Cultural Influence As a Factor in Determining the Distribution of a Rare Sage, *Salvia dorrii* subspecies *mearnsii*

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Abstract: Although related taxa occur throughout the western United States, *Salvia dorrii* ssp. *mearnsii* is endemic to central Arizona. In part, its narrow distribution may be attributed to prehistoric human influences. A spatial analysis was used to determine the relationship of archaeological sites and populations of *S. dorrii* ssp. *mearnsii*. In the lower Verde Valley, approximately 89 percent of the plant populations were spatially related to archaeological sites. Plant populations from a different geographic area in the upper Verde Valley were also spatially related to known archaeological remains, although only 75 percent of the time. Consultations with traditional scholars of three indigenous tribes, the Hopi, Paipai, and Kumiai, were conducted to gain a better understanding of the cultural significance of the plant and to aid in the interpretation of plant–archaeological remain relationships. The consultants indicated that certain taxa in the genus *Salvia* (*S. dorrii* var. *dorrii* and *S. pachyphylla*) are used in ceremonies and as medicine. These plant–archaeological site associations may be the result of prehistoric plant husbandry systems including trade and dispersal of seeds via Native American clan travel.

Cultural factors affecting plant distribution have been discussed by many researchers in the past (Clark 1968, Yarnell 1973, Minnis and Plog 1976). It is well accepted that some plants have received special care by people, a practice known as plant husbandry (Winter and Hogan 1986, Anderson and Nabhan 1991, Minnis 1992, Smith 1992, Ford 1997). Generally, indigenous peoples were managing the entire ecological landscape in which they lived (Nabhan 1997) although in some cases, evidence of this management is ephemeral or completely absent. As Ford (1978) has discussed, there is a spectrum of plant husbandry techniques that includes activities such as tolerating or eliminating weeds, pruning, thinning, transplanting, tending, burning, cultivation, and domestication (Table 1).

Some plant husbandry techniques have significantly altered the distribution of certain plant species. Minnis and Plog (1976) concluded that the elevational range of *Agave parryi* had been increased by human movement. Other studies have discussed plant–archaeological site relationships for genera such as *Opuntia, Lycium, Cleome, Pinus, Juglans,* and *Malus* (Gilmore 1931, Mosely 1931, Zeiner 1946, Yarnell 1965, Clark 1968, Minnis and Plog 1976, Frison 1978). These relationships are difficult to interpret using modern ideas about human ecology and plant dispersal patterns. Consideration of ethnobotanical uses, characteristics of archaeological sites, cultural migration, and history of the study area should be included in analyses of such associations.

The distribution of *Salvia dorrii* ssp. *mearnsii* in central Arizona lends itself to an investigation of plant–archaeological site relationships. It is distributed in disjunct patches along the Verde River from Perkinsville to Camp Verde (Figure 1). The plants are often found adjacent to archaeological sites, although not all of the populations show this pattern. They appear to inhabit unique substrates (limestones, sandstones, mudstones) but are not limited to one vegetation type. Plants are found in desertscrub, chaparral, and pinon-juniper communities.

The ethnobotanical value of plants in the genus *Salvia* is useful in interpreting a plant–archaeological site relationship. Some taxa in the genus *Salvia* have been used for medicine by North American tribes such as the Diné (Navajo), Hopi, Kumiai, Northern Paiute, Paipai, Shoshone, Washoe, and Kawaiisu (Whiting 1939, Train et al. 1941, Zigmond 1981, Moerman 1986, Fowler 1989; and Teodora Cuero, Theodora Homewytewa, Benito Peralta, and Robin Taylor, personal communication). *Salvia dorrii* ssp. *mearnsii* may have been used by people living in central Arizona in the past. Traditional scholars from several tribes (Hopi, Kumiai, Paipai) have been consulted; they have indicated that relatives of this subspecies (*Salvia dorrii* ssp. *dorrii* and *S. pachyphylla*) are used extensively for stomach-aches, headaches, and

Table 1. The spectrum of plant husbandry techniques (Smith 1992, Ford 1997).

Least intensive management	Toleration of weeds Weeding Pruning Thinning Active encouragement Active selection of certain traits Burning
Most intensive management	Gardening Management of trees/nuts Cultivation Domestication

other medicinal uses, and that *S. dorrii* ssp. *mearnsii* was probably used in central Arizona in the past as an alternative to plants that people knew from different geographical areas for similar medicinal and ceremonial reasons (Homewytewa and Taylor, personal communication).

I investigated whether human influence was a factor in the distribution of *Salvia dorrii* ssp. *mearnsii* by analyzing the spatial relationship between archaeological sites in central Arizona and the culturally significant plant, *Salvia dorrii* ssp. *mearnsii.* I addressed the following two questions: Are archaeological sites and populations of *Salvia dorrii* ssp. *mearnsii* in the upper and lower Verde Valley spatially independent? How can we use modern distributions of plants to interpret past human influence on the distribution of plants? This study is unique because it analyzes the relationship between plants and archaeological sites using spatial statistics. In addition, I consulted traditional scholars to better understand the cultural importance of this subspecies and plant husbandry systems in the Southwest and to verify historical writings and biological patterns.

Taxonomy and Description

Salvia dorrii ssp. *mearnsii* is one of two subspecies in the *S. dorrii* complex. *Salvia dorrii* ssp. *mearnsii* is geographically isolated from *S. dorrii* (Kellogg) Abrams ssp. *dorrii* (Strachan 1982). It is

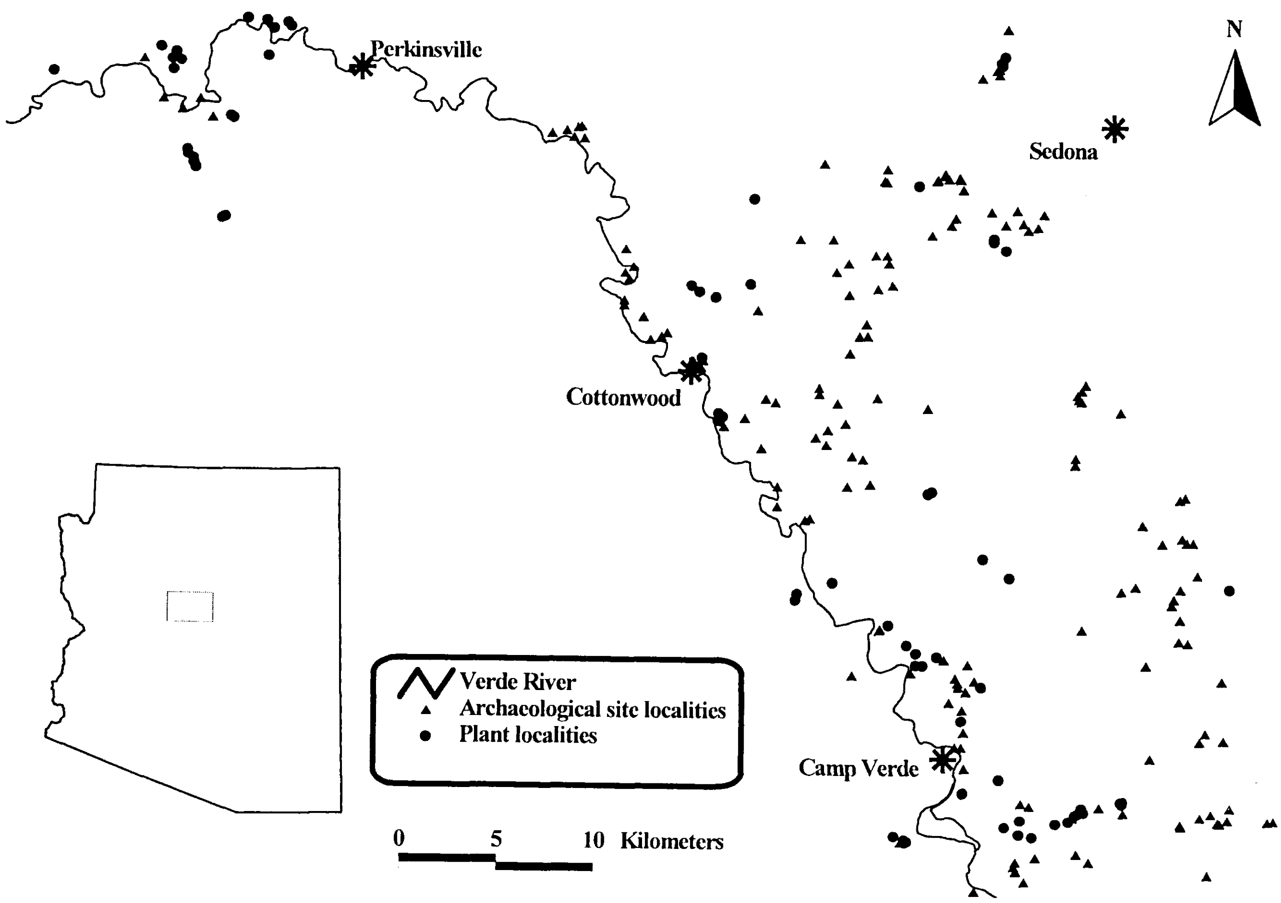

Figure 1. Distribution of *Salvia dorrii* ssp. *mearnsii* and archaeological sites in the study area. Inset is study area on Arizona map.

also morphologically distinct from *S. dorrii* ssp. *dorrii* by its reduced stature (15–30 cm vs. 10–50 cm), narrow leaves (1.5–3 mm wide vs. 6–10 mm wide), and low number of verticels per branchlet (1–3 vs. 2–5). *Salvia dorrii* ssp. *mearnsii* is limited to central Arizona, whereas the other subspecies, *S. dorrii* ssp. *dorrii*, and its varieties, var. *dorrii*, var. *clokeyi* Strachan, var. *carnosa* (Douglas ex Greene) Cronq., and var. *pilosa* (A. Gray) Strachan & Reveal, are widespread throughout the western United States and into Mexico. *Salvia pachyphylla* Epling ex Munz is closely related to members of the *S. dorrii* complex and occurs in disjunct populations in northern Arizona, California, and Mexico (Strachan 1982).

The U.S. Forest Service lists *Salvia dorrii* ssp. *mearnsii* as a sensitive species because of its limited distribution and threats to its survival. The rapid development of the Verde Valley potentially threatens the plant and its habitat; specific activities that endanger this taxon are mining, land trades, and other development projects. If not protected, *Salvia dorrii* ssp. *mearnsii* may not persist in nature.

Cultural History of Central Arizona

Not only is central Arizona in the midst of a biological transition zone, it is a cultural transition zone as well (Gummerman and Johnson 1971, Pilles 1981). The upland habitats of the Colorado Plateau and the desert scrub and grassland habitats of the Sonoran Desert merge in a valley used by many groups of people (Table 2). The most essential resources required for human survival were all available: water for irrigation and consumption, wild plants and animals for food and medicine, building material, salt, clays and ores for paints, and fertile soil for agriculture. Based on archaeological remains, written histories, and oral tradition, many cultural groups (Table 2) with different lifestyles are known to have lived in this area since 12,000 B.C. (Fish and Fish 1977, Pilles 1981, Fish and Fish 1984, Macnider et al. 1989, Downum 1992). The many types of archaeological sites in the Verde Valley, including caves, large and small pueblos, pithouses, fieldhouses, cliff dwellings, ballcourts, roasting pits, and forts, give evidence of distinct lifestyle differences, time periods, and cultural groups.

Table 2. Cultural history of central Arizona (Fish and Fish 1977, Fish and Fish 1984, Pilles 1981, Macnider et al. 1989, Downum 1992).

Date*	Period and cultural group	Lifestyle and other notes
12,000–8000 B.C.	PaleoIndian	Little evidence because of alluvium deposits; hunters likely to be present
8000 B.C.–1 A.D.	Archaic	Migratory hunters and gatherers
1–800 A.D.	San Pedro Cochise/ Basketmaker II	Hunters, seasonal use, and beginnings of agriculture
ca. 1–900 A.D.	Early Sinagua and Anasazi	Puebloan farmers
ca. 700–1100 A.D.	Hohokam	Irrigation farmers
1100–1300 A.D.	Southern Sinagua	Farmers
ca. 1200 A.D. (1300–1450 A.D.)	Pueblo IV (Tuzigoot, Montezuma Castle)	Hopi clans travel through on the way to the mesas; claim ancestral land here
1000–1275 A.D.	Prescott/Cohonina	Puebloan farmers
ca. 1500–1850s (to farming present on reservations)	Yavapai	Hunters & gatherers with some irrigated
ca. 1500–1800s farming	Apache	Hunters & gatherers with some irrigated
1500–1650s	Spanish	Scientists and military
1860s	American	Miners, beaver trappers, and first settlements

* Dates vary according to the author and geographical area; earliest and latest hypothesized dates are noted.

Most of the remains in the Verde Valley area are from the Southern Sinagua and Hohokam cultures, found in this area from approximately 700 to 1300 A.D. (Pilles 1981, Fish and Fish 1977, Fish and Fish 1984, Downum 1992). Evidence of these two groups appears near Perkinsville, although most of the remains in this region are of the Prescott and Cohonina cultures. Due to the lack of archaeological studies on the Prescott culture, their ancestry is unknown. However, the Prescott-Yavapai, Zuni, and Hopi tribes claim direct ancestry with the Prescott people (USDA 1996, Elaine Zamora personal communication) and the Hualapai and Havasupai are also thought to be related to the people who once lived in the upper Verde Valley (Schwartz 1955, Dobyns 1956, Heueh 1974, Manners 1974, Dobyns and Euler 1976, Euler 1981, Weber and Seaman 1985).

Materials and Methods

Identification of Plants and Archaeological Sites

Plant locality information for *Salvia dorrii* ssp. *mearnsii* was collected using two methods. Sixteen distinct sites of the plant were mapped using a portable GPS. Due to time constraints and accessibility to certain plant populations, the remaining sites were gathered from the Heritage Database Management System at the Arizona Game and Fish Department, which contains 48 point localities of *Salvia dorrii* ssp. *mearnsii*; 27 of the 48 sites were observed during this study. To obtain accurate statistical results, the study area was divided into two distinct geographical areas, the upper and lower Verde Valley, in accordance with their actual locations in Arizona (Figure 1).

Archaeological site locality information was gathered for all geographical areas where populations of *Salvia dorrii* ssp. *mearnsii* are known to occur. Information describing each archaeological site was collected from records at the U.S. Forest Service and from the archives at the Museum of Northern Arizona in Flagstaff. Map coordinates for the archaeological sites, their descriptions, and their approximate dates of occupation were used to subdivide the archaeological remains into logical categories that aided in determining which archaeological sites were appropriate for spatial analysis (Table 3).

Two separate spatial analyses were conducted for each geographical area because some archaeological remains are more indicative of past environments than others. If people were manipulating the growth and reproduction of *Salvia dorrii* ssp. *mearnsii*, it follows that the plants would be found more frequently on or near old home sites than near petroglyphs or lithic scatters. In each geographical area, the first analysis included only habitation sites such as pueblos, caves, and pithouses. The second analysis was more inclusive, using all habitation sites as well as other archaeological remains that may have been associated with homes, such as ballcourts or irrigation canals (Table 3). In addition, it should be noted that the archaeological sites analyzed in this study are from a wide variety of cultural groups from different time periods. This analysis does not distinguish between the different time periods due to the difficulty of interpretation based solely on limited archaeological records.

Table 3. Classifications of archaeological remains.

Habitations only *
Temporary campsite, structure
Pithouse, fieldhouse
Cliff dwelling
Pueblo
Unspecified habitation
Cave structure
Habitations and other archaeological remains *
Rock alignment
Stone area (possibly houses)
Terrace, irrigation canal
Old field
Ballcourt
Yavapai-unspecified structure with rooms
Other archaeological remains **
Plant or food processing area
Artifact scatter, lithics
Roast pit
Burial
Manos and metates
Historic remains
Petroglyphs

* Remains that were used in the statistical analysis.
** Remains that were not used in the statistical analysis

Plant–Archaeological Site Associations

Scatter plots relating individuals of *Salvia dorrii* ssp. *mearnsii* to archaeological sites did not determine whether the components were spatially related; therefore, spatial statistics were employed. Duncan's spatial analysis software was used to investigate spatial independence between two components. This program calculates a value $K_{12}(t)$ using x,y coordinates for two variables, in this case plants and archaeological sites (Lotwick and Silverman 1982, Diggle 1983, Upton and Fingleton 1985, Duncan 1991, Duncan and Stewart

1991, Duncan 1993). The value is calculated using the formula $K_{12}(t) = \lambda_2^{-1}$ E [number of type 2 events within distance t of an arbitrary type 1 event], where t = 0, (t) is the distance, lambda (λ) is the mean number of type 2 events per unit area, and E is the expectation (Lotwick and Silverman 1982, Diggle 1983, Upton and Fingleton 1985). The null hypothesis is that the two components are spatially independent and randomly distributed. The null is rejected if the $K_{12}(t)$ values fall above or below a 99 percent confidence interval whereby the two variables could be attracted (positively associated) or repulsed (negatively associated), respectively.

Every point on the graph represents a $K_{12}(t)$ value calculated every 20 m up to 1200 m. The program compares the actual positions of the components to 99 simulated combinations of a random distribution pattern. When these data points fall between the lower and upper confidence limits, the two variables exhibit a random distribution and are spatially independent. However, when the observed data points fall outside of the lower and upper confidence limits, there is spatial dependence.

The percentage of plant populations of the total that could be associated with archaeological sites was determined from the raw data. All plant localities that occurred within the distances of spatial dependence (see results) were included in the total percentage of plants associated with archaeological sites.

Results

In the lower Verde Valley, 34 *Salvia dorrii* ssp. *mearnsii* populations, 137 habitation sites, and 25 non-habitation sites were used in the analysis; in the upper Verde Valley, 14 *Salvia dorrii* ssp. *mearnsii* populations, 44 habitation sites, and 4 non-habitation sites were used.

Archaeological sites and populations of *Salvia dorrii* ssp. *mearnsii* are spatially dependent. As explained above for spatial analyses, two components are positively associated when the data points lie above the upper confidence interval limit. At distances between 500 and 1200 m, populations of this subspecies (n = 34) and archaeological sites that are old home sites (n = 137) in the lower Verde Valley are spatially dependent (99% CI; Figure 2a). Similarly, when other archaeological remains (Table 3; n = 162) are included in the analysis, plants and archaeological sites at distances between 500 and 950 m are spatially dependent (99% CI; Figure 2b). This relationship with archaeological sites is representative of 89 percent of the plant populations found in this area.

Similarly, in the upper Verde Valley, Duncan's spatial analysis indicates that archaeological sites and populations of *Salvia dorrii* ssp. *mearnsii* are spatially dependent. The plants (n = 14) and sites that were old habitations (n = 44) are spatially dependent at distances between 1100 and 2000 m (99% CI; Figure 3a). Similarly, when other types of archaeological sites are included (n = 48), plants and sites in the upper Verde Valley are spatially dependent at distances between 1000 and 2000 m (99% CI; Figure 3b). This relationship with archaeological sites is representative of 75 percent of the plant populations found in this area.

Populations of the subspecies are found away from archaeological sites up to 25 percent of the time. This lends support to the hypothesis that *Salvia dorrii* ssp. *mearnsii* was present in central Arizona before humans inhabited the area. The statistical analyses provide clues as to why *Salvia* appears to be on archaeological sites more often than not, but does not explain why it is found in areas without archaeological sites. However, through time, associations between plants and archaeological sites may diminish as plant husbandry traditions cease (Karen Adams, personal communication).

Discussion

It is extremely difficult to determine why *Salvia dorrii* ssp. *mearnsii* is not more widespread in central Arizona. Spatial statistics provide a means of analyzing relationships that may not be evident using scatter plots and standard statistics. The positive spatial relationship of *S. dorrii* ssp. *mearnsii* with archaeological sites (75–89%) lends support to the theory that this subspecies was cared for by people. It appears that humans have, at least in part, had a role in its dispersal and reproduction. Brooks and Johannes (1990) reported that "positive [vegetative] indications include the presence of plants brought to, or raised at specific sites for express purposes, usually nutritional or ceremonial." In addition, consultations with traditional Hopi scholars and medicine people have indicated that *Salvia dorrii* ssp. *mearnsii* was probably used as a medicine and in ceremonies, and people were probably involved in its care and dispersal (Homewytewa and Taylor, personal communication).

Manipulation of *Salvia dorrii* ssp. *mearnsii* by people may have altered its abundance and its range. It is well known that plant husbandry

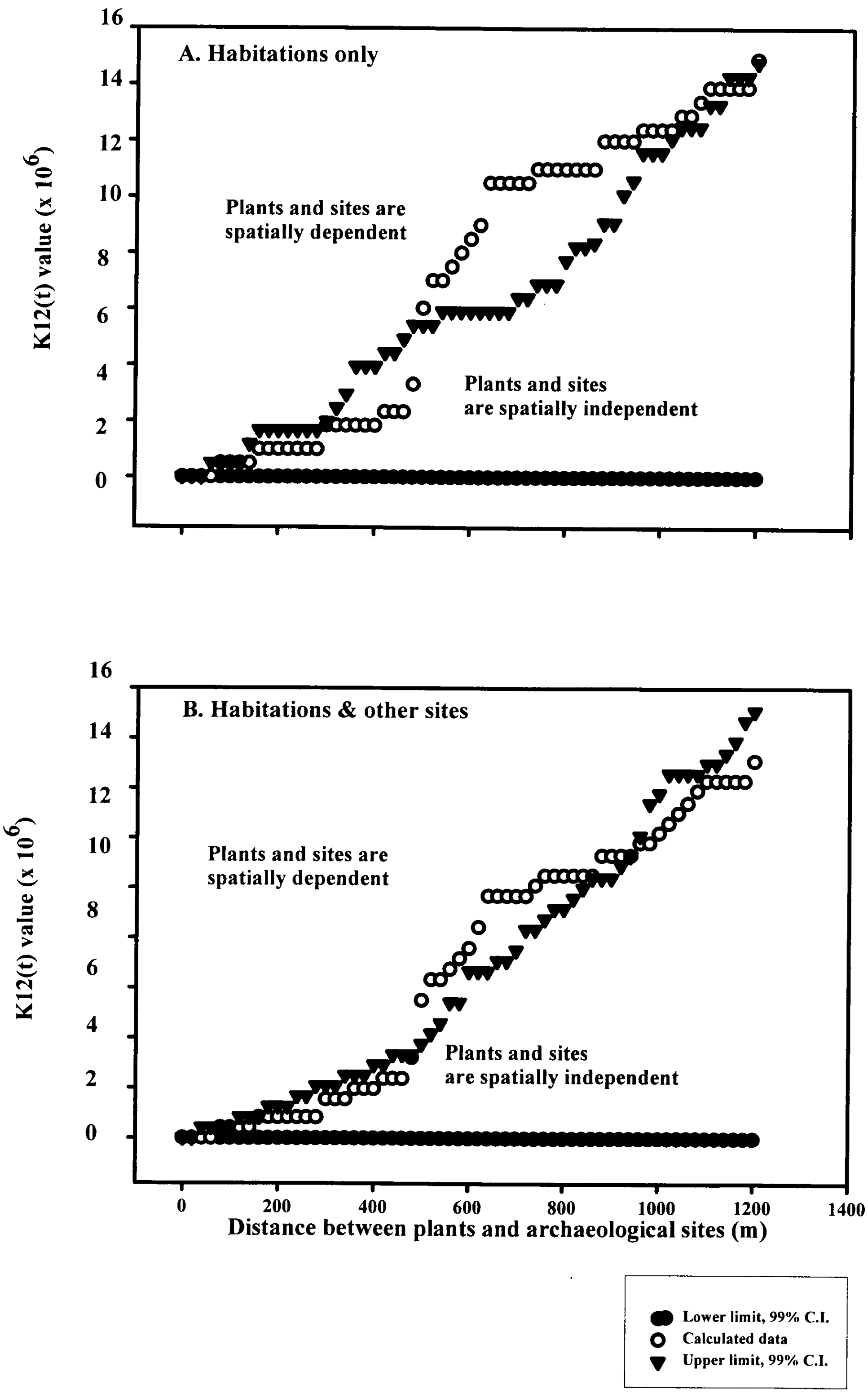

Figure 2. Populations of *Salvia dorrii* ssp. *mearnsii* in the lower Verde Valley and archaeological sites are spatially dependent at distances between (a) 500 and 1200 m when habitations were included in the analysis, and (b) 500–950 m when habitations and other archaeological sites were included in the analysis.

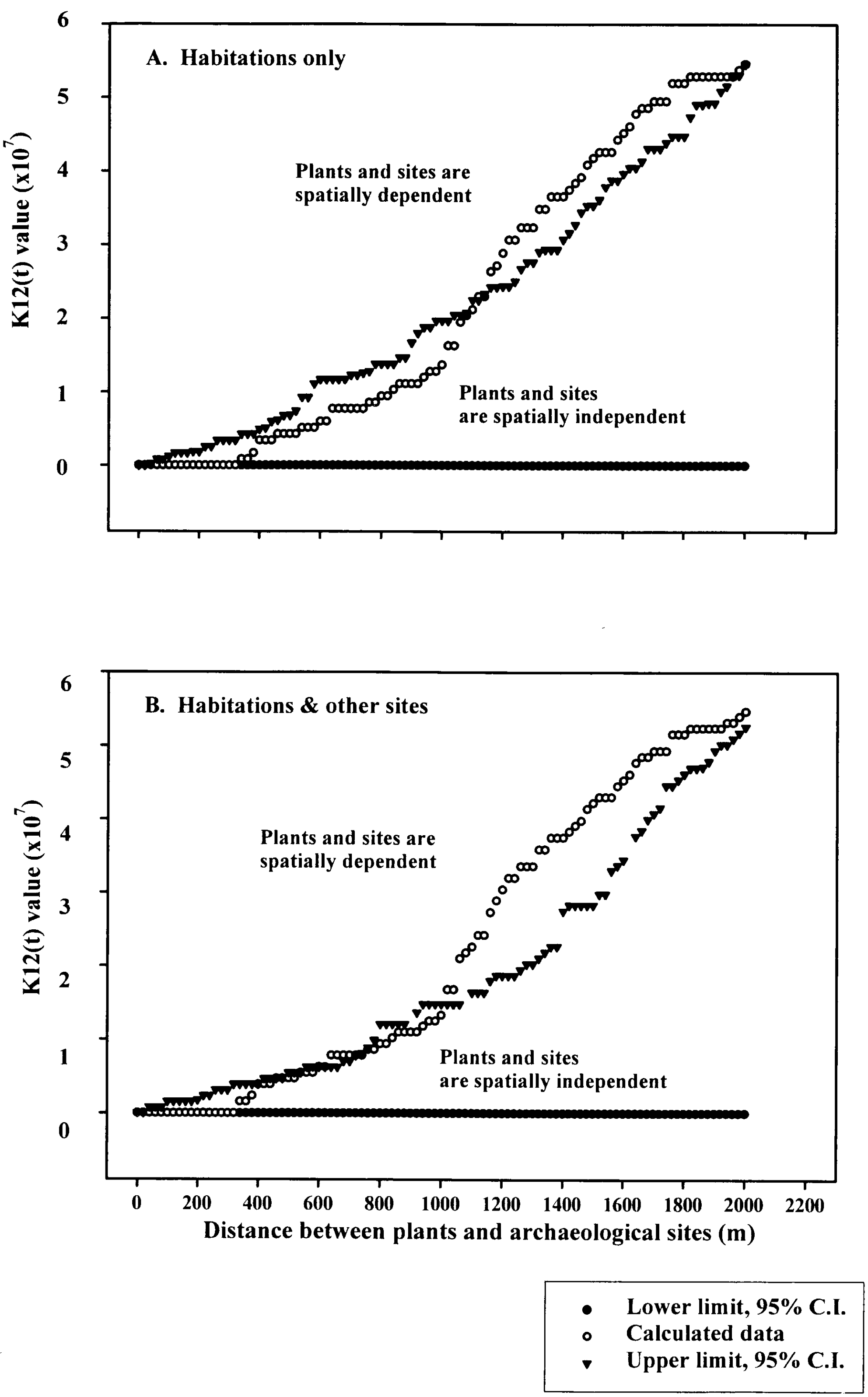

Figure 3. Populations of *Salvia dorrii* ssp. *mearnsii* in the upper Verde Valley and archaeological sites are spatially dependent at distances between (a) 1100 and 2000 m when only habitations are included in the analysis, and (b) 1000–2000 m when habitations and other archaeological sites are included.

activities have affected the present-day abundance and distribution of other species (Whiting 1939, Wells 1959, Winter and Hogan 1986; and Hogan and Taylor, personal communication). For example, pruning of shrubs and trees affects the abundance of fruits desired for harvest. Similarly, pruning of *Salvia dorrii* ssp. *mearnsii* may have been a technique to stimulate new growth of fresh leaves.

Trade is also an important component when discussing the movement of plants. Ford (1984) has hypothesized that plants were traded over long distances as well as within localized exchange systems. Trade routes can function as mechanisms for overcoming geographical barriers, enabling new subspecies to develop (Brooks and Johannes 1990). Traders carry seeds of many plants from place to place (Young 1990, Slifer and Duffield 1993, Hill 1995; and Hogan, Homewytewa, and Taylor, personal communication) and trade of *Salvia* species between people in the western United States and Mexico is likely to have occurred. Extensive trading of the seeds, leaves, and flowers of this taxon may have resulted in a human-mediated founder effect that allowed the morphologically distinct plants to become established in central Arizona.

Furthermore, whole groups of migrating people, called clans, brought plants from their homelands to new places of habitation (Lowie 1929, Herrington 1939, Sherer 1965, Lynch 1987). This theory has been validated on several accounts through consultations with clan leaders, herbalists, and medicine people from indigenous American groups such as the Hopi and Diné (Navajo) that are still organized in clans (Hogan, Homewytewa, and Taylor, personal communication). For example, important plants such as tobacco have been carried by some tribes (whole plants or seeds) for centuries (Homewytewa and Taylor, personal communication). In fact, it is logical to assume that "any group of people accustomed to using these plants might be inclined to bring them along when traveling" (Black 1978).

Significant plants used for certain medicines or ceremonies may have been important enough to transport and replant in new settlements. *Salvia* may have been one of these plants. One Kumiai medicine woman, Teodora Cuero (personal communication), noted that *Salvia pachyphylla* was one of her most revered plants. The establishment of new populations of *S/ dorrii* ssp. *mearnsii* as people moved around central Arizona is likely. The collection of seeds from this plant may have enhanced its distribution in some areas, especially in disturbed sites like habitation areas.

Without human-mediated dispersal, *Salvia dorrii* ssp. *mearnsii* is not equipped to disperse itself over large distances. Although many seeds are adapted for animal, wind, and water dispersal (Lidicker and Caldwell 1982, Swingland and Greenwood 1983), this plant has large seeds that are not adapted for these types of dispersal. However, its seeds have a polysaccharide coating when imbibed with water, and may be dispersed by ants (Beattie 1985, Horvitz 1991). Ant dispersal does not explain the disjunct populations of *Salvia dorrii* ssp. *mearnsii* that are more than 100 miles from the closest populations of its relative *Salvia dorrii* ssp. *dorrii*.

In addition, *Salvia dorrii* ssp. *mearnsii* is not easily established in undisturbed, untended areas in nature. It is not considered to be a weedy plant although it can flourish in disturbed areas, such as old mine sites. Old mine sites provide optimal colonization sites for many plants due to the high degree of disturbance and increased levels of available minerals in the soil (Bradshaw and McNeilly 1981, Brooks and Johannes 1990). In fact, *Salvia dorrii* ssp. *mearnsii* has become established at one major mine site near Perkinsville (upper Verde Valley). Archaeological sites are also highly disturbed and may therefore provide an optimal habitat for *Salvia dorrii* ssp. *mearnsii*.

Conclusions

Many factors affect the unique distribution of the endemic sage, *Salvia dorrii* ssp. *mearnsii*. After 3 years of study and through consultations with traditional scholars, I believe that *Salvia dorrii* ssp. *mearnsii* was tended by people in central Arizona, changing its natural distribution. It is an important plant in medicine and in ceremonies, and a high percentage of plant populations occur near archaeological sites. Current molecular genetics studies (Taylor, unpublished data) will aid in the interpretation of the distribution and phylogenetic relationships between members of the *Salvia dorrii* complex and *Salvia pachyphylla*.

As Gary Nabhan (1997) has suggested, vegetation distribution and change must be viewed by incorporating both environmental and cultural influences when studying ecological systems. Each set of data can provide supporting information in explaining ecological patterns. As scientists we must consider the knowledge that indigenous people hold about their environments and collaborate with them in our studies of the ecological relationships between plants and animals (Nabhan 1997).

Many researchers believe that Native American land management practices acknowledged and considered rare species (Nabhan 1997). Anderson and Nabhan (1991) suggested that "Native Americans not only were stewards of major food resources, they also protected certain plants and animals that were too rare to have ever been valued on utilitarian grounds alone." *Salvia dorrii* ssp. *mearnsii* is a plant that was probably more important to people living in central Arizona than can be gathered through a spatial statistical analysis. Each piece of information about this taxon, ecological or cultural, adds a new perspective on its unique distribution.

Acknowledgments

I would like to thank my thesis committee: Drs. Tina Ayers, Randy Scott, George Koch, and Mike Kearsley, and Phyllis Hogan. Special thanks to Teodora Cuero, Theodora Homewytewa, Josefina Ochurte, Benito Peralta, Michelle Sockwyma, Dalton Taylor, and Max Taylor for their willingness to discuss the cultural significance of this plant. Thanks to those who assisted with fieldwork: Kambria Beck, Leslie Brandt, Melissa Jurgenson, Gabe Martinez, Dr. Neil Cobb, Elaine Zamora, Peter Pilles, Barbara Phillips, Jean Searle, Tracy Murphy, Marc Baker, Brad Blake, and Jeff Schively; all assisted with design and statistical analysis. The National, Pacific Region, and State Councils of Garden Clubs, the Orchid Society of Arizona, NAU's Ecological Restoration Institute, and the Arizona Ethnobotanical Research Association all provided support for this project.

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