a value in the process. In fact, keeping groups together in the field raised problems of gender (Agrawal, 1995) and power dynamics regarding the TEK. Specifically, we were concerned women might be less open in front of men given conventional and traditional power structures. We also brought people into the field with varying degrees of harvesting experience and didn't want newer harvesters to fall silent in the presence of experienced harvesters.

As a result of these concerns, we broke the community members into smaller groups of one or two, as homogenous in gender and experience level as possible. In a community mapping project done with youth in DC, Edberg et al. (2009) broke young adults into groups of five to also minimize groupthink but also allow for some productive conversation. Given our small sample size, groups of one or two seemed best to still achieve these goals.

Explanation to Participants

In explaining our pilot community mapping project to our field participants, we incorporated Parker's (2006) mapping theme of transparency and approaches recommended specifically for university-community partnerships. In a university partnership community mapping project in Galway, Ireland, the university first briefed community members on the technology used, other community mapping projects, and their methods. Importantly, they also emphasized project uniqueness (Fahy and Cinnéide, 2008).

For our research project, we developed a hand drawn sketch of what an area with !nara might look like: a river, large hummocks, small hummocks, etc. We showed this diagram to our field participants and explained that we wanted to use their guidance to create a real map on a computer that mirrored what they said. We used a hand-drawn map versus a computer-generated map to remove the idea of map permanence. An expert GIS instructor explained that when people see a computer-generated map, they often focus on the details and identify if the map is or is not correct. For our purposes, we just wanted to give participants a sense of the kind of data we were hoping to collect. We were also concerned with participant comfort with computer-generated maps. To remain transparent regarding technology as well, we demonstrated and explained how our GPS devices and cameras worked.

Our Role in the Field

In the field, we strove to play the role of observer, as most community mapping scholars ultimately do under a longer time frame. However, given our time frame, we were less able to train our field participants to use the technology and equipment independently. Ultimately, we found ourselves playing the role of student. From our perspectives this seemed to fulfill the Parker (2006) criteria of empowerment. Our participants were the experts, not us. We hoped this would help build capacity around self-representation and TEK in general.

Interview Style

We incorporated several forms of interview styles in our research. Before going into the field, we conducted semi-directive interviews with Gobabeb scientists and !nara researchers. As a pilot program, our intention in these interviews was to gain an understanding for the potential usefulness of our project and understand scientists' perceptions and perspectives on !nara and harvesting. We eventually incorporated this information in our map, but we saw the main value of these interviews as helpful for background research, because we have not previously worked in this larger community or with this ecosystem. The types of questions we asked during the interviews are written below.

We also conducted a semi-directive interview with a group of male Topnaar !nara harvesters outside of the field. Given that this semi-directive interview was a group interview, it incorporated some analytical workshop components when the harvesters interacted with one another. We hoped these anecdotes would provide relevant background knowledge and help us determine if information we got from harvesters in the !nara fields was (in)consistent with data collected during interviews outside of the fields. We also saw this information as possible data to incorporate in our maps.

Finally, outside of the field we conducted an email questionnaire interview with Desert Hills management, Bianca Braun. We saw this as an opportunity to introduce the business preferences in !nara commercialization and compare and contrast these to other findings. We used these out-of-field interviews as primary sources to supplement information given in literature and in the field. As this information applied, we integrated it into our maps and further discussion of the maps.

In the field we conducted collaborative fieldwork interviews. While this type of work

should include work both collecting data from the field and interpreting it, we used this protocol solely in the field given our access to these participants. As a result, we ask questions that required our participants to guide us around the field and teach us about where we are, what happens here, and why. Huntington (2000) draws a line between all other forms of interviews and collaborative fieldwork. He argues that participants must become a locally hired field assistant in collaborative fieldwork. In our ethics and limitations section, we will further discuss our grappling with this literature and our unique position as we conducted our research.

Before each interview, we outlined the information we hoped to gather from the specific interviewee. We then incorporated the above interview styles to cater to the goals of the interview and profile of the interviewees (Seidman, 2006). (For our specific questions goals, see Appendix I). In general we were concerned with getting each profile to discuss !nara uses, values, preferences, harvesting, changes over time and sustainability of the plant.

Data Analysis

Our results came in three different forms: qualitative interviews, literature research of current science on !nara, and the results of integrating our qualitative interview results with GIS mapping. We used a common approach of analyzing thematic connections to process our results and present them in this section (Seidman, 2006; Jasis and Jasis, 2011). The results from the scientific research on !nara are incorporated in Tables 1-3 below and within the discussion section.

We used our qualitative interviews and fieldwork in different ways to contribute to our map and this paper. Our interviews outside of the field were supplemental and used to increase perspectives and quantities of opinions. Our interviews with Gobabeb staff largely served as a way for us to understand the larger community in a short time, and our roles in that system. Data gathered during our interviews with !nara researchers and Desert Hills management were included in our map. We used these interviews, along with the literature, to add layers to the map created through our fieldwork. Additionally, the information from these interviews played a large role in our interpretation of the layers on our map and in this larger community system.

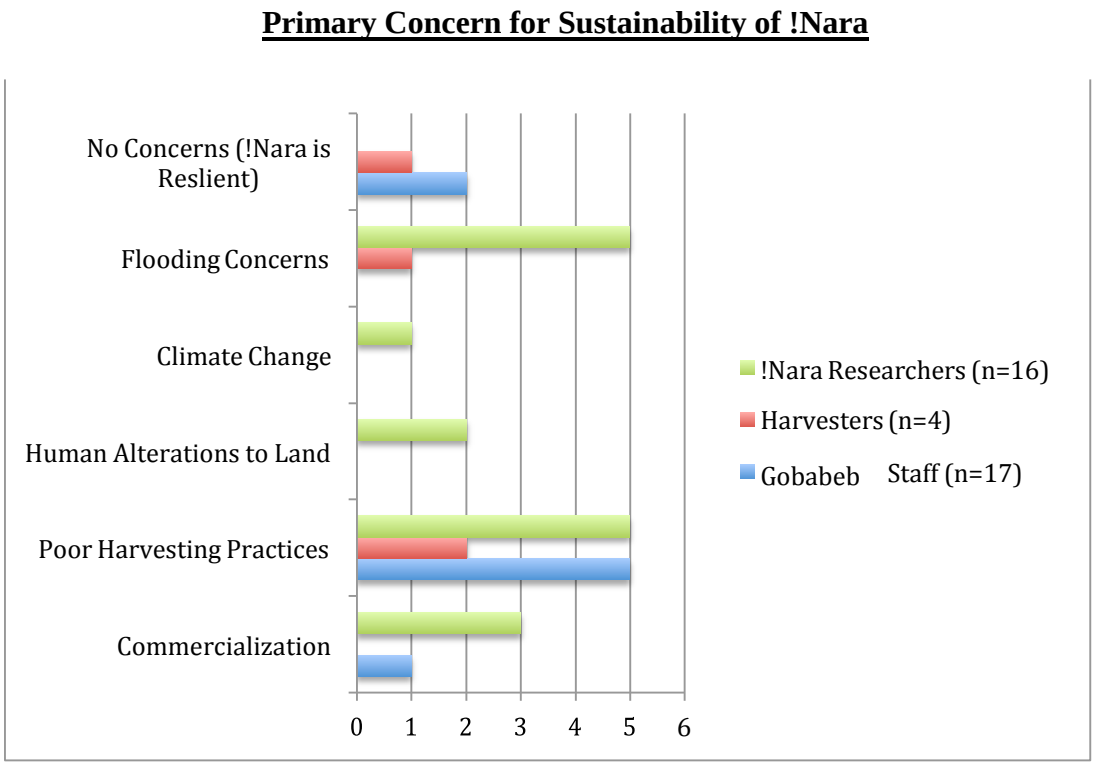
Our collaborative fieldwork allowed us and our field participants to collect photos and anecdotes associated with specific GPS points. We imported our GPS points into ArcMaps and added symbols to represent information on each point. Then, we exported the map and layered in photos and written descriptions. This work most directly contributed to the creation of our map, which served as our main result and the topic of discussion throughout this paper.

Results

The results we gathered are best synthesized through the major themes of our interviews: perceptions on the value of !nara, uses of !nara, role of !nara within its ecosystem, and the longterm sustainability of !nara. Tables 1-4 below present the differing perspectives within each theme. Although the tables show each partner's various understandings, many of the

participants echoed each other's concerns for and opinions of !nara. In the discussion section we will elaborate on the common interests held by all four partners: harvesting, hydrologic geography, physiological fruit quality, ecological interactions and uses.

Graph 1



Graph 1 represents each interviewee's primary concern for the future of !nara. Each partner showed a significant concern that poor harvesting practices could affect the sustainability of !nara. Although Gobabeb staff are not yet convinced flooding decreases !nara resilience, it is of primary concern to many researchers and the harvesters.

Table 1 **Perceptions of !Nara Interactions with the Ecosystem**

Gobabeb staff	• Supports microhabitats and stores fog used by many organisms • Decline in !nara due to increased flooding (Gobabeb Interviews, 11/6)
Harvesters	• !nara must be sustainability harvested or else it will disturb the larger ecosystem (Field Day, 11/7) • Decline in !nara due to increased flooding (Group interview, 11/6) • !nara provides food for jackals, mice and other wild animals (Field Day, 11/7)
!Nara Research/Literature	• Used as a living space for lizards, beetles and rodents (Pfeifer, 1979; Klopatek, 1994) • Provides feeding opportunities for rodents (Klopatek, 1994) • Essential to diet of wild and domestic animals (Henschel and Jankowitz, 1998; Pfeifer, 1979; Muller, 2005) • Flooding plays a vital role in its growth (Ito, 2005)
Commercial Users	• It is an important plant so must be harvested sustainably (work within the guidelines of the Ministry of Environmental Tourism and Topnaar Traditional Authority)

All partners are in tune to the value !Nara has within the ecosystem and each is interested in sustainably using the plants. Researchers and Gobabeb are particularly interested in exploring !nara's specific contributions to the ecosystem (e.g. fog, microhabitats, and its nutritional value), but the harvesters and commercial users are also generally aware of these elements of !nara.

Table 2

Perceptions of !Nara Harvesting

	Contemporary	Traditional
Gobabeb	• Income, food for a small number of Topnaar • On communal land	• Complete livelihood of entire Topnaar population • Used to be done by families
!Nara/Topnaar Research and Literature	• Antiquated practice, but sometimes supplementary to food or income • Tragedy of the commons caused shift from familial to communal ownership (Pfeifer, 1979) • Unsustainable harvesting due to Westernization and commercialization (Henschel and Jankowitz, 1998; Visser, 1998) • Stick used as a harvesting tool (Pfeifer, 1979) • Plot system (Widlok, 2000)	• Sustainable resource used for all parts of life: medicine, food, containers, sugar beer • Familial ownership (Pfeifer, 1979) • Traditional harvesting was most sustainable option (Visser, 1998)
Harvesters	• Value is dietary staple, primary source of income, medicine, commercial use (sometimes exclusively) (Field Day, 11/7) • Camel thorns play an important role in the process by providing fuelwood (Field Day, 11/7) • Younger generations techniques are wasteful (Group interviews, 11/6; Field Day, 11/7) • Growth of family size resulted in transition from familial land ownership to communal ownership (Field Day, 11/7) • Stick used as a harvesting tool • Various names are still used to refer to areas in the field (Field Day, 11/7)	• Same value as today, only commercialization was not as large of value (Field Day, 11/7) • Elders' harvesting techniques were more widely used (Group interviews, 11/6, Field Day, 11/7) • Familial land ownership • Various names were used to refer to areas in the field (Field Day, 11/7)
Commercial Users	• The !nara plant and harvesting practices have always changed annually depending on the rain patterns and other weather conditions (Desert Hill interview)	

Table 2 demonstrates that the contemporary value of !Nara to local harvesters far exceeds the perceptions of existing literature. However, existing research is attempting to understand the science that is likely related to Topnaar preferences.

Table 3

Uses of !Nara

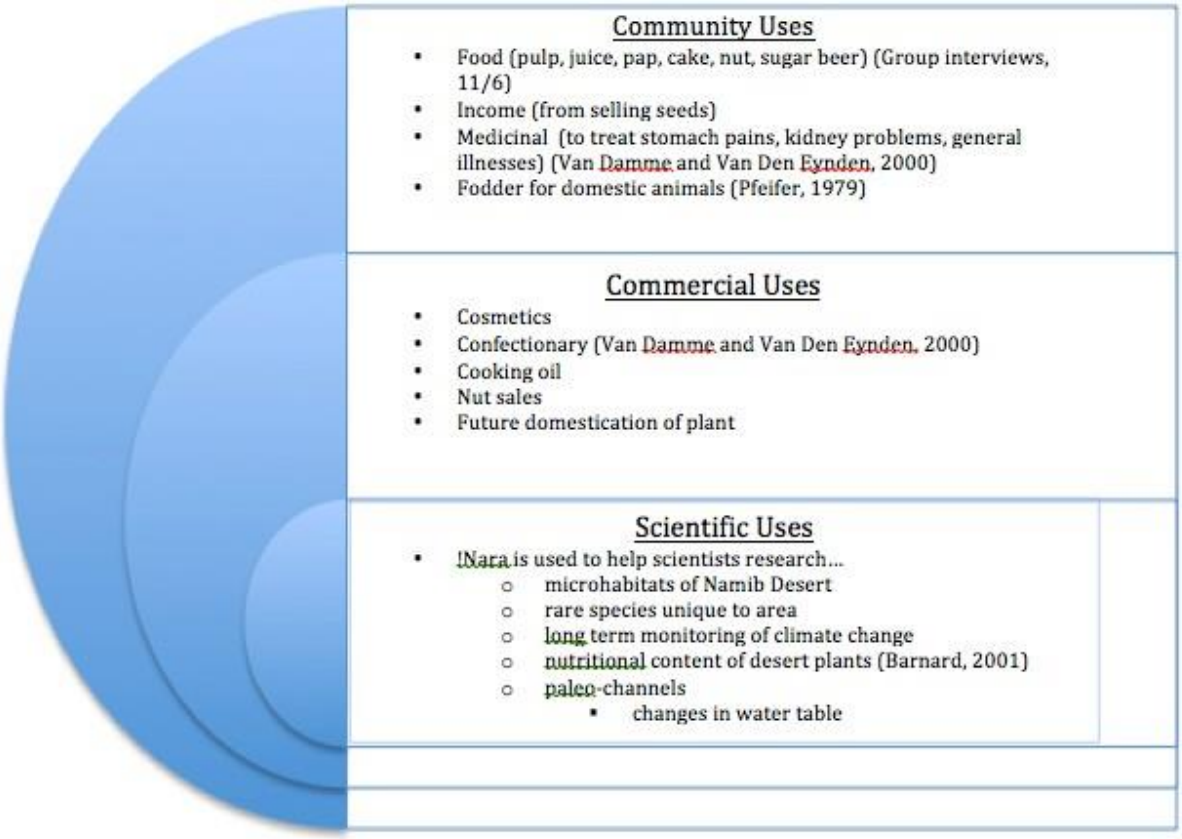


Table 3 shows the varying uses of !nara. Although each partner utilizes !nara in differentiating ways, their uses indirectly inform one another through harvesting, sales, and research.

Table 4

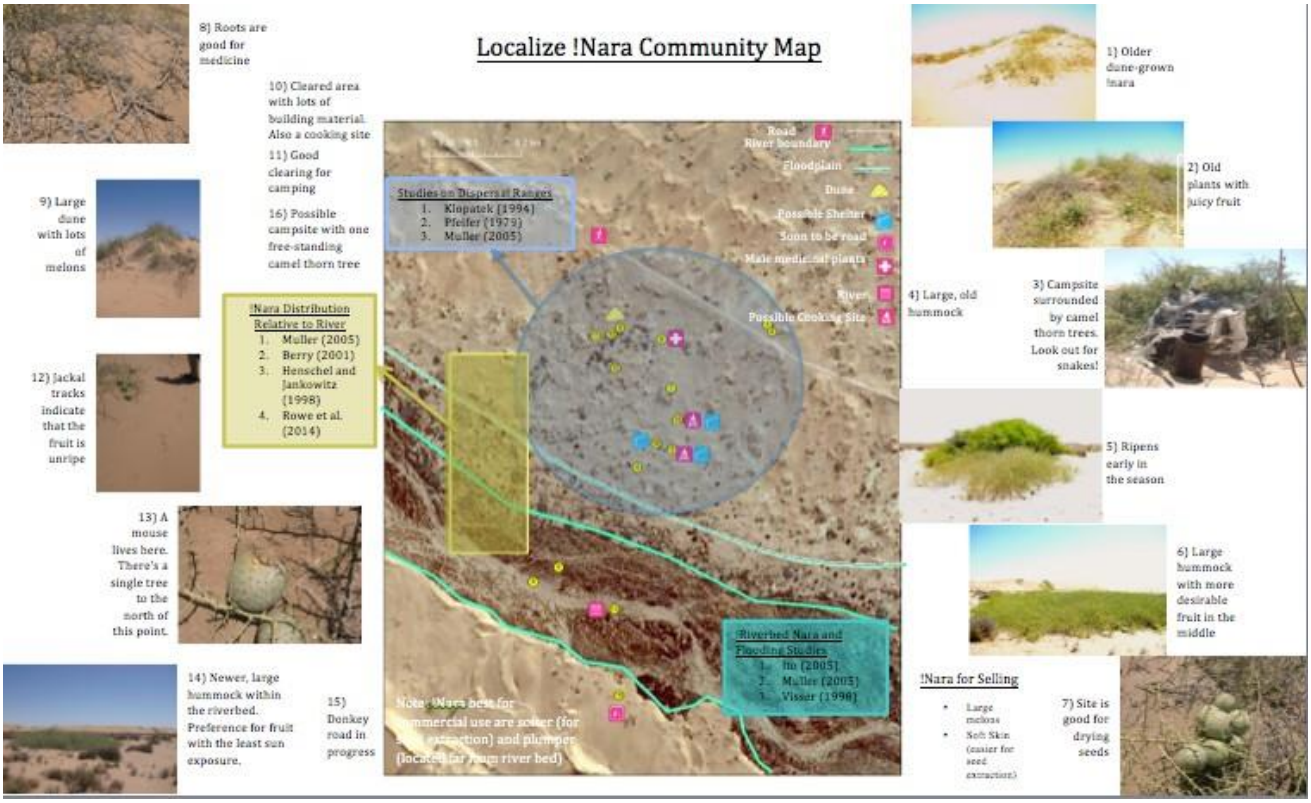
Perceptions on Quality of !Nara Fruit

Desirable !nara fruit	Undesirable !nara fruit
• Ripe (older) (Field Day, 11/7) • Soft to the touch, falls when poked with a stick (Field Day, 11/7) • Light green in color • Spiky exterior • Dunes have more desirable fruit even though there is weaker plant growth (Field Day, 11/7; Moser, 2001) • Usually have more seeds (Field Day, 11/7) • Jackal tracks usually found near the hummock (Field Day, 11/7) • Fruit is closer to the sand and in the middle of the hummock (Field Day, 11/7) • Contains less cucurbatacins (Gwash's interview; WilkinsEllert, 2004) • Plump seeds (Bianca's interview, 11/12) • Soft skin (for early seed extraction)	• Unripe (younger) (Field Day, 11/7) • Hard, damages the bush when it is harvested (Field Day, 11/7) • Dark green in color • No developed exterior • Riverbed has less desirable fruit even though there is stronger plant growth (Field Day, 11/7; Moser, 2001) • Usually have less seeds (Field Day, 11/7) • No tracks near the hummock (Field Day, 11/7) • Fruit is closer to the sun and near the exterior of the hummock (Field Day, 11/7) • Contains more cucurbatacins so more bitter to the taste (Gwash's interview; WilkinsEllert, 2004)

Table 4 demonstrates the preferences different partners have when utilizing !nara. Commercial preferences are not always aligned with harvester preferences so this graph can serve as an information sharing mechanism for each partner.

These tables, our GIS results, and research were all incorporated to create our final map**.**

Final Community Map



Using the themes generated by our interviews, we created this community map. This community map further lends itself to discussion around five proceeding themes: harvesting, hydrologic geography, physiological fruit quality, ecological interactions and uses.

Discussion

Harvesting

Although seemingly simple !nara harvesting is a dynamic process with different perceived values to each individual throughout the process, as seen in Table 2. General Gobabeb staff understanding of !nara harvesting was that it was done by entire families as a source of food and income. Although the Topnaar staff at Gobabeb were the only ones who knew which !nara were harvestable, most of the Gobabeb staff were able to provide at least a general understanding of the value of !Nara to the Topnaar. There was also a large consensus that the younger Topnaar generation does not use the same sustainable harvesting practices as previous generations, and although the fruit is currently resilient, poor harvesting practices could jeopardize the future of !nara. A few mentioned that harvestable land used to be divided by families, but is now communal.

In the field, many of these perspectives were illuminated. Harvesters confirmed that the younger generations' harvesting techniques are wasteful; some harvesters now collect unripe !nara from the vine without first testing to see if it is ripe. Furthermore, the harvesters' recollection of land ownership were similar to those perceived at Gobabeb.

Ultimately, as Topnaar family size grew through inter marriages, familial land ownership was not viable for harvesting and the community agreed to share the !nara harvesting land (Field Day, 11/7). !Nara researchers have a slightly different perspective on !nara harvesting land ownership, as scholars largely explain the transition to communal ownership as a result of the tragedy of the commons. Literature investigating Topnaar harvesting practices unanimously agrees that an increase in westernization and commercialization of !nara led to unsustainable harvesting practices and decreased cultural appreciation of !nara (Pfeifer, 1979; Henschel and Jankowitz, 1998; Visser, 1998).

Despite the dissimilarities between scholarly and Topnaar accounts of land ownership debates, the two are aligned in their portrayal of harvesting techniques. Literary portrayals of harvesting align with local Topnaar accounts of harvesting twice a year, using a long stick to first identify and then pick the ripe !nara (Pfeifer, 1979). Despite its accurate portrayal of Topnaar harvesting practices, the literature incorrectly depicts !nara harvesting as an antiquated process, claiming "Topnaar today no longer depend on the !nara" as it is a "supplement to their diet and or income" (Pfeifer, 1979; Visser, 1998). Contemporary harvesters beg to differ, claiming "!nara is life" (Group Interviews, 11/6).

In reality the !nara harvesting process takes a few months and requires harvesters to set up camps within a !nara field. The local people use various names for certain areas within the harvesting site, such as "Mile 7", to demarcate the areas they move around to. The !nara field "plot" system represents an elaborate cultural system for which families can easily refer to in their native tongue (Widlok, 2000). In general, they start in the riverbed area, as is evident in the map as the area between the turquoise lines, to harvest the more accessible fruit and then gradually move inland to collect the fruit that are more difficult to harvest. There are also more trees in the riverbed area that can be used for cover. The camel thorn tree (*Acacia erioloba)* is a tall tree that grows in the driest regions of the Kuiseb River and one of the most important sources of fuelwood, offering shade and shelter during the harvest season (Mizuno, 2005; Field Day, 11/7). In the map, points 3 and 16 indicate that the camel thorn trees are located in close proximity to the riverbed area. "We sometimes collect wood from [the riverbed area] and bring it all the way to our base in the dunes," one interviewee reported, speaking of the additional work harvesters take on during the process.

Hydrologic Geography

Each component of the community mapping process had a rich perspective on the relationship between water and the historical productivity of !nara, as seen in Table 1). In the map, the floodplain is illustrated as the brighter turquoise line above the riverbed area. Our first exposure to the contention surrounding the relationship between flooding and !nara was during our interviews with Gobabeb staff. One Gobabeb scientist, an employee who has devoted much of his life to !nara, indicated harvesters believe there is an alleged decline in !nara due to increased flooding. As a scientist, she is not yet convinced that there is even a decline in !nara, less a correlation between flooding and !nara populations (Gobabeb Interviews, 11/6). During our fieldwork, this Gobabeb scientist's theory was confirmed, as harvesters' number one concern in the sustainability of !nara was increased flooding diminishing !nara populations (Field Day, 11/7). Many

harvesters cited the 1996 and the 2010 flooding seasons as particularly detrimental to the !nara population. !Nara literature has attempted to explain this relationship that has proven noteworthy to Gobabeb scientists as well as community harvesters.

Historically, Topnaar have been marginalized in their access to water. Under the South African Odendaal Plan in 1960, Topnaar were supposed to relocate to the Gibeon area in Southern Namibia and, despite their houses being destroyed, many Topnaar refused to move (Steyn, 1978). The government largely ignored the Topnaar who remained as huge water extraction schemes were built on Topnaar land to pump subterranean water from the Kuiseb River to Walvis Bay, Swakopmund, Henties and Topssing Mine. In 1961, a flood protection wall was built and a tributary was dammed to protect Walvis Bay from flood, and as a result a large percent of !Nara were killed (Masaaki, 2005). It was not until twenty years later that Topnaar settlements gained water supply and their voices regarding !nara decreases were heard (Visser, 1998).

After the particularly harsh flood of 1996, the Topnaar Community Foundation requested that the Desert Research Foundation of Namibia develop a study to explain the factors leading to the decline in !nara productivity. Ultimately, through community workshops, it was concluded that although 26% percent of the community believed issues with water to be contributing to the decline in !nara, but the study only concluded speculations that over pumping and damming take a toll on !nara productivity and that the decline in the Kuiseb water table could be correlated with the decline in !nara (Henschel and Jankowitz, 1998). Furthermore, the study explains that flooding is a natural process and confirms harvester's suspicions that a heavy flood easily washes the !nara plant away. Some studies, have found that flooding can play a vital role in its growth because it contributes to germination and regeneration of individual plants, and the moisture supplied to the soil is thought to favor the renewal of vegetation (Ito, 2005).

More specified studies have investigated the relationship between !nara spatial distribution patterns and paleochannel maps and found a significant correlation between plant size and spatial distribution of the !nara (Muller, 2006). As is evident in the map, the yellow rectangle illustrates the !nara distribution relative to the river. An analysis of groundwater depth in conjunction with abundance of !Nara plants indicated that bigger !nara and more !nara plants are found in areas with shallow water table, making the riverbed a potentially good place for seedling growth. Sand dunes that previously supported !nara growth are now out of reach of groundwater supply, which has made it more difficult for new plants to grow in the dunes (Mizuno, 2005). Interestingly, in other scientific literature, this plant has been characterized as a dune community even though it occurs close to the river (Gardiner et al, 2006).

In a study that explored conditions that are most favorable to the !nara in relation to water availability, three separate !nara populations were monitored from 1989 to 1992 (Berry, 2001). Between the three study sites (dunes, riverbed and coastal area), it found that fruit production was highest in the coastal site because regular freshwater seepage under the dunes contributed to a considerably higher production of fruit. However, it also found that the Topnaar utilized more of the fruit from the plants in the dunes and riverbed regions than at the coast. Although the coastal !naras have the greatest numbers and the highest total biomass of fruit (see Table 4), they are constantly exposed to unstable

conditions in the environment, such as the encroachment of the ocean.
During our fieldwork, we found that this is precisely the reason why the Topnaar choose to only harvest in the dune and riverbed area. However, when presented the choice between these two remaining sites, harvester number one explained that there is a difference in quality of the melons across geographic ranges. In the dunes, the melons tend to be older—as the harvesters give them more time to grow—and have more seeds, whereas the melons in the riverbed area tend to have less seeds and less time to grow (Field Day, 11/7). In the map, points 1, 2, 4 and 9 show sites with older dune-grown !nara, while points 5, 6 and 14 show the younger riverbed plants. This difference can be attributed to the fact that the floods play a large role in the periodic regrowth of the plant and that water availability allows more flesh to grow (Field Day, 11/7). Because the !nara is a geologically old plant with a lifespan of centuries (Klopatek and Stock, 1992), any environmental disturbance can inhibit continual growth to its maximum age potential. Furthermore, the !nara's growth rate of 0.6 to 1.3 mm per day (Ito, 2005) further slows down its development. The slow growth rate allows the plant to mature and allow its fruit to further ripen in the dune area, which according to one interviewee, is the most favorable component harvesters seek.

In a detailed look into chemical composition, nitrogen and phosphorus levels can contribute significantly to the plant's development. The water supply of the riverbed has higher nitrogen content than the dune areas that helps to stimulate seed growth and biomass production (Moser, 2001). The riverbed is also nutrient rich and has higher phosphorus content and lower pH, which contributes to stronger stem and branch development (Moser, 2001). Despite the stronger plant growth in this study, it is the quality of the melons that is the most favorable in the dunes (Field Day, 11/7). The fruit found in the dunes are clustered in larger hummocks, and they are also generally older and riper than the ones found in the riverbed hummocks (Field Day, 11/7).

Physiological Fruit Quality

Individual !nara plants can grow to a size of 510 m high and 1040 m in diameter, with the plant projecting 0.11 m above the large hummock that grows with the plant (Henschel et al, 2004). Interviewee 1 explained to us that !nara dune mounds form from a !nara plant that is relatively flat in the beginning. Branches allow the sun to shine through, but as sand covers the openings, the bush will continue growing and push out of the sand to reach the sun (Field day interviews). A single plant can produce up to 500 melons that each contains 200,300 seeds (Henschel et al, 2004). From February to May, the melons become ripe and ready to be picked (Field Day interview)

Although Gobabeb staff were not keen on the characteristics of ripe !nara, many naturally assumed harvesters select for the most accessible and largest fruits. Our map reveals that the harvesting of !nara does not follow as simple of structure as one might logically assume. Despite popular perceptions, ripe fruit is collected from both the interior and exterior of each plant, and seldom are all fruits on one plant ripe enough to collect. One interviewee noted that the "fruit on the inside are usually the best because the jackal cannot get to them" (Field Day 11/5). In the map, point 6 marks a large hummock that, according to the harvesters we interviewed in the field, contains riper fruit in the middle. These are the qualities the Topnaar look for when observing physical characteristics.

Harvesters use all five senses to determine which individual !nara are ripe. Visual cues indicate that desirable !nara are a darker shade of green without their flower stem. When they are flicked, the ripe ones sound like a football (Field day interview). They develop spikes that are uncomfortable to touch. When ripe, the flesh surrounding the seeds dissociate from the skin, turning orange in color. Regarding her harvesting techniques for !nara consumption, Interviewee 3 said: "The !nara closer to the sand is often ripe sooner and tastier than the !nara in the same hummock. The !nara on the top of the hummock get dry from the sun." (Field Day, 11/7). As can be seen from the map, point 14 shows that although a large hummock may contain unripe fruit, riper ones can most likely be found close to the sand.

Unripe flesh is usually white and tastes slightly bitter due to the cucurbitacins it contains, which can burn the mouth and lips if too much of the fruit has been eaten (Field Day interview; Henschel et al, 2004). It can contain varying amounts of these bitterness-inducing compounds, however, cucurbitacins B and D have been identified as the primary source of bitterness. As the fruits ripen, they rapidly lose their bitterness under the influence of the enzyme elaterase (Wilkins Ellert, 2004). Researchers continue to study the variations of cucurbitacins across geographic areas, but studies have concluded that the more cucurbitacins the fruit contains, the more bitter it will taste (Gwash's interview). Because of the long standing use of !Nara by native people, a number of nutritional studies have been carried out on the flesh and seeds of the melon and additional work has investigated the medicinal properties of !Nara, primarily focusing on cucurbitacins found in the roots.

Ecological Interactions

Participants articulated the immense value of !nara within its larger ecosystem. As seen in Table 1, the Gobabeb staff was keen on the microhabitats !nara supports, as it is a large part of their !nara education programs and guided tours (Staff Interviews, 11/4). They were able to provide a preliminary background on the ecological significance of !nara within the larger ecosystem, namely the microorganisms, fog and adaptations of the fruit. !Nara's role within the Namib Desert ecosystem is also widely supported in the relevant scientific literature. It is considered a keystone species, garnering high scientific interest because of the ecological importance to many animals and desert surroundings. !Nara provides shade for numerous organisms, and it was found that over a two day period, a single !Nara bush was home to 5 lizards and 2,500 beetles (Pfeifer, 1979). Gerbils and striped mice nest under the plants and feed on beetles and seeds (Klopatek, 1994). Gerbils contribute to short-distance dispersal by hiding seeds near the base of the plant. The !nara is also fodder for many domestic and wild animals, as it is the primary source of nutrition for donkeys, ostrich and jackal (Henschel and Jankowitz, 1998; Pfeifer, 1979, Muller 2005). As noted by Muller (2005), the jackal plays an essential role in the resilience of !nara because it is the only animal who has been shown to contribute to the spread and germination of new !nara. This information can be seen on the map as the large, light blue circle that illustrates dispersal ranges. A study that collected pellets found that most seeds found in jackal droppings were able to germinate, concluding that the Blackbacked Jackal is the most important long distance disperser. Regarding the provision of !nara for future generations, Interviewee 2 believes "We can say, the jackal poo takes care of this" (Field Day, 11/7). When asked about his concerns of the future of

!nara, Interviewee 1 replied, "I am less worried because this plant has been around for hundreds of years and always regenerates" (Group Interviews, 11/6). The role !nara has within the larger ecosystem is a common ground between the interests and observations of harvesters, Gobabeb staff, and the scientific literature on !nara.

Uses

The !nara provides practical and cultural value to multiple stakeholders. Its fruit serves as a staple diet to the Topnaar people, as seen in Table 3. Its inner pulp has a rich, creamy taste and can be eaten raw. "Eating lots of it can clean a person's stomach," Interviewee 1 explained (Field Day, 11/7). It can be cooked to prepare as a soup or preserve as a dried flat cake. Sometimes, the pips can be left to dry and eaten as nuts or compressed to extract oil. Its high sugar content in the juice can be used as an acid for brewing sugar beer (Pfeifer, 1979). The tasty seeds, called butter pips, contain 31% protein and 57% oil, which is high in polyunsaturated fatty acids. By comparison, peanuts contain between 42 and 52% oil (Barnard, 2001). They are usually stored for use in the winter months (Field Day, 11/7). Additionally, the peels are fed to local people's donkeys and goats while the seeds are fed to the chickens. Because its roots are believed to cure ailments, practically every people in the region has a supply of medicinal !nara root (Van Damme and Van Den Eynden, 2000; Field Day, 11/7).

Within outer spheres, the !nara plays a role in the South African cosmetics industry (see Table 3). Part of the harvest of the Topnaar people is sold to traders in Walvis Bay, who then export the products to Cape Town (Van Damme and Van Den Eynden, 2000). It is also a form of cooking oil, nut and cosmetics sales. In terms of research, it has been used in studies monitoring the surrounding microhabitat and the effects of climate change, as well as nutritional content research and the possibility of domestication (Bianca's interview, 11/12).

Ethics

In evaluating and understanding the ethics of our project, we consulted literature on community-based work. We explored how these theoretical works aligned with our own moral consciousness and experiences throughout this process.

Participation

Our work ultimately fell into a category of community based participatory research (CBPR). This categorization of a community mapping project is not necessarily an ideal role for researchers to play (Fahy and Cinnéide, 2008) given the inherent participatory role of the researcher (Minkler, 2004). Many community mapping projects are not considered fully successful until the academic partner becomes merely an observer (Fahy and Cinnéide, 2008). However, other projects take pride in the synthesis capabilities of an academic partner (Edberg et al., 2009).

Our lead role was largely a result of not having the time or rapport with our participants to include them fully in work outside of the field. We found value in the role we could play as synthesizers of information given in one-on-one or small homogenous settings,

avoiding unproductive intergroup dynamics, such as certain gender norms (Seidman, 2006). Ideally, we would then present this synthesized information individually to our participants and solicit feedback to further improve the map before reaching a final version.

Issue Selection

Community partnerships frequently struggle to identify "community-driven" issues (Minkler, 2004). In this project, we played the roles of outsider "initiators" as we created our project independently of our work with community members (Minkler, 2004). We questioned whether us playing this role would make our work less successful within community-based frameworks. The few scholars who argue outside initiators can indeed do successful community work insert qualifiers, such as that these initiators must possess dynamic personalities that will eventually shift control to the hands of the community (Stoeker, 1999). However, academic partners can play a multitude of roles other than the initiator role that may be more successful, depending on the personalities involved (Minkler, 2004).

In our case, we played an initiator role given that our time constraints did not allow us to build rapport with the community at large to let their needs or ideas drive our project (Seidman, 2006). Given this time constraint, we certainly do not fall under the category of initiators that can then gracefully transfer the project into the hands of community members. However, as a pilot program we saw our project as testing out a method within this community and determining if it has value to the larger system. Given the merits we found throughout this process, we hope community members from different spheres (e.g. Gobabeb, !nara researchers, Topnaar harvesters, commercial users) will come together and take ownership of larger scale community mapping projects. Together, this large community has the capacity to execute community mapping without an outside community partner.

Insider-Outsider Relations

We struggled with and benefitted from our position as outsiders in a multitude of ways. In relations with Topnaar harvesters, there may have been historical tensions in their perceptions of us as Western and nonblack (Minkler, 2004). Our "Westernness" may have brought up conflicts the Topnaar have with Western scientists culturally or over land and resources, especially given Gobabeb's proximity to Topnaar villages (Seidman, 2006; Tomlinson et all, 2014). Our skin color may have introduced historical tensions of apartheid and other race relations with Namibia. Additionally, the language barrier seemed to make us further cultural outsiders; however, we were fortunate to have Topnaar translators who probably successfully conveyed culture or responses that could have otherwise been lost in translation. In these relations, we may have benefitted from our disassociation, however small or unclear to our Topnaar participants, with Gobabeb. Participants may have been more honest with us about the roles researchers and scientists play than they would have with a Gobabeb staff member. We also benefitted from our age and distinction as students. In this way, we were able to empower our participants as experts and teachers. Their confidence made them more open in discussion, but also

made our project more empowering to this group involved.

In relations with Gobabeb, our insider-outsider relations were more straightforward because expectations had been established prior to our arrival. Dartmouth faculty have a long-term relationship with Gobabeb staff, and Dartmouth College pays Gobabeb for us to utilize their resources. We also share a common Western science background with the institution, making it more likely that they saw us as insiders instead of outsiders.

In our in-person relations with !nara researchers, we introduced ourselves as !nara researchers as well, sharing a Western science background again. We also introduced ourselves as undergraduate students in talks with a PhD candidate. These interactions fell somewhere between insider-insider relations and student-teacher relations.

Finally, our insider-outsider relations with Desert Hills were bridged by an instructor on our program that is personal friends with Desert Hills management. As a result, our position as students with an interest in !nara was clear. Desert Hills had discussions with previous Dartmouth College students the prior year. As a result, their understanding of this as a specific interview for our specific project was slightly confused before the interview, but clarified when stated explicitly in our questionnaire.

Sharing Findings

CBPR and most modern successful community partnership work have firm groundings in giving study findings back to community members (Minkler, 2004). Given our deliverables of both a map and this paper, we have deliberated the ethics of distribution. We hope our map is accessible enough to all community members involved and that the gravity of information provided is useful to all members as well. Language barriers may prove to make our map less accessible to some community members than others, but we hope that there are still benefits all members can find despite the text components of the map. We encourage future researchers to translate our map as a part of their work.

We have debated whether or not this paper should be a deliverable to any community members at all, especially given our small sample sizes and concerns of anonymity. Our perhaps idealized hope was that our map would serve as a potential model for how knowledge can be disseminated in a way that works within the dismantled divide between indigenous and scientific knowledge, not contributing to the existence of these two separate spheres (Agrawal, 1995). We saw the indigenous knowledge aspects of our map as simply "knowledge" that fit into both spheres and didn't need further justification. This is further emphasized in our synthesizing of knowledge from multiple spheres equally in a shared output. However, we understand the value of distributing this paper to encourage future research and explicate to these future researchers our methods, ethics, findings, and suggestions. We hope to distribute this paper to Gobabeb, !nara researchers, Topnaar participants, Desert Hills, and other research participants. This distribution does not ensure equal access given language and education barriers.

Compensation

We grappled greatly with the role of compensation in our research. Our previously explicated relationship with Gobabeb involved compensation for our accommodations and access to resources. However, we did not compensate any participants in our project separately for their time. In on-site interviews at Gobabeb with both scientists and Topnaar staff, we felt their time was on the Gobabeb payment clock. Gobabeb staff go above and beyond, giving generously of their time, and we appreciated their generosity. As a result of our relationship with Gobabeb, in some ways, the institution paid for these interviews as part of salaries.

In off-site collaborative fieldwork, we worked with one Topnaar Gobabeb staff member and two Topnaars not affiliated with Gobabeb. Gobabeb considered this fieldwork part of the staff member's job, so her compensation was simply her paycheck. We only compensated one of the two additional Topnaar participants for their time and knowledge. Huntington (2000) defines collaborative fieldwork as the line of participation that deserves compensation. He declares that at this point, the participant is a "hired field assistant" (Huntington, 2000). Our position as university students in a larger system and institutional relationship that is managing expectations for further work did not allow us to compensate one of our field participants either monetarily or in-kind during the process. However, when the final products were complete, participants were presented with tokens of appreciation (e.g. cooking oil, sugar, tea, etc) and copies of the final map. With more preplanning and communication between us, our institutional partners at Gobabeb, and the Topnaar participants, we could have worked out a more appropriate ethical compensation.

Entry into the Community

Given the scope of our study, we sought entry into many different facets of the larger sociopolitic system surrounding !nara in the Kuiseb. Our unique position as Dartmouth students, especially given that students last year did community research, eased our entry into many aspects of the community. This was vital given we only had a week to do our fieldwork.

Our entry into Gobabeb was relatively easy given our institutional relationship that set forth clear expectations. Consequently, we had access to Gobabeb scientists along with Topnaar staff. The institutional relationship served as a bridge to relations with !nara researchers that had previously worked at the center. Our work with Topnaar Gobabeb staff along with Dartmouth students' foundational community work last year helped us to further access the Topnaar community. Specifically, one of our field participants had assisted Dartmouth students last year as well and understood the role we sought to play. Dartmouth students last year had also spent time with Desert Hills management. This made entry easy in that we had contacts and these people understood our position in the greater community. However, it may have been unclear as to why our group needed to consult with Desert Hills again given extensive interviews last year. We sought to clear this communication pathway and lay further groundwork for a positive relationship and easy community entry. Desert Hills was also in the midst of opening a new store location

during the time window we had for interviews. As a result, chaotic schedules were also an obstacle.

We did face a specific challenge in recruiting Gobabeb Topnaar staff to work with us as field participants. During the week they had too much work to do at Gobabeb and, thus, they could not take the time to come to the field with us. We attempted to schedule a field day during the weekend multiple times, but this perpetually fell through. We assume, based on commentary from other Gobabeb staff, that this was because they were home visiting their families and to work on a weekend Gobabeb pays a lofty overtime salary. Relating back to our complexities with compensation, we could not offer to these participants payment in the process in any form other than joining us for a meal. Overall, we are grateful for all the aspects of this community for allowing us to enter in any capacity. We learned from this community not only for our project, but also on a multitude of personal levels. We hope only to see these relationships grow.

Transparency

We sought to be as transparent as possible with all of our participants. In our field work we explained our project to our participants (as detailed in our methods section). Given language and cultural barriers, this explanation may not have been perfect and still left ambiguities. We also only detailed that we would be making a map and did not set expectations for writing a paper as well. In our interviews out of the field we explained our project relatively similarly, we just did not include a map sketch. In interviews with !nara researchers, Gobabeb scientists, Desert Hills management, and outside researchers, we can perhaps assume that cultural similarity helped these interviewees understand we would be writing a paper in addition to producing a map. In our out-of-field interviews with Topnaar harvesters, given that they were Gobabeb employees, they may have understood that we would be producing papers. However, given language and cultural differences, we cannot be sure which of our intentions translated.

Limitations

Despite efforts to contribute to a body of work that makes indigenous and scientific knowledge of equal value and equally accessible, we found our circumstances dictated that we still place knowledge in these boxes. Given the previously discussed uses and distribution of data, this paper will be largely inaccessible to the greater Topnaar community. As students of a Western university in efforts to maintain an institutional working relationship with Gobabeb, we felt we had to distribute this paper to their body of scientific knowledge. We will also be giving copies to Topnaar participants, despite potential language and educational barriers. We recognize that this may perhaps make aspects of our project neoindigenista despite efforts to keep our work out of this theoretical category.

Furthermore, there are inherent risks and limitations within all community mapping participatory GIS projects (Tripathi and Bhattarya, 2004). Given our structural flaws in quantity of participants and parts of the process that participants assisted in, we risk the community feeling left out of the process and the disadvantaged feeling further disempowered (Tripathi and Bhattarya, 2004). Maps like ours run the risk of misuse;

some decision makers can use community maps to abuse land, resources, or people (Tripathi and Bhattarya, 2004).

Our time and resource constraints limited the scope and execution of this project in several ways. Regarding Parker's (2006) first principle of representing a range of community members, the timeframe of our study did not allow us to do so. We were only able to go into the field with three Topnaar harvesters, and interview four harvesters outside of the field. While we only were able to interview one !nara researcher, the published !nara literature assisted us in expanding our scientific perspective on !nara. In interviews with Gobabeb staff, we were able to interview all but five employees, a relatively comprehensive sample. We were only able to interview one representative of Desert Hills management. While Desert Hills is mentioned only rarely in literature, we were also able to supplement this interview with literature on !nara commercialization and ongoing research from Bianca Braun. Our sample size from each stakeholder was rather small, but we strove to represent a range of community member interests with the community defined as those who interact with !nara. In conjunction with the time frame of our study, access to resources made it impossible for our participants to help us with mapping on the computer, increasing ownership of the project (Fahy and Cinneide, 2008). We were also unable to have community members correct our map before its final draft, another method employed to democratize the mapping process (Parker, 2006).

Given all of these factors, and our struggles with community entry, we were not able to make more than one localized map. Therefore, this project does not explore the implications of magnification of localized geographic maps, but we do not forsee this being a major issue.

Conclusion

Ultimately our project proved to be a successful pilot capacity-building project by enhancing knowledge raising consciousness and mobilization within the community (Parker, 2006; Tripathi and Bhattarya, 2004). The map is valuable due to the information shared, results gleaned, empowerment of participants and potential implications for further community empowerment (Fahy and Cinneide, 2008). Given the widespread concern for the loss of !nara through poor harvesting practices, this map, at the very least, serves as a preservation of TEK (Tripathi and Bhattarya, 2004). Future harvesters can benefit from this reference, as can contemporary harvesters seeking more information about specific elements of !nara. Many Topnaar have identified that they wish Gobabeb could share more of their research results, so the map's delineation of previous studies opens the door to new information sharing between Gobabeb and the local community (Capacity Building Interviews, Dartmouth College at Gobabeb, 2014).

This consolidation of research on the map also helps to organize the wide range of references Gobabeb has in their archives. This map will also inform future understandings of harvesting practices and provide a base line for any research on !nara distribution or composition. The interconnectedness of this map serves to show the value of collaboration between Gobabeb, researchers, Topnaar and the commercial sector. Each partner has individual concerns for !nara, but, as our results show, the concerns continuously overlap. If shared separately, one would only be able to collect

single-sided and even misleading information. Hence, we merged scientific, commercial, and indigenous knowledge in one plain, providing the opportunity to identify disparity and similarity in knowledge, concerns, and behavior.

Hopefully, this proxy map paves the way for future community mapping projects within the Namib Desert and further equalizes the knowledge gaps within this dynamic sociopolitic system. It can serve as a model for future studies, not only in this region, but also in communities around the world. Projects in this field bring to light indigenous information that perhaps would not have been shared otherwise. Our study has shown that it is possible and valuable for projects like these to give voice to the marginalized while linking all views onto a shared spectrum of knowledge. Rather than bridging the gaps, we are cementing what information exists, proving that common theoretical frameworks may not always provide a complete picture. Transcending that mindset requires challenging engrained norms and one's own thinking to accomplish a multifaceted yet unified approach. It means taking in every piece of knowledge with a critical eye and analyzing the information on an equal level. Only then can a holistic and just research process be achieved.

Future Studies

Given our own limitations, we suggest that future research extend this study in a multitude of ways. We recommend that researchers conduct field interviews with a larger sample of harvesters that use the same localized fields to make a perhaps even richer maps. Furthermore, we suggest incorporating field participants in the map creation process outside of the field to increase empowerment and ownership components of the project, and to increase accuracy with data checking and map editing by field participants. We also see great opportunity in mapping more localized !nara fields incorporating harvesters of those areas. If these maps prove to extract uniform information, regardless of local site, future mappers might conclude that these localized maps can be generalized. If this is the case, we hope community mapping of !nara fields still continues because of the benefits we found in the process itself. However, if these maps vary, this will highlight the importance of community mapping for !nara fields because of the benefits of the process and for the dynamic results it gleans.

Our limitations also meant that we were only mapping during one season.
We recommend a series of temporal community maps (annually, seasonal, monthly, or otherwise) that annotate which hummocks get ripe when, changes in the landscape, and perceptions of the landscape over time. Future maps might also have more time and resources to quantify features on localized maps (e.g. size of hummocks, number of fruits, etc). These quantifications might prove particularly useful in a series of temporal maps to show changes over time.

The results we found also lend themselves to future studies. Since all partners identified !nara's relationship to water as of utmost importance, this relationship should continue to be explored. Studies might consider massing seeds and flesh per plant and examine if this is correlated to distance from the river. Similarly, the chemical components that determine !nara's ripeness could be further studied to help understand the feasibility of

domesticating !nara harvesting.

Furthermore, we suggest that future studies address questions generated by interviewees. Interviewee research questions included:

1. How many seeds are produced from each donkey cart of !nara?
2. How much money can a harvester make selling a donkey carts worth of seeds?
3. How many tons of !nara are harvested per season? Per year?
4. How many tons of !nara are purchased per year?

Our final recommendation is to incorporate a reflection process into the mapping process. This process would allow all partners to further identify the values of this process moving forward in the merging of fields of community mapping and TEK (Jasis and Jasis, 2011).

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Appendices

Appendix I: Interview Questions

Gobabeb Staff Interviews:

- Who harvests !Nara?
- What !Nara are desirable for harvest?
- Why?
- Is it done sustainably?
- Has !Nara changed over time?
- Has harvesting changed over time?
- What is the value of !Nara to Topnaar people?
- Does it depend on the village?
- What is your job at Gobabeb?
- Where are you from?
- Where do you live?
- Education?
- How many years have you been working here?
- How old are you?

Topnaar Interviewes:

- What !Nara are preferable for harvesting?
- Why? (The specific characteristics and uses of the plant)
- Are different !Nara used for different purposes?
- What areas are preferable? Why?
- Have they ever harvested anywhere else?
- What is their personal history with harvesting !Nara?
- How has harvesting changed over time?
- How has the plant itself changed over time?
- How does !Nara contribute to their life?
- What are the challenges of harvesting !Nara?
- Are there concerns about the history of !Nara?

Interview with Gwash, PhD Student:

- What is her research
- When and where was it done?
- How do the qualities of !!Nara vary based on cucurbatacins?
- How has the !!Nara changed over time, composition wise?
- Any other significance of genetic makeup?
- What is the chemical relationship between cucurbatacins and !!Nara quality/tastes?

Appendix II: Annotated Bibliography

Henschel and Jankowitz (1998). The !Nara and Factors that Lead to its Decline in Productivity. *Desert Research Foundation of Namibia*; 582.1'688 SHI.

Assumption: there was a decline in nara productivity and therefore the Topnaar Community Foundation requested that the Desert Research Foundation of Namibia support the establishment of a longterm management study. This article aims to explain the factors that lead to the decline in nara productivity; it is the result of a workshop in the Lauberville delta of the Kuiseb river.
Core Argument: Tragedy of the commons has led to unsustainable nara harvesting and can explain the decline in nara productivity.
Recommendations: There is a need for a rural awareness program among the harvesters, particularly the youth, to help them gain a more realistic and honest perspective on the sustainable management utilization of nara.

- "This is due to the young people who ignore the cultural value of the nara plants. The majority of the Topnaar interviewed were aware of their damage to the nara plants. They only need to change their attitudes to appreciate the vale of the plants as in the past. IN addition, there is a lack of selfreliance in the community and therefore, the harvesters could be assisted with plants to mange resources sustainably (p. 14)"

Visser (1998). Nara of the Namib. *Living Africa*; May; 6875.

- *Assumptions: Nara harvesting is an antiquated practice. The issues of land rights have pushed people away from harvesting nara and therefore only a few harvesters remain and the tradition is dying as the value of nara is decreasing to the Topnaar.*
- *Core Argument: The Topnaar were historically marginalized under South African apartheid government. Disputed land rights led to the destruction of the Topnaar's homes. The Topnaar's water resources have been exploited as the area has been left largely underdeveloped. This has resulted in many Topnaar moving away from the area and thus allowing the nara harvesting tradition to die.*
- *Recommendations: The nara community is optimistically exploring cultivating the nara or developing joint venture tourism projects to ensure their livelihood.*

Pfeifer (1979). !Nara and Topnaar Hottentots. *S.W.A Annual;* 158159.

Assumptions: Families have plots of land to harvest their nara twice a year; however westernization has decreased the value of nara to the Topnaar and nara has become as 'luxury' food source and the income derived from it only supplements the cash income of the Topnaar of the Kuiseb area.
Value of Nara to Environment

- Provides shelter to many desert animals
    - 5 lizards and 2,500 beetles were found living in a single nara bush
- Source of food for Namib animals
    - Especially the ostrich

Value of Nara to Topnaar

- The only source of food (except for fish)
- 46% oil and 32% protein
    - fodder and cooking oil
- uses immediate consumption, cooking the fruit extracting the pips, or to bury under the sand to cover them and stimulate juice development
- *Harvesting*
    - The picker will either tap the melon with a long stick and listen to the sound OR cut a coneshaped piece to taste
    - "If the fruit is ripe enough to be eaten on the spot its outside parts will taste bitter, whereas the portion closest to the middle tastes sweet, very similar to a pineapple"(159)
    - During the 19741975 season approx. 269 bags of nara pips (24,212 kg) were sold to Walvis Bay traders for R2421.20
- "Topnaar today no longer depend on the nara, as its importance has decreased with the advent of western civilization. The nara has therefore become a "luxury" food source and the income derived from it only supplements the cash income of the Topnaar of the Kuiseb area"

    - Shell dried to use as cooking pot or food container

Muller (2006). *Dispersal ecology of the !naramelon along the Kuiseb River, Central Namib. The Changing Culture and Nature of Namibia,* 181184.

The purpose of this article is to determine if the declining nara outputs are caused by internal dynamics of the plant population. It also explores the role that Oryx, jackals and free roaming donkeys function as nara seed dispersers.

Methods: Used GIS software to map GPS points for the entire nara population around Gobabeb to analyze spatial distribution patterns. Then they overlaid paleochannel maps (former riverbeds, now sand0convered, but still containing water below the surface). Then they calculated the distance between surface and water resources.
Separately, feces were analyzed for nara seeds that could germinate.

Conclusions: There was a significant correlation between plant size and spatial distribution of the naras. The Blackbacked Jackal was the only feces that had intact nara seeds, so it is the most important if not the only longdistance disperser.

Recommendations: The nara plant is dependent on groundwater conditions and the effect of water use and changes should be taken into account when investigating the nara. Furthermore, the blackbacked jackal plays a crucial role in dispersing the

nara seeds 'which so far has not been acknowledged; rather jackals are still widely hunted due to their reputation as alleged goat thieves" (p.183.)

- Other suggestions for potential future projects on cultivation methods etc.

Value of Nara to Topnaar

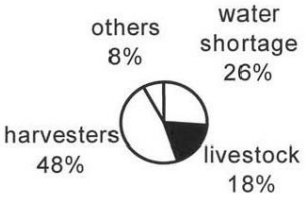
- Eaten raw, fruit rolls, seeds (highly nutritious, 57% oil high in poly unsaturated fat and 31% protein p.7), pulp given to feed livestock
- Used to make sugar beer (Pfeifer, E.H., (1979). !Nara & Topnaar Hottentots. S.WA. Annual book, p. 158159.)
- Medicinal value
- Cash value, one kg of pip ranges between N$45
  - Focus on nutritional value

Value of Nara to Ecosystem

- Most life around the dunes depend on the nara
  - Shelter for many creatures and fodder for wild and domestic animals
- Donkey grazed caused a 55%62% loss of the female shoots during a 2.5 month period

Issues in Harvesting

- Because of the declining yield of the !nara fruits in recent years the Topnaar Community Foundation requested that the Desert Research Foundation of Namibia (in March 1997) support establishing a longterm management system for the nara fruit production
  - This resulted in a workshop
- In the past families passed down land through unwritten law, but now the land is commercialized
- Currently only 10 families out of the 500 people live in the area, all the rest live in the suburbs of Walvis Bay
- Factors and their percent contribution to the decline of nara



Changes over time

- Flooding issues
  - Speculations that over pumping and damming take a toll on nara productivity
    - Decline in Kuiseb water table= decline in nara productivity

    - Flood is a natural process, therefore there is 'no remedy for this; a heavy flood can easily wash the new nara plant away. With big plants it can break the roots that are above the ground. This might be the reason why the yield was low in 1997…"
- El Niño can effect the growth rate of nara because of the high temperature of the earth's surface
    - High temperatures decreases the amount of fog that gets to the nara plants further from the coast
- *Despite natural changes, over pumping, damming and overstocking have impacted the general health of the nara plants and lead to the decline in productivity*
- Tragedy of the commons land became communally owned land instead of family owned
    - The potential lack of subterranean water is one of the factors that cut down the Topnaar inherited plot system
    - Also contributing was the barrier constructed in the northwesterly arm of the Kuiseb that prevents harvesting in the region (1960s)
        - COMPETITION INCREASED AND NOW UNSUSTAINABLE PRACTICES
- Harvesters have become increasingly impatient
- Now "nara plants are unhealthy and the decline is enhanced by anthropogenic factors such as extraction of ground water from the Kuiseb River and the incorrect harvesting procedures by the harvesters" (p.10)
- Trespass is common
- Incompletely ripe melons are harvested
    - In the past the color of the melon was used to determine the ripeness of the melon, now ripeness is judged by beating the melon off from the plant with a wooden stick or iron rod