CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

How Does Harvesting Impact White Sage (*Salvia apiana*) as a Cultural Resource in Southern California?

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Science

In Biology

By Cassidy C. Adlof

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Abstract

How Does Harvesting Impact White Sage (*Salvia apiana*) as a Cultural Resource in Southern California?

For the degree of Master of Science in Biology

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Demand for non-timber plant products has increased and with the stress of pressures, such as invasive species and habitat fragmentation, the sustainability of some culturally important plant populations may be at risk. *Salvia apiana* (white sage) is a plant used in cleansing ceremonies by Native Americans and adherents to other nature and Earth-centric spiritualties. Some Native Americans have suggested that the species is in decline and there is concern that over-harvesting may be the cause. This study addresses that concern by examining (1) how different ethnic and spiritual groups harvest or otherwise acquire *S. apiana* and (2) how plants respond to different harvest practices. People were surveyed to learn about their harvest practices and wild plants were subjected to combinations of harvest treatments to examine their biological effect. Treatments included gathering technique (by hand, cutting, leaf only), removal amount (0%, 5%, 25%, 50%), and harvest season (spring, summer). While various ethnic and spiritual groups acquire and harvest materials from *S. apiana* differently, these practices did not have significant impacts on plant size, leaf-volume ratio or flower abundance. Therefore, harvest is not a likely reason for decline of this species. A more likely cause of decline is the conversion of coastal sage scrub vegetation to invasive grass-domination due to increases in urban development and fire frequency.

Introduction

Over the last few decades there has been an increased global demand for wild non-timber plant products, such as herbs for medicinal uses (Cunningham 2001, Ticktin 2004). While demand for individual species have fluctuated over time, the use of non-timber plant products has increased throughout United States since the mid-1900s (Jones and Lynch 2007). With this increase in demand for wild herbs there is also an increase in concern about overharvest (Ticktin 2004).

The risk of extinction is even higher when harvest is occurring in biodiversity hotspots and other areas of special conservation concern. The California floristic province has been recognized as a biodiversity hotspot (Myers et al. 2000) because of its approximately 4,976 native plant species, 1,315 species (26.4%) are endemic (Baldwin et al. 2012). In addition, California ecosystems are experiencing pressures, such as habitat loss and fragmentation, associated with urban and agricultural development, which can cause declines or extinctions in plant populations (Riitters and Wickham 2003). Less than 25% of the California floristic province's original vegetation remains (Myers et al. 2000) and 60 - 80% of land that historically supported coastal sage scrub and chaparral, important shrub-dominated vegetation types in southern California, is located within just 0.382 km of a road (Riitters and Wickham 2003). This means that human impacts on native plants are widespread.

Habitat fragmentation typically results in fewer species (Fahrig 2003) and lower abundances within species (Haila 2002) in the sections of newly separated habitat. Non-endangered populations, especially plants with limited ranges are at particular risk of rapid decline or extirpation (Malcolm et al. 2006, Dirnböck et al. 2011, Lindenmayer et

al. 2011). If, in addition to experiencing habitat degradation, a species is harvested, this additional pressure adds to the extinction risk and could have consequences for cultural practices as well as for the species itself.

Native Americans rely on the environment for traditional foods and spiritual resources. Environmental disturbances that affect wild populations of organisms can have cultural effects (Akaka 2012). In the United States, natural resources, including wild organisms that are collected for spiritual purposes, are protected by the American Indian Religious Freedom Act (AIRFA 1996). Declines in local wild resources can be of concern, even if the species are not listed as endangered or threatened by the state or federal government. Traditional cultural practices may be impeded and increased costs (monetary and/or socio-cultural) to tribal members may be incurred (Beck 1996). This is a particular problem when multiple groups harvest materials from a dwindling number of populations (Beck 1996). While previous studies have looked at how losses of wild animal populations affect Native American culture (Beck 1996, Worthen 2005), the declines of any culturally or spiritually important population (plant, animal, fungus, etc.) may have severe cultural impacts (Pungetti et al. 2012).

For example, gray whales and the whale hunt are central aspects in Makah tribe (Washington State, USA) culture and are protected by a treaty made between the tribe and the United States in 1855 (Beck 1996). When this whale species was listed as endangered in 1973, the Makah voluntarily stopped whaling (Beck 1996) and as a consequence unemployment, alcoholism, and diabetes steadily rose (Beck 1996). Once gray whales were removed from the endangered species list in 1994, the Makah tribe requested to resume hunting, hoping to reverse some of their community's problems

(Beck 1996). Instead, prolonged litigation has added to the cultural costs associated with whale's decline (Beck 1996). When managing an environmental resource that is of cultural importance, the indirect effects of harvest must be recognized if the species and the cultural practices associated with it are to persist.

Harvest can affect plants in a variety of ways depending on the types of tissues that are harvested, the response to wounding and herbivory, and the methods used for harvest (Ticktin 2004, Cunningham 2001). All aspects of life history (growth, survival, and reproduction) can be affected by harvesting (Cunningham 2001). Harvest can be detrimental to a plant's health, survivorship, and fitness. For example, a two-year comparison of leaf harvest techniques on the medicinal plant, *Rhododendron groenlandicum,* in northern Quebec, showed that methods that simulated commercial harvest were associated with high rates of plant mortality (Tendland et al. 2012). In contrast to commercial harvest techniques, traditional Native American techniques harvested only old leaves which had no negative effects on plants (Tendland et al. 2012). Similarly, a study on *Heteropsis flexuosa*, an Amazonian vine used for producing wicker furniture in Brazil, found that 63% of plants that had been subjected to commercial harvest died and only 16% of the survivors had regrown within seven months (Plowden et al. 2003).

However, harvest is not always harmful to individual plants. This was the case for *Chamaedorea radicalis*, a Mexican understory palm from which leaves are used in floral arrangements (Endress *et al*. 2004). When all leaves were taken for two consecutive years of experimental harvest, leaf production subsequently increased and there was no difference in survival between the treatment and the control (Endress *et al*. 2004). In the

perennial grass, *Hierochloe odorata*, in New York, USA, Shebitz and Kimmerer (2004) showed that harvest was beneficial and that the plant requires the disturbance caused by harvest to persist.

Plants often respond to wounding by reallocating resources. A study of elderberry, *Sambucus canadensis,* cultivation in Missouri, USA found that pruning branches led to the production of larger flower cymes (Thomas et al. 2009). However, the plants flowered later and had lower overall fruit yield (Thomas et al. 2009). Studies that use defoliation to simulate herbivory (a manipulation that, from a plant's perspective, is similar to leaf harvest), show other examples of resource allocation. A review by Strauss and Agrawal (1999) demonstrated the range of tolerance to herbivory. One species, *Piper arieianum*, a forest understory species in Costa Rica, lost fitness when more than 10% of is leaves are lost whereas, *Raphanus raphanistrum,* a weedy annual common to old fields and other disturbed sites, experienced no decrease in fitness even after losing 25% of its leaves (Strauss and Agrawal 1999). A plant's response to herbivory determines whether or not there is a decrease in fitness (Strauss and Agrawal 1999). Plants may not loose fitness when they have large carbon stores, a capacity for photosynthetic compensation, or if the timing of damage does not coincide with the phenology of key events such as flowering or fruiting (Strauss and Agrawal 1999). Cucumber plants, *Cucumis sativus,* tolerated 80% leaf loss without loss of fitness if the leaves were removed before the plant began flowering (Thomson et al. 2003). Additionally, after three weeks new leaf growth, the plant had recovered the lost biomass (Thomson et al. 2003).

This study addresses the effects of harvest on *Salvia apiana*, white sage, a shrub endemic to the coastal sage scrub and chaparral plant communities of southern California and northern Baja California (Davis et al. 1994, Baldwin et al. 2012). While *S. apiana* is not classified as endangered (USDA NRCS Plant Guide 2015), populations are fragmented and occur in low densities throughout the northern part of its native range (Davis et al. 1994). Its leaves are traditionally burned in Native American cultures for purposes of purification and are considered essential for cleansing homes, people, and ceremonial areas (T. Garcia, per. com., April 2015). The use of this species has expanded into New Age, Druid, Wiccan, and other nature-centric religious groups for similar spiritual purposes (USDA NRCS Plant Guide 1999). Plants are grown and sold commercially; however, some Native American tribes believe that buying and selling *S. apiana* is immoral and they require that leaves be gathered from wild populations (R. Vann, per. com., March 2015). Stores that sell *S. apiana* products report that they harvest from wild populations rather than use commercially grown plants. As demand for *S. apiana* has increased there has been concern within the California Native American community that populations are in decline due to overharvesting (USDA NRCS Plant Guide 1999, R. Vann, per. com., March 2015).

The goals of this study were (1) to compare the *S. apiana* harvest practices used by different ethnic and spiritual groups and (2) to determine whether different harvest practices negatively impact *S. apiana* by examining the effects of harvest techniques, harvest amounts, and harvest times.

It was expected that the practices of different ethnic and spiritual groups would vary because the means by which techniques are taught or passed down are diverse. In

southern California, Native Americans have had a long history of harvesting the plant (Anderson 2005) and may have strict cultural guidelines for harvest. In contrast, groups with recently developed traditions involving *S. apiana* may not have particular rules or taboos regarding its harvest. If practices that negatively impact *S. apiana* populations are common among certain user groups, then education about more sustainable means of *S. apiana* harvest need to be directed toward them.

It was expected that the season of harvest would have different impacts on plants due to the relationship between climate and the phenology of growth and flowering. Southern California is characterized as a Mediterranean-type climate, with winter precipitation and summer drought (Minnich 2007). *Salvia apiana* most commonly occurs in coastal sage scrub, a community dominated by drought deciduous shrubs which lose their leaves during the summer and grow new ones after fall and winter rains (Rundel 2007, Riordan and Rundel 2009, Wainwright et al. 2012). While the leaves of *S. apiana* tend to fold in response to summer drought (DeSimone and Zelder 2001) and their whitish color reflects solar radiation (Ehleringer and Comstock 1989) plants will also facultatively shed leaves in response to drought (DeSimone and Zelder 2001).

Salvia apiana flowers between late April and early August (Baldwin et al. 2012), a stressful time due to low water availability and high temperatures (Riordan and Rundel 2009). Leaf removal while a plant is flowering can result in it being less able to recover (Thomson et al. 2003). Therefore, it was expected that medium and high levels of summer harvest would reduce subsequent growth and lower fertility such that summertime harvest would be more impactful than the springtime harvest. However, an alternate hypothesis was that spring harvest would have larger negative effects because

S. apiana is drought deciduous (DeSimone and Zelder 2001) and relies upon spring productivity to sustain it through the more stressful summer. In addition, it may be dormant, or at least much less physiologically active, during a late summer harvest and, therefore, less impacted by harvest at that time.

It was also expected that different harvest techniques would affect *S. apiana* plants differently (Pontoppidan et al. 2005). *Brassica napus* plants were observed to produce different amounts of the defense compound myrosinase depending upon whether leaves were cut by scissors, crushed by forceps, or eaten by moth larvae (Pontoppidan et al. 2005). The drought deciduousness of *Salvia apiana* (DeSimone and Zelder 2001) suggested that leaf harvest would be less impactful then stem harvest since stems are not shed annually.

Methods

Study Sites

Fieldwork was conducted in southern California in the northern part of *S. apiana*'s range, in Ventura and Los Angeles counties (Davis et al. 1994). Patches of *S. apiana* were selected at four sites; Malibu Creek State Park (34º5.830'N 118º43.388'W), HELP Ranch (34º18.105'N 118º52.833'W), Wheeler Gorge (34º30.787'N 119º16.282'W), and Towsley Canyon (34º21.533'N 118º33.548'W) (Figure 1).

The sites were representative of the different environments typical for *S. apiana* (Table 1). HELP Ranch is an equestrian ranch in the Simi Hills. The *Salvia apiana* plants there grew in a riparian area at the base of a small hill and on an adjacent slope. The riparian vegetation is composed of primarily native vegetation (*Salvia leucophylla and Baccharis salicifolia*) while the hill was dominated by invasive species (*Brassica nigra* and *Centaurea melitensis*) on hill. Although this site receives less rainfall than the Malibu Creek site (Table 1), the riparian area and water runoff from the ranch grounds keeps the site more mesic than the others.

Malibu Creek State Park is located in the Santa Monica Mountains. The site is surrounded by coastal sage scrub, with a mixture of native (*Hesperoyucca whipplei, Lupinus* spp.) and invasive species (*Centaurea melitensis, Avena fatua*).

Wheeler Gorge is located within Los Padres National Forest. The site is surrounded by coastal sage scrub, chaparral, and oak woodland and is dominated by native species (*Quercus berberidifolia, Paeonia californica, Salvia mellifera*). This site has the steepest slope (Table 1) and a substrate of loose rocks.

Towsley Canyon is managed by the city of Santa Clarita and is located within the Santa Susana Mountains. The area is predominately coastal sage scrub; however, the study site is dominated by invasive species (*Bromus madritensis*, *Carduus pycnocephalus*) with scattered natives, (*Lupinus* sp., *Salvia leucophylla*, *Salvia mellifera*).

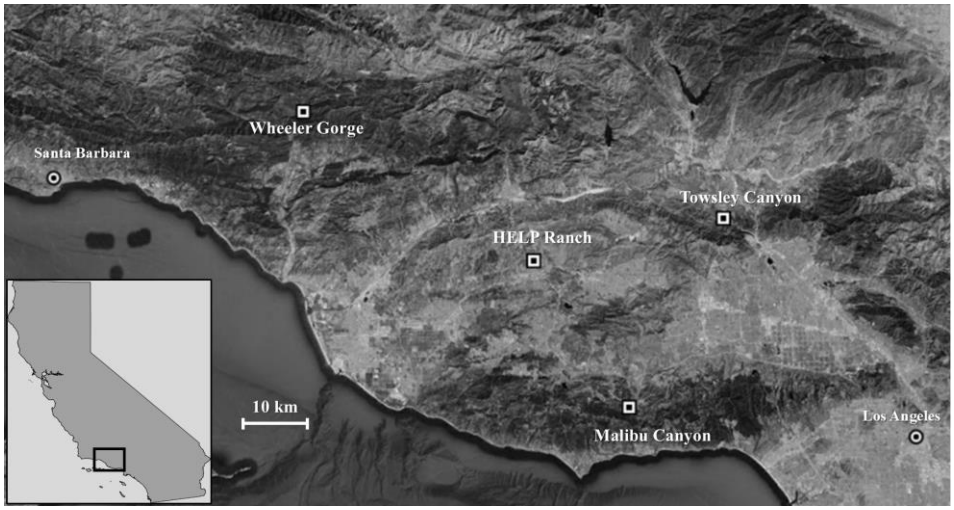

Figure 1: Location of research sites in relation to Los Angeles and Santa Barbara cities in southern California.

Table 1: Annual precipitation and site description. 2013 data calculated from July 2012 to June 2013 and 2014 calculated from July 2013 to June 2014. Summer Temperature calculated from average maximum temperature for July and August 2013 and 2014. Data taken from nearest weather station available at www.ncdc.noaa.gov.

Site	**Annual Precipitation**		**Summer Temperature**		**Slope**	**Aspect**
	2013	**2014**	**2013**	**2014**		
HELP Ranch	5.98	4.56	28.0ºC	28.9ºC	0º - 40º	south
Malibu Canyon	11.87	6.93	33.3ºC	33.0ºC	0º - 40º	south-east
Wheeler Gorge	10.16	8.53	34.3ºC	34.5ºC	50º - 70º	south-east
Towsley Canyon	5.14	5.33	35.4ºC	35.6ºC	40º - 60º	south-west

Harvest Practices

A survey was conducted from 2013 through 2014 to assess harvest practices used by members of Southern California communities when gathering *S. apiana*. Surveys were distributed online through social networking sites, Meetup.com and Facebook, and at events where people who use *S. apiana* typically gather, such as, pow wows, pagan ceremonies, and festivals. Participants were asked questions about how they acquired the *S. apiana* they use and, if they harvest, and their harvesting practices (Appendix 1).

Harvest Impact

Mature plants (possessed flowering stalks from previous year) were used to assess the biological effects of harvest and were indicated by the presence of persistent dried inflorescences remaining from the previous year. Harvest treatments occurred in late March (spring) and late July (summer) of 2013 and plants were monitored for one year to assess lingering harvest effects.

The experiment was set up in a factorial design and contained four independent treatment variables: harvest technique, amount collected, season of harvest, and site. The harvest technique treatment groups were leaf harvest only, branch harvest using clippers, and branch harvest by hand. These techniques were selected because they mimic the techniques traditionally used by Native American harvesters (R. Vann, pers. comm.) and those used by people collecting along hiking trails (pers. obs.). Additionally, these treatments wounded the plant in what appeared to be different ways (Figure 2). Clipping created a smooth wound that did not damage the stem below the removal point; however, breaking the branch by hand required a bending and twisting motion which left

a jagged wound and often caused a tear in the branch below the removal point. Leaf removal resulted in the smallest amount of wounding, with a small tear on the side of the branch. For each technique, low (5%), medium (25%), and high (50%) harvest amounts of the plant's total foliage and stems were removed.

These treatments were timed to assess the response of *S. apiana* to harvest during seasonal extremes. In addition, March and August are the traditional times of high harvest. Early spring is when pow wows begin to take place in southern California (pers. obs.) and *S. apiana* leaves are used during blessing and purification ceremonies (R. Vann, pers. comm.). August was also a peak harvest time because it precedes the harvest ceremonies that take place in many Native American and pagan communities at which the plant is used then as well (R. Vann, pers. comm.). Additionally, stores that wildcraft (harvest from wild populations) may harvest at these same times. Few retailers describe their harvest method in detail, with only one out of fifteen retail websites examined stating the season (Appendix 2). However, the retail website that included a description of harvest methods indicated that it was done in August (www.mynativespirit.com, Fontana, CA). It is likely that other retailers sold *S. apiana* that had been harvested in August as well.

Vegetative growth and flower abundance were assessed to determine the effects of the harvest treatments. Flowers, when present, were counted in alternating weeks from early April through September 2013 and 2014. Vegetative growth was examined in April and September 2013 and 2014 using shrub volume, leaf abundance (number of leaves per plant) and leaf abundance : shrub volume ratio. Shrub volume was estimated

as $V=\frac{4}{3}\pi d^2 h$ where *d* was the diameter and *h* was aboveground height of each shrub (not including the inflorescence structures).

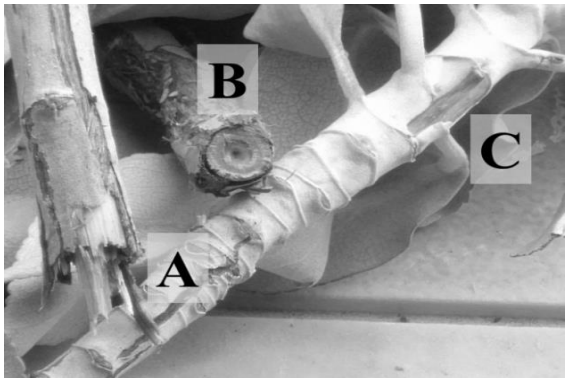

Figure 2: Wounds caused by different harvest technique treatments. Harvest techniques include: branch harvest by hand (A), branch harvest using scissors (B), and leaf harvest only (C).

Statistical Analyses

Survey participants were grouped by self-identified ethnic groups (Appendix 1, Question 22) and spiritual groups (Appendix 1, Question 23). If a respondent selected Native American they were asked to state their tribal affiliation. Harvest practices for the respondents were assessed through choice questions with open-ended response questions for additional details (Appendix 1). The aspects of harvest that were examined for this study were techniques used to harvest, time of year, and amounts harvested. G-tests were performed to look for differences in harvest practices and approaches to *S. apiana* acquisition between the groups. Options that were not selected by any respondents were removed from the analysis.

The harvest study was designed as a factorial ANOVA with 12 replicates for each technique group, 12 replicates for each harvest amount group, and 18 replicates for each

season group at the HELP Ranch, Wheeler Gorge, and Towsley Canyon sites and a total of 18 replicates for each technique group, 18 replicates for each amount group, and 27 replicates for each season group at the Malibu Creek site. Due to the low number of plants within patches, two control plants were included at HELP Ranch, Wheeler Gorge, and Towsley Canyon sites and three control plants were included at the Malibu Creek site, for a total of 171 plants used in the study. During the second year, two additional control plants were added to each of the first three sites and three additional control plants were added at the Malibu Creek site.

Pre-harvest vegetative measurements were assessed with a one-way ANOVA and were significantly different for each site (size: $F= 39.635$, $df=3,161$, $p<0.001$, leaf: $F=29.350$, $df=3,161$, $p<0.001$), so the four sites were all analyzed separately. Three-factor ANCOVAs were used to assess plant size and leaf abundance, with pre-harvest measurements as a covariate. Assumptions for normality and homogeneity of variance were examined before running the analyses and, when appropriate, the data were transformed to better fit the assumptions. Technique, amount, and season were treated as fixed factors. All tests were done using IBM SPSS version 22.

A three-factor ANOVA was used to assess flower abundance by comparing the highest number of flowers recorded for each plant. However, in 2013 only 36.8% of plants flowered and in 2014 only 51.4% flowered. Due to the large number of zeros a natural log transformation on abundances of flowers was closest to fitting the assumptions for ANOVA. Additionally, a chi-square test was performed for each site to assess whether the presence of flowers was associated with any of the harvest treatments.

Results

Harvester Identities

While approximately 160 people showed interest in the project by answering the questionnaire, contacting through online social media sites, or speaking informally at an event, only 58 used *S. apiana* in their practices. Respondents primarily collected *S. apiana* for personal use, with only four respondents stating that they sell *S. apiana* or products made of *S. apiana*. Therefore, no assessment of harvest by sellers could be made.

Respondents identified themselves as a variety of ethnic groups including Caucasian, Latino, Native American, Mongolian, Armenian, European, and Mediterranean. Ethnic groups were pooled into the following categories; Native American: specified tribe (n=14), Native American: no specific tribe (n=9), Caucasian (n=24), Latino (n=6), and Asian (n=1). The Asian ethnic group was dropped from the analysis since there was only one respondent in the category. Four respondents declined to state their ethnic group and were treated as a separate group.

Participants gave the following spiritual affiliations: Native American, Wiccan, Heathen, Pagan, New Age, Druid, Jewish, Christian, Catholic, "other", and "none". Those that stated "other" described themselves as following their own spiritual path, rather than a specific faith. Many respondents identified with more than one category. For this study, Native American respondents that specified a tribe were pooled into a separate group (n=14) from those that indicated Native American without a tribe affiliation (n=8). Wiccans, Heathens, Druids, and Other Pagans were pooled into single Pagan group (n=19) and Jewish, Christian, and Catholic were pooled into a Judeo-

Christian group (n=8). Respondents that selected either "other" or "none" were pooled (n=5) and the five participants than declined to state a spiritual affiliation were left as their own group.

Acquisition of *Salvia apiana*

Salvia apiana was acquired by the respondents through personal harvest, purchase, and as gifts. The primary mode of acquisition differed among ethnic groups. Respondents that identified as Native American (with or without a specified tribal affiliation), Latino, or declined to state their ethnicity reported that they harvested their own plant materials significantly more than did Caucasians (Figure 3A, G=10.82, df=4, p=0.029). The two Native American categories purchased *S. apiana* less than the other groups (Figure 3B, G=9.59, df=4, p=0.048). There was no difference in receiving white sage as a gift among the ethnic groups (Figure 3C, G=7.27, df=4, p=0.122).

It was also evident that the means by which *S. apiana* was acquired depended upon an individual's spiritual group affiliation. Those that identified with Pagan spiritualties were significantly less likely to personally harvest plant material than the other groups (Figure 4A, G=16.06, df=5, p=0.007). Those that identified with Native American (tribe specified) spirituality purchased *S. apiana* significantly less than other groups (Figure 4B, G=16.88, df=5, p=0.005) and received as a gift significantly more than other groups (Figure 4C, G=14.95, df=5, p=0.011).

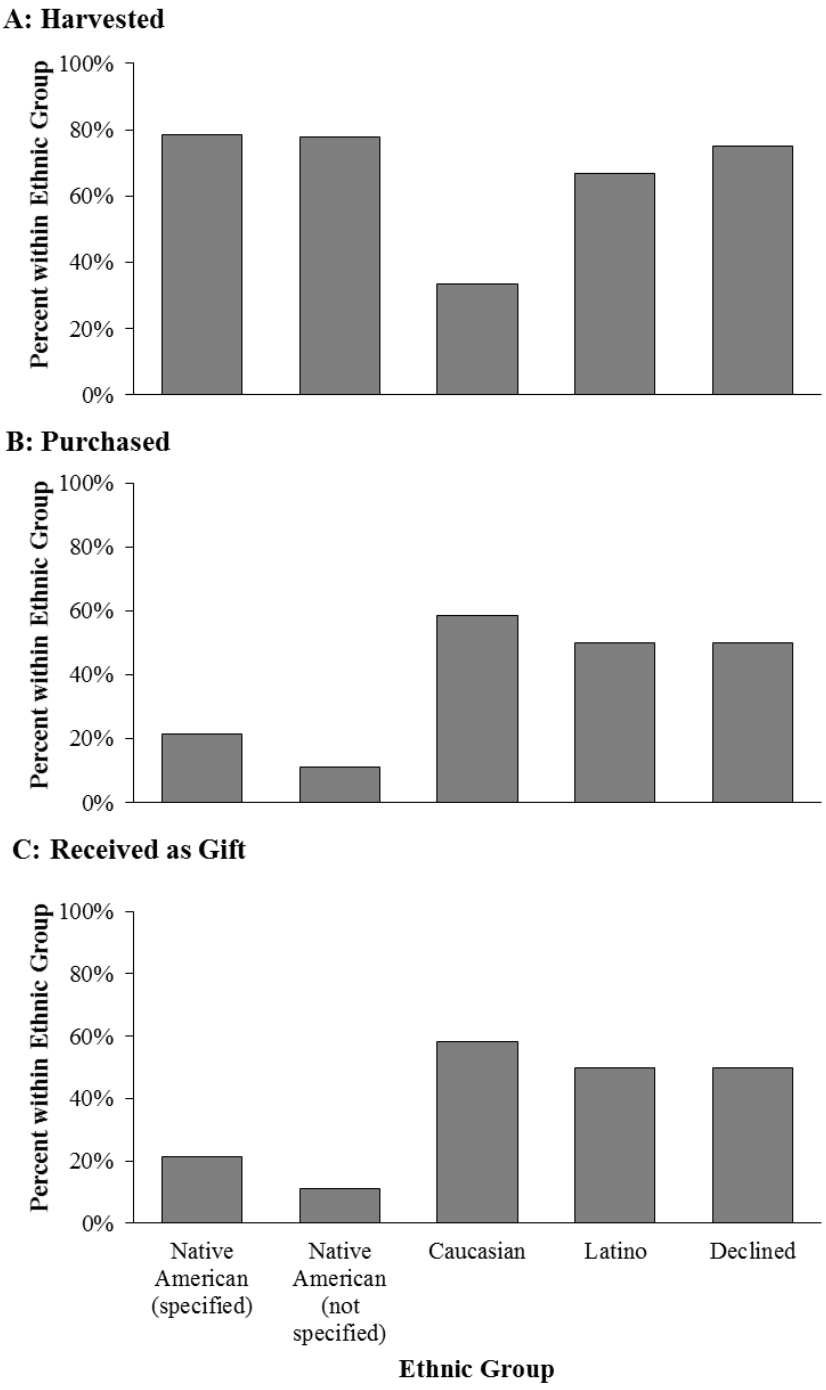

Figure 3: Common ways respondents acquire *S. apiana* depending on ethnic group. Bars show percent of respondents within an ethnic group that answered that they acquired white sage through the given method.

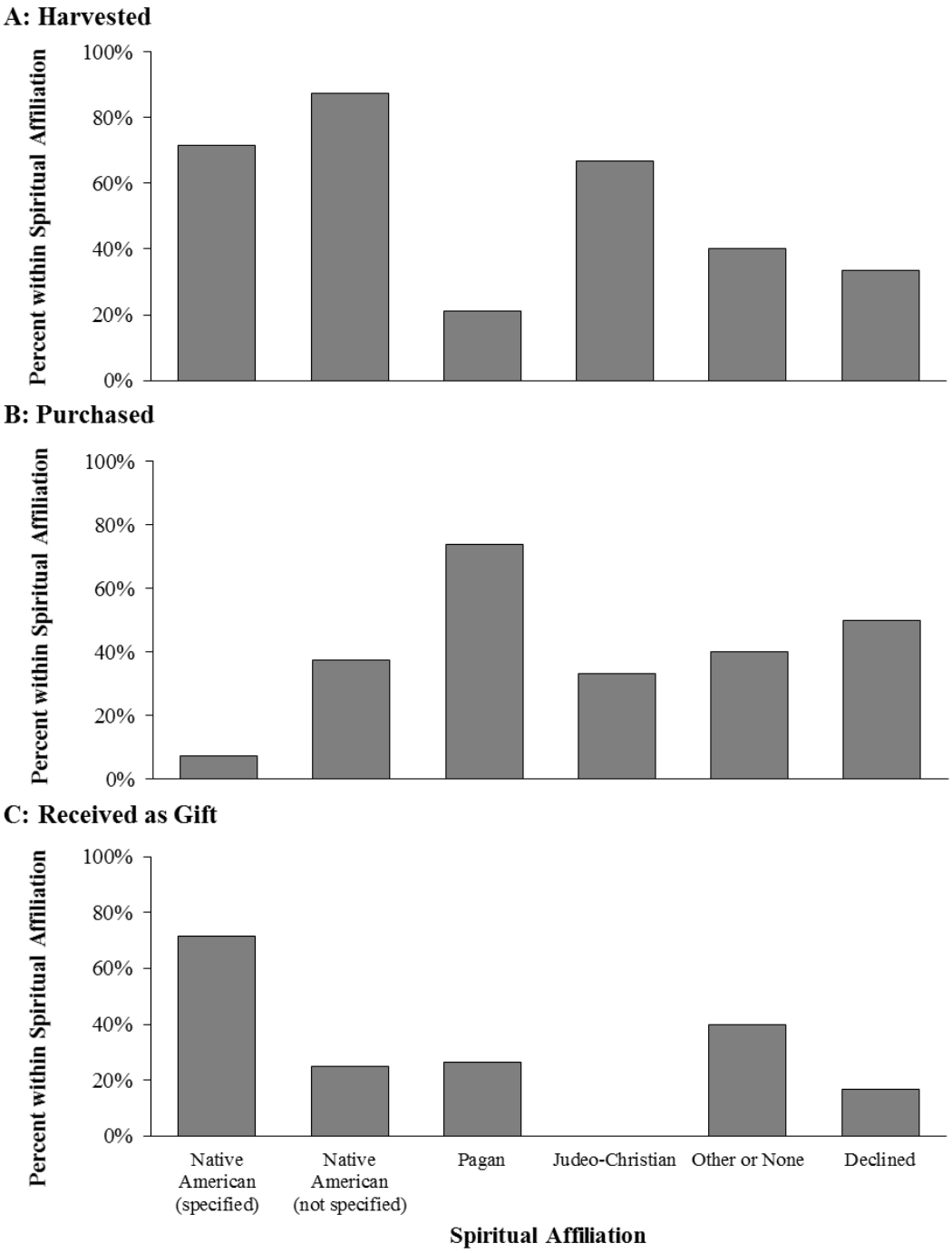

Figure 4: Common ways respondents acquire *S. apiana* (A: harvest, B: purchase, C: received as a gift) depending on spiritual affiliation. Bars show percent of respondents within an ethnic group that answered that they acquired white sage through the given method.

Harvest Practices of Respondents

Thirty-two respondents provided information on their harvest practices. They selected answers from a pre-determined list of choices: removing only leaves, breaking branches by hand, cutting branches with a tool, or other. Respondents could select as many techniques as were applicable to them. They then provided expanded descriptions of the techniques they used in answers to open-ended follow-up questions (Appendix 1, Questions 8 and 9). Most respondents selected one or more of the techniques listed, with only 13.8% selecting "other". Techniques used by these other respondents included picking up fallen leaves or leaves that fell when touched.

When harvest techniques were examined without regard to respondent ethnic or spiritual groups there was no preference for one technique over another (χ^2=5.04, df=2, p=0.080); ten respondents (31.3%) only broke branches by hand, nine (28.1%) only removed leaves without damaging branches, and five (15.6%) only cut branches. The remaining respondents (25%) used two or more of the harvest techniques.

Ethnic and spiritual groups used a different combinations of these methods (Figure 5, Figure 6) and 25% of individuals reported employing multiple techniques. While Caucasians, Latinos, and those that declined to state an ethnicity were not significantly different from each other (G=5.44, df=4, p=0.245), Native Americans (tribe specified) and Native Americans (tribe not specified) were distinct from the other groups (G=19.30, df=8, p=0.013) and each other (G=13.86, df=2, p<0.001). Native Americans who specified their tribe tended to break branches by hand more than any other technique, while the other groups favored removing leaves and cutting branches (Figure 5). Native Americans without a specified tribe showed no technique preference. A

similar pattern was apparent among spiritual groups. Non-Native American spiritualties were not significantly different from each other ($G=11.68$, $df=6$, $p=0.069$). However, Native Americans (tribe specified) and Native Americans (tribe not specified) were distinct from the other groups ($G=25.00$, $df=10$, $p=0.005$) and each other ($G=13.32$, $df=2$, $p=0.001$). Native Americans who specified their tribe tended to break branches by hand more than any other technique and those without a specified tribe used the three techniques in about equal proportions (Figure 6).

While harvest amounts varied between respondents, most (43.8%) emphasized that they only took small amounts of plant material, between 5% and 10%. Considerably fewer respondents (28.1%) removed approximately 25% of the plant when they harvested. About 25% of the respondents selected Other Amount. These respondents either were inconsistent in the amounts they harvested or collected only plant material that had fallen to the ground. For example, one respondent stated that she took "only what the plant releases on its own," suggesting that she looked for leaves in the process of abscission or those that had already fallen. Three respondents stated that the amounts they harvested depended on the overall health of the plant. Later in the survey six others also mentioned plant health when asked to describe what qualities they look for in the plants they harvest from. Overall, there were no significant differences between the ethnic and spiritual groups in amounts taken from single plants (ethnic: Figure 7, $G=6.09$, $df=8$, $p=0.638$; spiritual: Figure 8, $G=10.27$, $df=10$, $p=0.417$). Only one individual took 50% or more of a plant. In a conversation with me, this person went on to emphasize that she watered the plants when she walked the trail and this allowed her to take more without harming the plants.

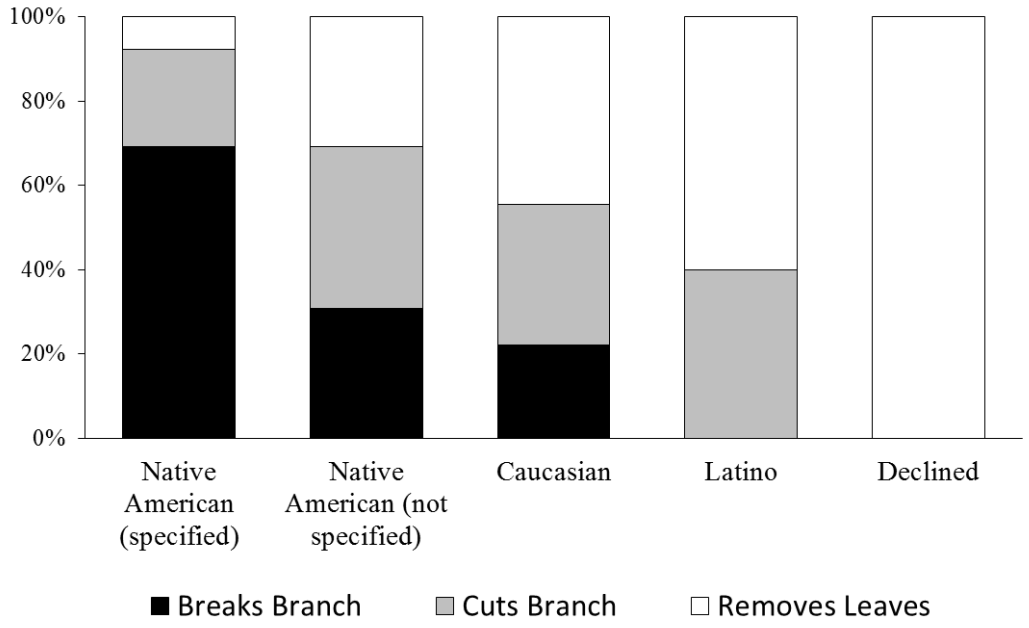

Figure 5: Percent of respondents that used a harvest technique based on ethnic group.

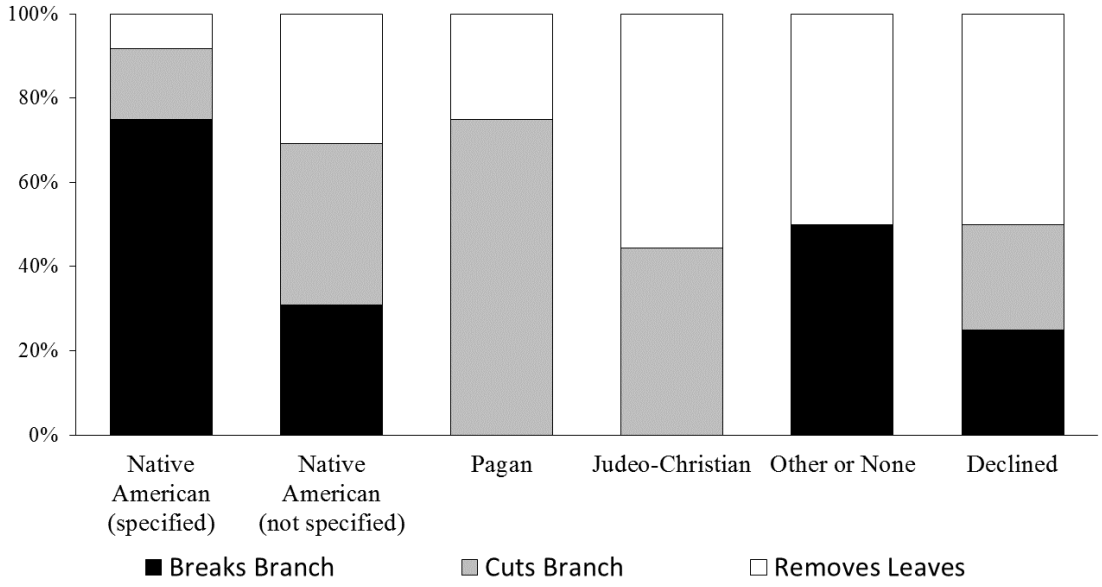

Figure 6: Percent of respondents that used a harvest technique based on spiritual affiliation.

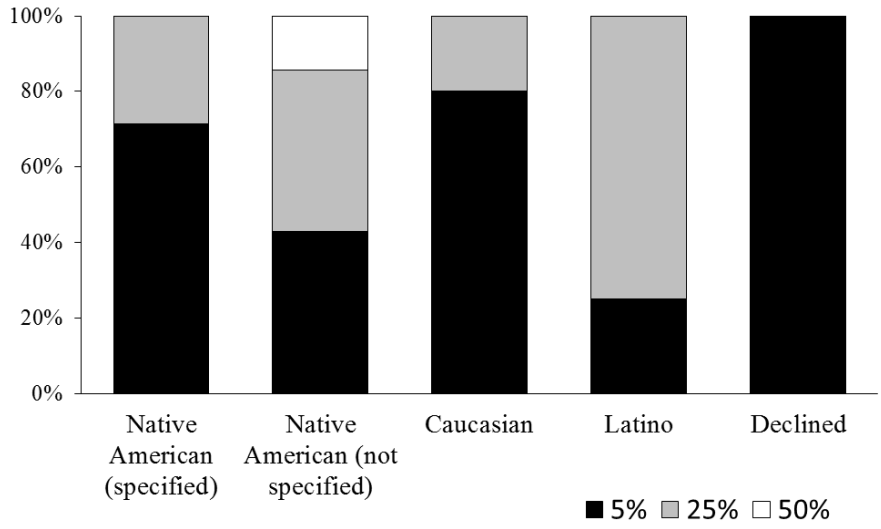

Figure 7: Percent of respondents that selected the option for amount gathered based on ethnic group.

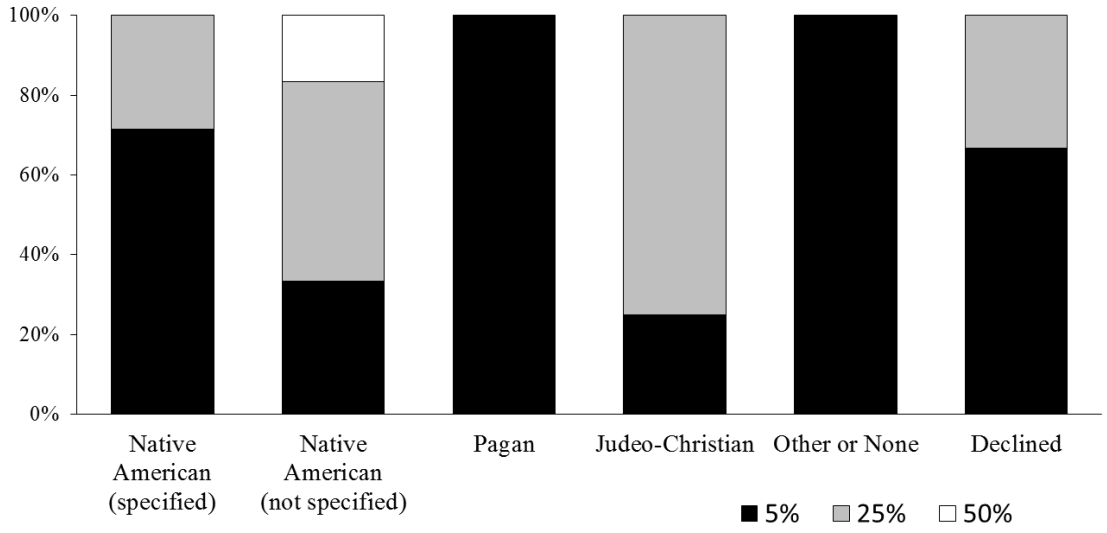

Figure 8: Percent of respondents that selected the option for amount gathered based on spiritual affiliation.

Other Harvest Factors

Respondents had several characteristics they looked for in a plant from which to harvest. The most common factor listed was plant health. Evidence of this included lack of insect damage, a large number of leaves as well as just being described as healthy looking. The size of the plant was also an important factor for some respondents. However, people differed in their preferences for large plants or small plants. Additionally, respondents were mixed about whether they favored soft (fresh) leaves or dry (dead) ones and whether the leaves were green-white or completely grey-white.

Season of harvest was stated as an important factor by only two of the respondents (6%) and factors related to season, such as flowering, were included by four additional respondents (12.5%). One respondent described harvesting flowers but four others explained that they specifically avoided plants with flowers and three others harvested only at times when plants were not flowering. One respondent emphasized the importance of "respecting the plant and its cycle" to maintain plant health. The times of harvest varied and although they occurred throughout the year there were peaks in early spring (February and March) and late summer (August and September; Figure 9).

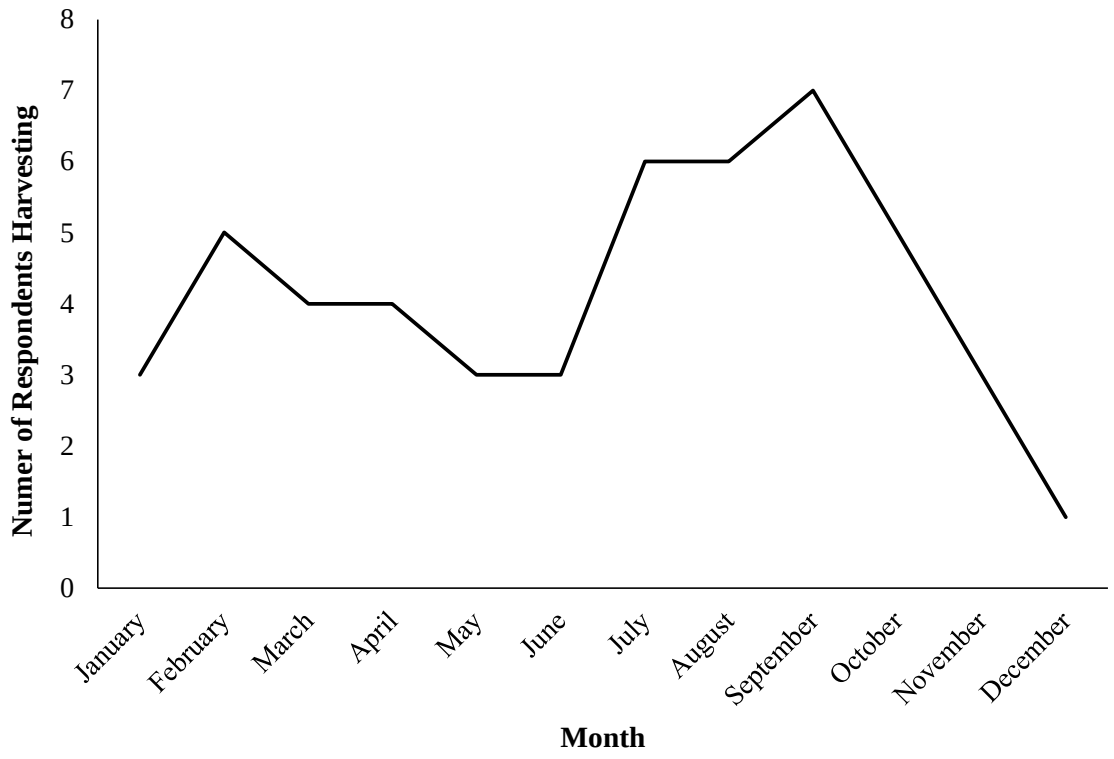

Figure 9: Months when respondents harvest, independent of ethnic or spiritual group. Respondents may harvest for more than one month.

Effects of Harvest

In March 2014 seven plants at the HELP Ranch site were inadvertently damaged by removal efforts. Of these, three had been completely cut off at the soil surface. These plants were removed from all 2014 analyses and no regrowth was observed by September 2014. In February 2015 these plants' locations were revisited and examined for signs of recovery. The four less severely damaged plants had regrown to be similar in size to the undamaged plants at the site. The three individuals that had been cut to their bases had also regrown but only to approximately half their pre-damage sizes.

Plant Volume

Plants had a mean volume of 2.3 (± 0.204) m^3 and a median of 1.54 m^3 in April 2013 (pre-harvest) with those at Towsley Canyon and HELP Ranch similar in size ($p=0.661$) but approximately three times larger than those at Malibu Creek ($p<0.001$) and Wheeler Gorge ($p<0.001$) based on a Tukey HSD post-hoc test.

Five months later, in September 2013, the plants at HELP Ranch, Malibu Creek, and Wheeler Gorge were not significantly different in volume based on treatment (Table 2). Only the plants at Towsley Canyon showed significant differences based on the three-way interaction of technique, season, and amount (Table 2, $F=3.860$, $df=4,18$, $p=0.020$). Plants that had 5% and 50% of their branches snapped by hand during the summer were significantly smaller than their pre-harvest size (Figure 10). However, by April 2014 these differences were no longer statistically significant (Table 3, $F=2.792$, $df=4,18$, $p=0.058$) and remained non-significant in September 2014 (Table 3, $F=2.077$, $df=4,18$, $p=0.126$).

Table 2: ANCOVA results for the effect of harvest treatments on plant volume for each site in September 2013. Significant results are in bold.

	HELP Ranch			Malibu Canyon			Wheeler Gorge			Towsley Canyon		
Source	**df**	**F**	**P-value**	**df**	**F**	**P-value**	**df**	**F**	**P-value**	**df**	**F**	**P-value**
Size Start 2013 (covariate)	1	**19.596**	**0.001**	1	**15.051**	**0.001**	1	**4.482**	**0.048**	1	2.803	0.111
Technique	2	0.047	0.954	2	0.182	0.834	2	2.902	0.081	2	0.354	0.707
Season	1	0.260	0.616	1	0.257	0.615	1	3.565	0.075	1	0.449	0.512
Amount	2	2.312	0.128	2	2.344	0.110	2	2.795	0.088	**2**	**4.174**	**0.032**
Technique * Season	2	2.776	0.089	2	1.187	0.317	2	3.071	0.071	**2**	**12.689**	**0.001**
Technique * Amount	4	0.495	0.739	4	0.358	0.837	4	1.232	0.332	4	1.166	0.359
Season * Amount	2	0.005	0.995	2	0.021	0.980	2	2.357	0.123	2	0.514	0.606
Technique * Season * Amount	4	0.727	0.585	4	1.024	0.408	4	1.701	0.194	**4**	**3.860**	**0.020**
Error	18			37			18			18		
Total	38			57			38			38		

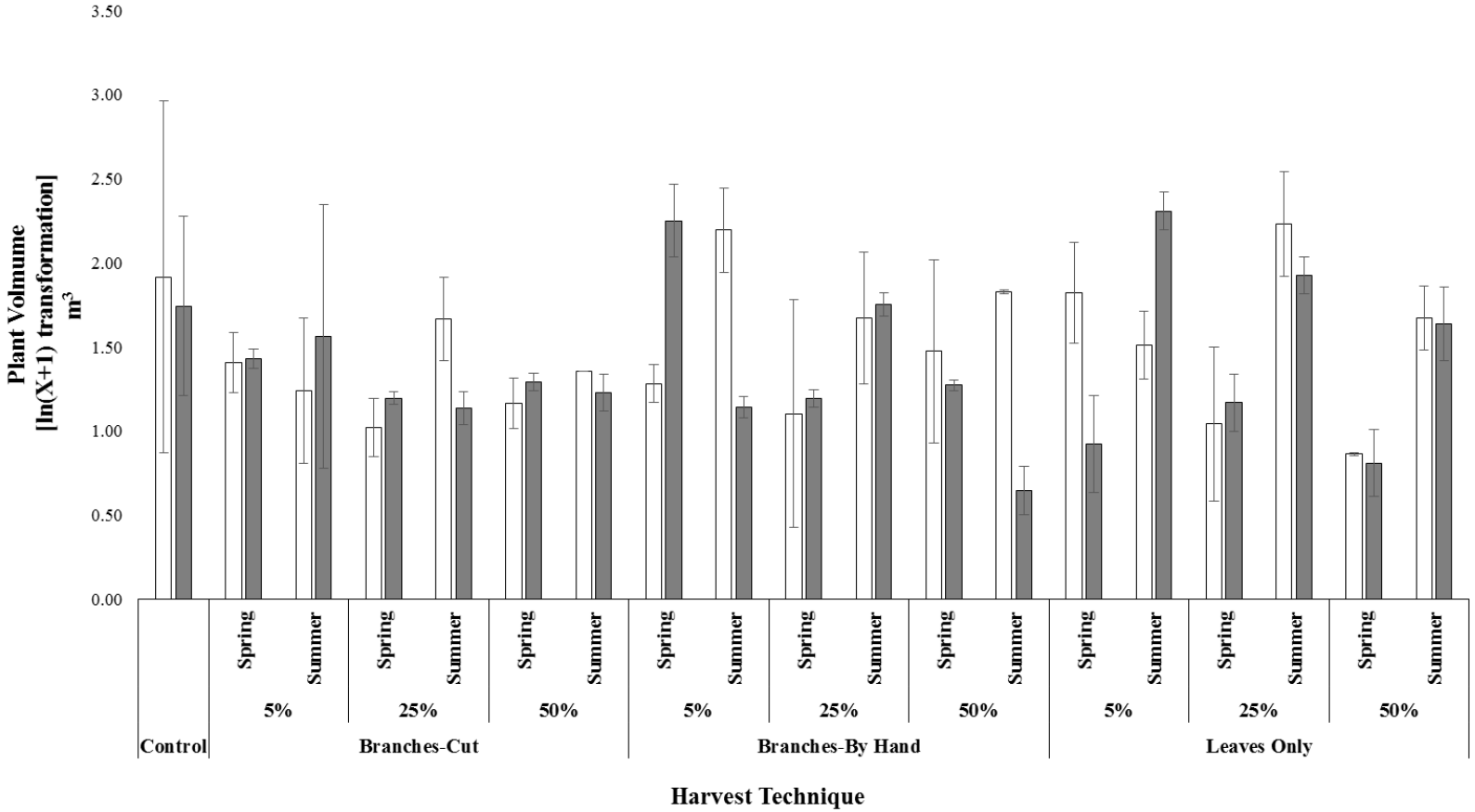

Figure 10: Plant volume at Towsley Canyon in September 2013 (dark bar) compared to pre-harvest plant size (light bar). Data for control plants collected in March 2013 and September 2013. Plant volume is transformed using ln(X+1). Error bars show ± SEM.

Table 3: ANCOVA results for the effect of harvest treatments on plant volume for Towsley Canyon in April 2014 and September 2015. Results that were significant in September 2013 are in bold.

	April 2014			September 2014		
Source	**df**	**F**	**P-value**	**df**	**F**	**P-value**
Size Pre-harvest (covariate)	1	**5.304**	**0.033**	1	4.304	0.053
Technique	2	0.682	0.518	2	0.167	0.847
Season	1	1.406	0.251	1	0.115	0.739
Amount	**2**	**0.373**	**0.694**	**2**	**0.282**	**0.757**
Technique * Season	**2**	**0.545**	**0.589**	**2**	**0.777**	**0.475**
Technique * Amount	4	1.384	0.279	4	0.805	0.538
Season * Amount	2	2.045	0.158	2	0.101	0.904
Technique * Season * Amount	**4**	**2.792**	**0.058**	**4**	**2.077**	**0.126**
Error	18			18		
Total	38			38		

Number of Leaves to Plant Volume Ratio

In April 2013, prior to harvest, plants averaged 882.47 (± 109.33) leaves/m^3 and had a median of 455.76 leaves/m^3. Plants at Wheeler Gorge and HELP Ranch had similar leaf abundance to shrub volume ratios ($p=0.569$) but these values were significantly less (40%) than those for plants at Malibu Creek ($p<0.001$) and much more (232%) than those for plants at Towsley Canyon ($p=0.004$) based on a Tukey HSD post-hoc test.

In September 2013 it was apparent that the various harvest treatments had not produced any statistically significant differences in leaf abundance to shrub volume ratios among the plants at HELP Ranch, Malibu Creek, and Wheeler Gorge (Table 4). Only the plants at Towsley Canyon had significantly differences based on the two-way interaction of technique and season (Table 4, $F=5.151$, $df=2,18$, $p=0.017$). Not surprisingly, plants that had branches cut or leaves removed during the summer had ratios that were smaller than their pre-harvest values (Figure 11). In April 2014 the two-way interaction was no longer significant ($F=0.057$, $df=2,18$, $p=0.945$); however, the

effect of harvest technique was significantly different (Table 5, F=5.076, df=2,18, p=0.035). Additionally, the amounts harvested were different at Towsley Canyon (Table 5) but post hoc tests (Tukey HSD) on the factors were not significant between the groups and all fell well within the variance observed for the control plants (Figure 12 and 13). In September 2014 the two-way interaction remained non-significant (F=1.579, df=4,18, p=0.233) and technique and amount were also non-significant (F=2.050, df=2,18, p=0.158 and F=1.605, df=2,18, p=0.228).

Table 4: ANCOVA results for the effect of harvest treatments on leaf abundance per m^3 for each site in September 2013. Significant results are in bold.

	HELP Ranch			Malibu Canyon			Wheeler Gorge			Towsley Canyon		
Source	**df**	**F**	**P-value**	**df**	**F**	**P-value**	**df**	**F**	**P-value**	**df**	**F**	**P-value**
Leaf Abundance Pre-harvest (covariate)	1	**7.069**	**0.016**	1	3.081	0.087	1	1.267	0.275	1	0.627	0.439
Technique	2	0.404	0.673	2	0.111	0.895	2	0.813	0.459	2	0.961	0.401
Season	1	0.011	0.916	1	0.053	0.819	1	3.028	0.099	1	2.820	0.110
Amount	2	3.0309	0.060	2	1.517	0.233	2	0.639	0.539	2	1.863	0.184
Technique * Season	2	0.851	0.443	2	1.502	0.236	2	0.924	0.415	2	**5.151**	**0.017**
Technique * Amount	4	0.347	0.843	4	0.288	0.884	4	0.436	0.781	4	1.034	0.417
Season * Amount	2	0.210	0.812	2	1.164	0.323	2	0.687	0.516	2	1.997	0.165
Technique * Season * Amount	4	1.166	0.359	4	0.262	0.900	4	0.856	0.509	4	1.583	0.222
Error	18			37			18			18		
Total	38			57			38			38		

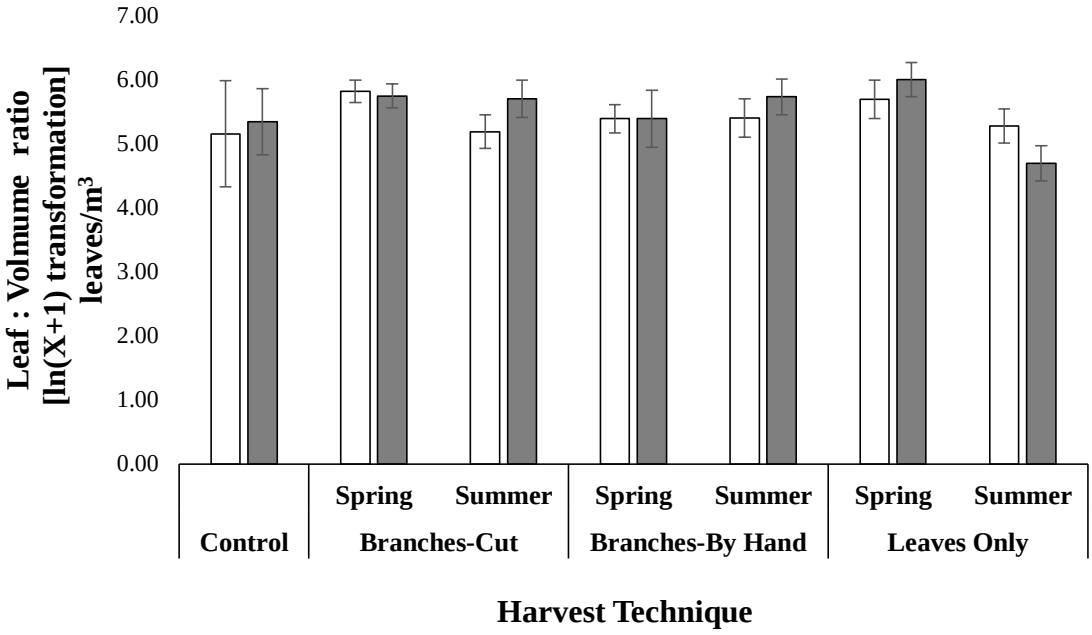

Figure 11: Leaf abundance per m^3 for Towsley Canyon in September 2013 (dark bar) compared to pre-harvest plant size (light bar). Data for control plants collected in March 2013 and September 2013. Data is transformed using ln(X+1). Error bars show ± SEM.

Table 5: ANCOVA results for the effect of harvest treatments on leaf abundance per m^3 for Towsley Canyon in April 2014 and September 2014. Significant results are in bold.

	April 2014			**September 2014**		
Source	**df**	**F**	**P-value**	**df**	**F**	**P-value**
Leaf Abundance Pre-harvest (covariate)	1	**5.435**	**0.032**	1	**0.759**	**0.395**
Technique	**2**	**5.076**	**0.018**	2	2.050	0.158
Season	1	1.044	0.320	1	0.122	0.731
Amount	**2**	**4.080**	**0.035**	2	1.605	0.228
Technique * Season	2	0.057	0.945	2	1.579	0.233
Technique * Amount	4	0.376	0.823	4	1.764	0.180
Season * Amount	2	1.805	0.193	2	0.293	0.749
Technique * Season * Amount	4	1.650	0.205	4	0.856	0.509
Error	18			18		
Total	38			38		

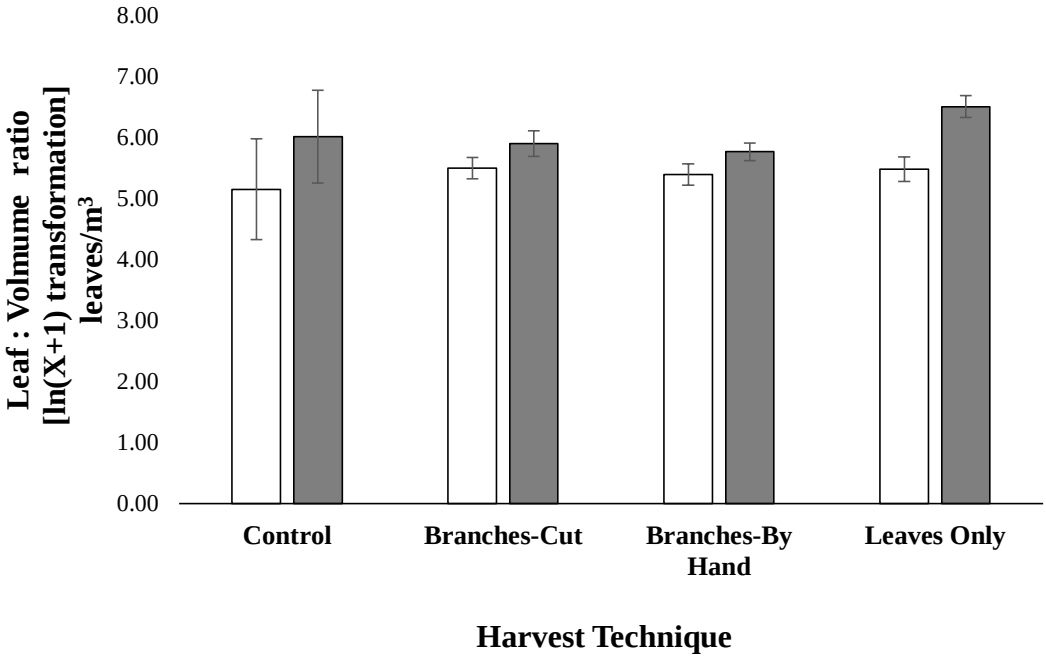

Figure 12: Leaf abundance per m^3 for Towsley Canyon in April 2014 (light bar) compared to pre-harvest plant size (dark bar) based on harvest technique. Data is transformed using ln(X+1). Error bars show ± SEM.

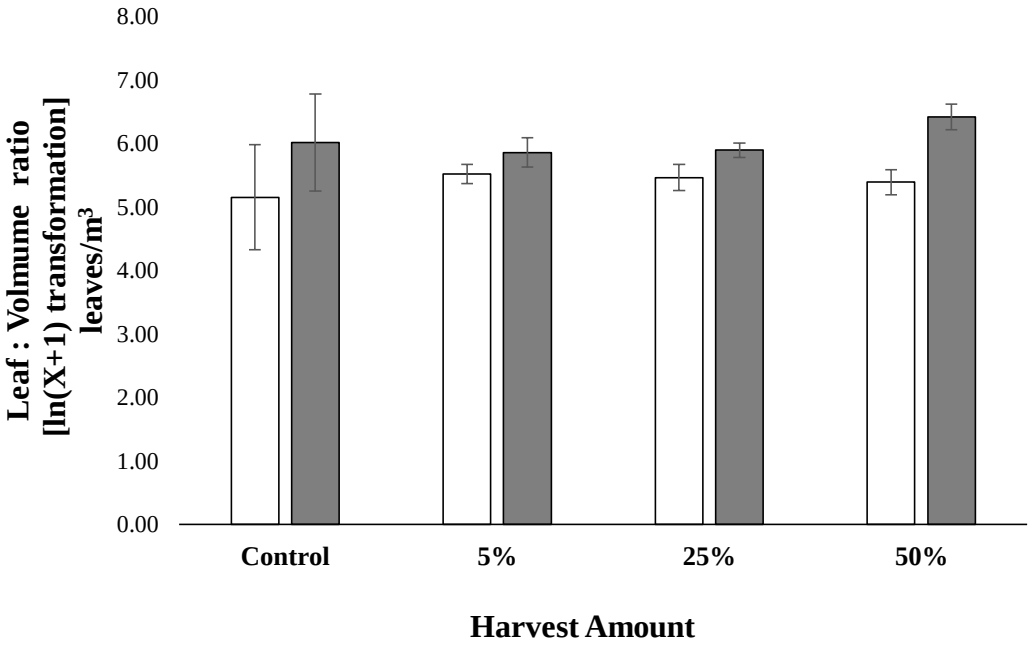

Figure 13: Leaf abundance per m^3 in September 2013 (light bar) compared to pre-harvest plant size (dark bar) based on harvest amount. Data is transformed using ln(X+1). Error bars show ± SEM.

Flower Abundance

Plants flowered in different proportions depending on site in both 2013 and 2014. In 2013, 47.4% of the plants flowered at HELP Ranch, 66.7% at Malibu Creek and 8.4% Towsley Canyon. Malibu Creek and Towsley Canyon were similar in the peak number of flowers produced ($p=0.926$) whereas plants at HELP Ranch produced six to seven times more flowers ($p<0.001$) based on a Tukey HSD test. Interestingly, the *S. apiana* plants at Wheeler Gorge did not flower that year. While the sites differed in numbers of flowers/plant ($F=17.119$, $df=3,167$, $p<0.001$), there were no significant differences between the treatments within each site (Table 6).

In 2014, 45% of the plants at HELP Ranch flowered but just 21.7% of the plants flowered at Malibu Creek and 72.5% flowered at both Towsley Canyon and Wheeler Gorge. The number of flowers produced per plant were significantly different among sites ($F=17.119$, $df=3,167$, $p<0.001$). Flower numbers at HELP Ranch, Towsley Canyon, and Wheeler Gorge were similar ($p=0.992$, $p=0.996$) but plants at Malibu Creek produced about 32% fewer ($p=0.018$). At HELP Ranch, Malibu Creek, and Towsley Canyon the harvest treatments did not have a statistically significant effect on flower numbers (Table 7). However, at Wheeler Gorge plants that had been subjected to harvest by hand snapping of branches produced significantly fewer flowers than all of the other treatments (Table 7, $F=17.119$, $df=3,167$, $p<0.001$, Figure 14).

Table 6: ANOVA results for the effect of harvest treatments on flower abundance for each site in 2013. Wheeler gorge is excluded from this due to none of the plants flowering.

	HELP Ranch			Malibu Canyon			Towsley Canyon		
Source	**df**	**F**	**P-value**	**df**	**F**	**P-value**	**df**	**F**	**P-value**
Technique	2	0.167	0.848	2	0.449	0.642	2	0.653	0.532
Season	1	0.092	0.765	1	0.458	0.503	1	0.005	0.944
Amount	2	0.009	0.991	2	0.552	0.581	2	2.709	0.092
Technique * Season	2	0.492	0.619	2	0.090	0.915	2	3.005	0.073
Technique * Amount	4	0.093	0.983	4	0.803	0.531	4	0.463	0.762
Season * Amount	2	0.255	0.777	2	0.413	0.665	2	0.571	0.575
Technique * Season * Amount	4	0.165	0.953	4	0.346	0.845	4	0.861	0.505
Error	18			37			18		
Total	38			57			38		

Table 7: ANOVA results for the effect of harvest treatments on flower abundance for each site in 2014. Significant results are in bold.

	HELP Ranch			**Malibu Canyon**			**Wheeler Gorge**			**Towsley Canyon**		
Source	**df**	**F**	**Sig.**	**df**	**F**	**Sig.**	**df**	**F**	**Sig.**	**df**	**F**	**Sig.**
Technique	2	1.060	0.373	2	0.704	0.500	**2**	**4.021**	**0.033**	2	0.606	0.555
Season	2	1.998	0.172	2	0.482	0.621	2	3.218	0.060	2	0.339	0.717
Amount	1	0.100	0.757	1	0.389	0.537	1	0.350	0.561	1	0.419	0.524
Technique * Season	4	1.043	0.420	4	0.964	0.437	4	0.335	0.851	4	0.698	0.602
Technique * Amount	2	1.489	0.259	2	0.330	0.721	2	1.961	0.166	2	0.355	0.705
Season * Amount	2	2.086	0.161	2	2.422	0.101	2	2.040	0.155	2	1.452	0.257
Technique * Season * Amount	4	0.302	0.872	4	0.910	0.467	4	0.358	0.835	4	1.095	0.385
Error	14			41			21			21		
Total	33			60			40			40		

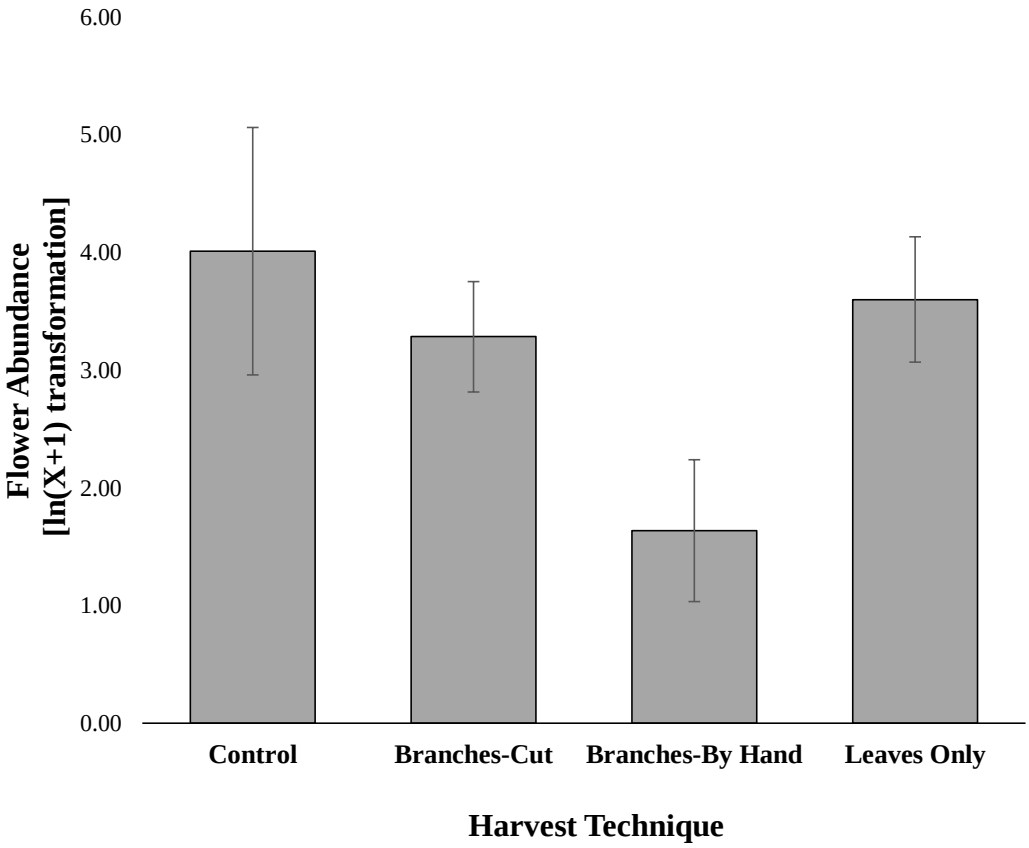

Figure 14: Flower abundance depending on technique used for Wheeler Gorge in 2014. Data is transformed using ln(X+1). Error bars show ± SEM.

Discussion

Harvest Practices

As expected, people who identified as being members of the Native American ethnic group or who practiced Native American spirituality and had a specific tribal affiliation were less likely to purchase *S. apiana* than any other group. This was likely due to cultural taboos associated with buying and selling spiritual herbs. Taboos play significant roles in many aspects of societies, including the determination of what is acceptable for purchase or sale (McGraw and Tetlock 2005, Ferstman et al. 2011). If a taboo is violated, the action is viewed as morally offensive (McGraw and Tetlock 2005). Evidence of this was apparent at a pow wow at which this project's surveys were distributed. Several elders told me repeatedly that the selling of spiritual plants was immoral.

However, the existence of this taboo was not consistently evident across the groups that participated in the survey. The members of cultural and spiritual groups that were not Native American were apparently more comfortable with purchasing *S. apiana*. The exchange of items of sacred values, such as plants used in ceremonies, for things of secular value, such as money, can be perceived as a taboo trade-off by some people (McGraw and Tetlock 2005, Ferstman et al. 2011). When a taboo isn't shared across groups, cross-cultural conflicts can occur. In such cases, the individual or group that makes the taboo trade-off may become the target of the anger or disgust by those who believe in the taboo (McGraw and Tetlock 2005).

To reduce this conflict, the group that made the trade-off may portray it in a benign or more acceptable way (McGraw and Tetlock 2005). In the case of this study, four

respondents who purchased *S. apiana* spoke with me informally in order to clarify some of their answers to the questionnaire. Each stated that they purchased *S. apiana* because they did not know how to harvest it properly. They explained that they were more comfortable paying someone who had the appropriate practical expertise and/or knowledge of the necessary spiritual ceremony to harvest materials from the plant without harming it.

However, of all the respondents who purchased *S. apiana*, only two knew if the seller harvested, purchased from a harvester, grew or purchased from a grower. The remaining respondents stated that they didn't know how the store got its *S. apiana*. Approximately half the people who filled out the questionnaire, regardless of spiritual or ethnic group, stated they thought it was purposefully grown, while the other half thought it was harvested from the wild. This lack of consumer information could result in overharvest if sellers are sourcing *S. apiana* in ways that are not sustainable.

Not knowing how to harvest probably explains some of the gifting of *S. apiana* across the various ethnic and spiritual groups. Gift giving is an integral part of Native American culture (pers. obs., R. Vann, per. com., March 2015, T. Garcia, per. com., April 2015). In addition to the obvious benefits of cementing friendships and building community unity, it also allows for the exchange of sacred plants. Trading one sacred herb for another is a common practice in Native American culture. One elder I spoke with at a pow wow gathered *S. apiana* to give to a friend who collected *Hierochloe odorata* (sweetgrass) for him. This exchange of gifts can extend beyond the Native American community. Two of the Pagan respondents also commented on the survey that they had received the *S. apiana* as gifts from Native American friends.

As expected, there were differences among groups of people who harvested *S. apiana*. Native Americans who specified a tribal affiliation favored breaking branches by hand, while other groups used other techniques more equally. The strong preference for hand breaking was likely due to stronger links to cultural guidelines for harvest among members of this group. Furthermore, only Native Americans associated with a specific tribe included a sacrifice prior to harvest, typically involving water or tobacco (Appendix 1, question 8). A sacrifice, as defined in this case, is a symbolic payment prior to the use of a certain plant (Quiroz and van Andel 2015). Presence of a ritual sacrifice tends to be associated with sacred plants that are either rare or perceived as rare by the community using them (Quiroz and van Andel 2015).

Members of all groups emphasized the desire to be respectful to the plant and not cause harm when harvesting. All groups tended to take 25% or less of the plant and several emphasized that they only took from plants that were unlikely to experience long-term harm because they had many leaves that were greenish-white in color and exhibited little evidence of insect damage. While individual harvesters focused on somewhat different characteristics when choosing plants from which to harvest, all harvesters tried to have as little impact on the plants as possible.

Effects of Harvest

Harvest treatments had fewer detectable negative effects on *S. apiana* plants than had been predicted. It was expected that season of harvest would have large effects due to the harshness of southern California's summertime climate (high temperatures and no rainfall). It was also expected that the harvest of leaves, rather than the removal of

branches by cutting or hand-breaking, would be the least impactful at all sites. It was not expected that site differences would be as important as they were.

Of the four sites only plants at Towsley Canyon and Wheeler Gorge showed significant differences between treatments. Only plants at Towsley Canyon were unable to fully recover in size and leaf abundance from some treatments by the end of the summer following harvest (five months after spring harvest and 1.5 months after summer harvest) with July removal of branches resulting in smaller plants than other treatments. Additionally, Wheeler Gorge was the only site where flower abundance was significantly lower for plants subjected to some of the treatments and during the first year plants at Wheeler Gorge showed strong signs of drought stress, with all plant having dropped most of their leaves (75% or more) by June. Of the four sites studied, Towsley Canyon and Wheeler Gorge were the hottest and driest (Table 1).

Water stress is the most likely explanation for the response differences at these two sites. Areas in southern California that support coastal sage scrub vegetation are characterized by mean annual rainfall amounts ranging from 250 to 450 mm (Rundel 2007). However, rainfall can vary tremendously between years (Minnich 2007). Both 2013 and 2014 were years of severe drought with just 148-239 mm of rainfall in July 2012 – June 2013 and 154-167 mm in July 2013 – June 2014 (Null 2013 and 2014). This extreme environmental condition almost certainly affected the responses of *S. apiana* plants to harvest.

Drought stressed plants have been shown to do less shoot growth after herbivory than well watered ones (Sun et al. 2010, Lui et al. 2011, Bansal et al. 2013, Kleine and Müller 2014). In a study of *Salvia miltiorrhiza*, Lui et al. (2011) showed that, when

compared to controls, plants subjected to drought conditions had reduced shoot growth and did more root growth. *S. apiana*, a congener, may have similar resource allocation priorities in drought conditions. In my study, plants did not recover from harvest until after the winter and spring rains the following year. Furthermore, leaf removal while a plant is flowering reduces recovery (Thomson et al. 2003). This probably explains the response of *S. apiana* plants at Towsley Canyon, which were still flowering at the time of the summer harvest.

Interestingly, at both sites the snapping of branches resulted in either less growth or fewer flowers. The drought deciduousness of *Salvia apiana* (DeSimone and Zelder 2001) suggested that leaf harvest would be less impactful than stem harvest, either by cutting or breaking, since stems are not shed annually. However, branch cutting was not significantly different from leaf only removal, which was not expected. It is likely that wound size is the reason, rather than whether a part is adapted to be shed. Of the three harvest techniques breaking branches by hand created the largest wounds (pers. obs.) because the branches must be bent and twisted in order to break off. Large size wounds may release more volatile compounds associated with plant defense (Pontoppidan et al. 2005) and expose large amounts of internal tissue that may be subject to infection (Sakamoto and Gordon 2006).

The seven plants that were accidentally damaged at HELP Ranch, while adding variability to the analysis, allowed for the opportunity to assess the responses of plants after 100% of above ground tissues had been removed, an experience akin to the harvest of all stems and leaves. While these plants had not fully recovered by February 2015,

they had grown to approximately half their original size. After a few more years, it is possible that they will fully recover.

Adaptations to fire in coastal sage scrub and chaparral environments probably explains the lack of detectable negative effects of harvest on *S. apiana* as well as the recovery of the plants that were accidentally mowed at the HELP Ranch site. After fires, *S. apiana* typically regenerates through the germination of seeds that have accumulated in the soil (Franklin et al. 2004). However, damaged plants can resprout as well (Franklin et al. 2004). Many coastal sage scrub and chaparral plants have below ground carbon stores. When above ground biomass is removed these stores make resprouting possible (Franklin et al. 2004). The facultative seeders observed by Marais et al. (2014) resprouted after 65 days, on average, and grew 2.54 mm/day. They also noted that 80% of facultative seeders, such as *S. apiana*, survived after resprouting (Marais et al. 2014). Syphard et al. (2007) estimated that, historically, fires burn wildland areas in southern California every 20-150 years and that even fire-adapted plants are killed by fires more frequent then that. This suggests that, although many plants can regenerate, complete removable of branches and leaves is probably not a sustainable harvest method.

Conclusions

The harvest practices reported by individuals interviewed for this study did not appear to have lasting harmful effects on *S. apiana* plants, at least in the short term. This was true for all harvesters, regardless of their spiritual or cultural background. However, the decline of *S. apiana* in southern California that has been widely suggested by the Native American community (R. Vann, per. com., March 2015) is still a concern. The

harvest done by individuals is unlikely to be the reason for decline but other factors can be negatively impacting *S. apiana* populations.

Commercial harvest of *S. apiana* still needs to be assessed as a source of decline. Only four of the fifteen online stores examined stated where they acquired their *S. apiana* and all of those either purchased from a harvester or harvested it themselves (Appendix 2). Additionally, two of the four respondents stating that they sell *S. apiana* or products made of *S. apiana* noted that they sell hundreds of bundles a year from *S. apiana* they harvest. One of the four described purchasing it from someone who did a mixture of growing and harvesting from wild plants.

Informal conversations with survey respondents who did not sell *S. apiana* also suggests that commercial harvest may be a potential source of decline. One respondent told of observing other people removing whole plants from patches of *S. apiana* and then selling bundles at a farmer's market weeks later. Another respondent described seeing several *S. apiana* sellers at a farmers market with hundreds of bundles. It takes 4-6 46-cm branches to create an average sized bundle (per. obs.) and if commercial sellers repeatedly harvest large amounts from plants, this could be a significant source of decline.

Another factor that may result in fewer stands of *S. apiana* is the frequency of fires in southern California. Fire frequency has increased dramatically in southern California in recent decades (Keeley et al. 1999) because widespread development has vastly expanded the urban and wildland interface (Syphard et al. 2007). Between 1910 and 1950 there were 143 wildfires were recorded in Ventura County and 357 in Los Angeles County (Keeley et al. 1999). However, between 1951 and 1997 the number of wildfires

had increased to 172 in Ventura County and 1392 in Los Angeles County (Keeley et al. 1999). Historically areas burned every 20 to 150 years (Syphard et al. 2007). Between-fire periods of less than 15 years threaten the survivorship of chaparral shrubs and periods of less than 10 years threaten coastal sage scrub shrubs (Syphard et al. 2007). Chaparral and coastal sage scrub sites that experience large amounts of shrub mortality because of increased fire frequency, often become converted to grasslands dominated by opportunistic and invasive non-native species (Zedler et al. 1983; Haidinger & Keeley 1993, Talluto and Suding 2008).

Salvia apiana typically occupies early successional community plant (Franklin et al. 2004) but it is a poor competitor with invasive non-native grasses (DeSimone and Zelder 2001). As fires become more frequent, *S. apiana* plants are probably less often able to regrow and their seedlings are not able to compete with invasive grasses. This shift from native shrub-dominated vegetation to communities with increasing proportions of non-native grasses, due to increased fire frequency, is a likely source of a significant amount of *S. apiana* decline.

Recommendations

If *Salvia apiana* is to persist as an important cultural resource, harvest methods that allow plants to regenerate and reproduce are necessary, particularly because the environments that support this species are increasingly threatened by urbanization, drought, and increased wildfire frequencies. The three harvest techniques examined for this study (removal of individual leaves, breaking branches, and cutting branches) did not differ from each other and, therefore, they are all equally appropriate means of *S.*

apiana collection. When selecting a method, harvesters are encouraged to cause as little damage to the plant as possible. For example, if a plant happens to be very leafy but has only a few branches, collecting leaves rather than entire branches would be the preferred method. In addition, to minimize any lasting effects of harvest on plants, particularly during times of drought, it is recommended that, harvesters collect from individuals in relatively mesic locations (such in coastal areas and sites with shade during part of the day) whenever possible.

Several Native American respondents to this study's survey indicated that they limited their collections to a few *S. apiana* plants per patch and typically did not harvest from the same individuals each year. This may be a cultural mechanism to avoid detrimental effects caused by repeated harvest. Repeated harvest was not examined in this study and so it is not known whether it has lasting negative effects on *S. apiana*. To ensure the sustainability of wild populations in the absence of such data, it is recommended that harvesters collect from several different plants rather than repeatedly concentrating efforts on just a few individuals.

Finally, there have been anecdotal reports of commercial harvesters cutting and removing large numbers of entire *S. apiana* plants from southern California wildlands. Concerned purchasers are encouraged to request that retailers not sell material harvested in this manner. When reputably sourced white sage cannot be assured, users may choose to employ the "best practices" recommended here to collect leaves or branches for their own personal needs.

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Appendix 1

Survey Distributed to Participants

Letter to Participants

Why Should I Take This Survey

Dear Participant,

I am Native American and a masters of biology student at California State University, Northridge. For my thesis project I am looking at the effect of harvest on white sage (Salvia apiana). White sage leaves are burned by diverse groups of people for purposes of purification, prayer, and the cleansing of homes, people, and ceremonial areas. I am interested in studying harvest on this plant due to concerns that different harvest techniques may be impacting the health of individual wild plants and wild populations of this plant.
Many harvest experiments done by researchers do not actually ask the community how they collect and use the resource. I do not wish to follow this pattern. Interaction and participation with communities relying on this resource are essential. I hope to use this survey as a means to find out about actual harvest on white sage, not just assumed harvest. By participating in this survey you are helping communities learn about sustainable harvest techniques.

Resources are provided by California State University, Northridge and funded by the National Science Foundation under the 2012-2015 Graduate Research Fellowship Program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

Time commitment: Your involvement in the White Sage Harvest project involves taking a survey, which will take approximately 15 minutes. If you wish to share many personal responses (writing about your experiences), it may take longer.

Who can participate?
• You identify as Native American, Pagan, Heathen, or another nature- or earth-centered spirituality.
• You use, buy, or collect white sage for either personal or commercial use.
• You live in southern California, United States.
• You are over 18 years of age.

Confidentiality: At the end of the survey you have the option of providing your email address if you are interested in having information about the results emailed to you once this project is complete. This email will not be used to identify you in any way. It will be kept separate from the rest of the data and will only be used to send you the results of the study. This will occur sometime in 2015 or 2016. No other identifying information

will be collected. Your participation in this study is completely voluntary and you may withdraw at any time. This study has been reviewed and approved by the CSUN Institutional Review Board.

Thank you very much for participating! If you know others who may be eligible and interested in participating, please pass on the link!

Cassidy Adlof, Masters Student
Department of Biology
California State University, Northridge
Contact: cassidy.adlof.80@my.csun.edu

Survey Questions

1) Do you harvest/collect, sell, and/or use white sage (Salvia apiana)? (Leaves, incense, smudging wand, etc.) (mark all that apply)

- ☐ I collect / harvest white sage
- ☐ I sell white sage
- ☐ I use white sage or products made from white sage
- ☐ I grow or farm white sage
- ☐ I do not harvest, sell, or use white sage
- ☐ I collect / harvest sage, but I am not sure if it is white sage
- ☐ I sell sage, but I am not sure if it is white sage
- ☐ I use white sage or products made from sage, but I am not sure if it is white sage
- ☐ Other (please specify)

Common sage species in Ventura County and Los Angeles County region

2) Which of the above sage species most closely resembles the species you collect from? (Please mark all that apply)

- A
- B
- C

3) Please identify which of the above species is white sage (Salvia apiana)?

- A
- B
- C

Harvesting White Sage

4) Where do you harvest from? (name of location(s) or direction(s) to location)

5) How much do you collect from a single plant?

- around 5% (just a few leaves)
- around 25% (a couple of branches)
- around 50% of the plant
- I take the whole plant
- Other (please specify)

6) How many plants do you harvest from at one time?

7) What do you collect and how do you collect? (Please mark all that apply)

- I just take leaves
- I cut the branch with shears or a knife
- I break the branch by hand
- Other (please specify)

8) Please describe in detail how you harvest and what parts you harvest.

9) What qualities you look for in the plant and location when you harvest?

10) How often do you harvest?

11) When do you harvest (check all that apply)

- January
- February
- March
- April
- May
- June
- July
- August

- September
- October
- November
- December
- Other

12) Why do you harvest? (please mark all that apply)
- I harvest for commercial purposes
- I harvest for personal use
- I harvest for personal use, but sell white sage I either grow or buy
- Other (please specify)

13) If you sell white sage; do you acquire sage through any means other than harvesting from the wild?
- I do not sell white sage
- No, I harvest all of my white sage
- Yes, I also buy white sage
- Yes, I also grow white sage

Selling White Sage

14) Where does your white sage products come from? (mark all that apply)
- I grow it
- I collect it
- I buy from someone who grows it
- I buy it from someone who collects it from wild populations
- I buy it from someone else but I am not sure where they get it

15) If you buy it, please list the names of the companies that you buy it from.

16) About how much do you sell in a year? (approximate number of wands, number of incense packs, etc.)

White Sage Usage
17) Where do you get your white sage? (Mark all that apply)
- I buy it
- I collect it from wild populations
- I grow it
- I receive it as a gift

18) What white sage products (smudging wands, incense cones or sticks, leaves only, etc.) do you use? (Please number each item, for example: 1. smudging wand 2. incense sticks...)

19) Approximately how many of each product you use? (Please number according to above answer)

Purchasing White Sage

20) Where do the white sage products in the store originate from? (mark all that apply)
- They grow it or buy from someone who grows it
- They collect it or buy it from someone who collects if from wild populations
- I don't know where the store gets their white sage from

21) Please list the names of the companies or stores that you buy from.

Demographics

22) What ethnic group do you consider yourself part of? (mark all that apply)
- Native American (Please specify tribe in the box below)
- Caucasian
- African American
- Asian
- Latino
- other (Please specify)

23) What cultural/religious group do you consider yourself part of? (mark all that apply)
- Native American (traditional for you tribe)
- New age or New thought
- Wiccan
- Druidic
- Heathen
- Other Pagan
- Christian
- Other (please specify)

24) With what genders do you identify? (Mark all that apply)
- Woman
- Man
- Gender Fluid
- Androgynous
- Intersex
- Transsexual
- Decline to State
- Other (please specify)

25) What age bracket are you a member of?

- 18-30
- 31-40
- 40-50
- 50-60
- 60 or older

26) Please provide your zip code. (This will not be used to contact you in any way. This will only be used to determine general geographic information.)

Thank you for participating. If you would like to have the results of this study emailed to you please type your email below. This project is expected to be complete sometime in 2015. If you do not wish to have the results of this study emailed to you please leave the box blank. If you change your email after this has been submitted or wish to contact me concerning this study I can be reached at cassidy.adlof.80@my.csun.edu.

Appendix 2

Websites Selling Wild-craft *Salvia apiana* Examined for Harvest Details

Website Name	URL	Details
Crazy Crow Trading Post	www.crazycrow.com	- No details provided
Enriching Elements	www.enrichingelements.com	- No details provided
Healing Crystals	www.healingcrystals.com	- Purchased from harvester in California
Hood Witch	www.thehoodwitch.com	- No details provided
Juniper Ridge	www.juniperridge.com	- Year round harvest
Kate's Magik	www.katesmagik.com	- Purchased from Juniper Ridge
My Native Spirit	www.mynativespirit.com	- August harvest - Tips of plant harvested
Matoska Trading Co.	www.matoska.com	- No details provided
Native Spirit Lodge	www.thenativespiritlodge.com	- No details provided
Owl Nest	www.theowlnestonline.com	- No details provided
Paranomal Warehouse	www.paranormalwarehouse.com	- No details provided
Scents of Earth	www.scents-of-earth.com	- No details provided
Shaman's Market	www.shamansmarket.com	- No details provided
Sweet Medicine Shoppe	www.sweetmedicineshoppe.com	- No details provided
Tao Sherb Co.	www.taosherb.com	- No details provided