Natural history of Hesperoyucca whipplei

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NATURAL HISTORY OF _HESPEROYUCCA WHIPPLEI_

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
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in
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Environmental Education

by
Lizabeth Ann Hope-King

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ABSTRACT

This project investigated the many fascinating aspects of Hesperoyucca whipplei. Formerly known as Yucca whipplei, the reclassified Hesperoyucca is explored in its many forms and habitats. Its five subspecies are individually described and discussed. Hesperoyucca’s unique lifecycle relationship with its pollinator, Tegeticula maculata, is traced and documented throughout the process of a reproductive season.

This project looked at the historic uses of H. whipplei by the Native Americans, and its current uses in the modern world. Environmental activities in the Appendix include Hesperoyucca recipes and field study lessons concentrating on the Hesperoyucca in four different seasons.
ACKNOWLEDGMENTS

I wish to thank all of my teachers and mentors for sharing their time and wisdom with me. I am especially indebted to Dr. Stoner for her guidance and support in this project and throughout my graduate education. Thank you for shaping my love of nature into a tool of education, where it can be best used. Finally, thanks to my husband Nolan, whose love and support made it all possible.
DEDICATION

This project is dedicated to the appreciation and preservation of *Hesperoyucca whipplei* and its vanishing habitat.
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CHAPTER ONE

INTRODUCTION

When I was growing up in the Cajon Creek wash area of San Bernardino County, the Chaparral Yuccas (*Hesperoyucca whipplei*) were plentiful in that region. It was hard to avoid their painful stabs while playing. But in the springtime they were breath taking. Each yucca would sprout a large asparagus like stem, covered with flower buds on the upper end and tip. By the beginning of May the yuccas were in full bloom with the delicate scent of the creamy white flowers filling the air for days. The yucca blooms are my favorite childhood memory.

Now they are gone from my home area. The land was purchased, and the new owner disked the soil destroying all of the natural vegetation. Many of the natural plants and grasses might rebound, but once the unique life cycle of the Chaparral Yucca is interrupted, it is difficult for the plant to re-establish itself (Tirmenstein, 1989).

Aside from being a beautiful and unusual species of *Hesperoyucca*, *H. whipplei* has many valuable properties. Native Americans ate the fruits and blossoms and used them to make fermented ceremonial beverages. The yucca root was used to make shampoo, and dried and ground into powder to
be used to help heal sores, skin rashes and poison ivy (Cornett, 1995; Harris, 2003; Jellin, Gregory, Batz, & Hitchens, 2002). Recent medical research has confirmed yucca’s medicinal properties (Jellin et al., 2002). *H. whipplei* contains high levels of a natural steroid called saponin. Unlike other vegetable and animal steroids, the saponins found in *H. whipplei* cause no known side effects. The saponins can be used to help lower blood pressure and cholesterol levels, and act as an emulsifier in the body removing fat and plaque build-up (Jellin et al., 2002).

Until recently, the Chapparal Yucca had been classified as a *Yucca* (*Yucca whipplei*). Recent DNA studies have shown this plant and its subspecies to be unique enough to be placed in a new genus: the *Hesperoyuccas*. *Yucca whipplei* is now known as *Hesperoyucca whipplei* (Clary, 2001).

There is much to learn from this special species. My project investigated the many fascinating aspects of this vanishing plant and its habitat. Environmental activities included in the Appendix are designed to teach young people to understand and respect the *Hesperoyucca* and its habitat. The activities include *Hesperoyucca* recipes and field study lessons concentrating on the *Hesperoyucca* during the four seasons of the year.
CHAPTER TWO

LITERATURE REVIEW OF ENVIRONMENTAL EDUCATION

This project focused on using a local native plant, Hesperoyucca whipplei, as a basis for developing nature study lessons that would promote the acquisition of environmental knowledge and attitudes. This literature review shows that nature study was a precursor of present day environmental education. It also presents an understanding of the field of environmental education.

History of Environmental Education

Environmental knowledge and direct contact with nature used to be part of everyday experience. Until relatively recently, Americans lived a predominantly agricultural lifestyle. Learning about the laws of nature, ecology, land use, wildlife, and animal husbandry was just part of growing up. People often derived their livelihood directly from the land, and understood the relationships between the food needed for survival, and soils, weather, insects, seasonal cycles, and all of the variables of nature. Environmental education used to be a way of life (Orr, 1994).

Some antecedents of environmental education were nature study, conservation education and outdoor education.
(Disinger, 1997, 2001). Nature study was popular in the late 1800s and early 1900s. Its practices focused on learning about nature out-of-doors in natural environments. Nature study was conducted with primary school students and set the foundation for science education in the elementary schools (Disinger, 1997, 2001). Nature study focused on learning about nature through personal observation and first hand experiences and discoveries (Disinger, 1997). These methods became nature education's contribution to environmental education. Learning about nature within natural surroundings creates a lasting impression on the students. First hand experience and personal discovery encourage excitement and an affinity for learning.

Conservation education became popular during Theodore Roosevelt's Progressive Era. President Roosevelt was deeply moved by the natural beauty of the American west. Also, during the early part of the 1900s, natural resources were being used and abused at an alarming rate. Natural prairies were being plowed under to plant domestic crops, forests were cut down for building materials, and coal and iron were being mined without concern for the environment (Gutek, 1997). President Roosevelt's concern for the conservation of the west and other natural
resources prompted him to convene the first national conference of national resources in 1908 (Gutek, 1997). This marked the beginning of conservation as an issue in American education and political life.

The nation's first history-changing environmental disaster occurred during the dust bowl of the 1930s when natural drought cycles destroyed domestic grain crops, and wind carried away all of the topsoil (Gutek, 1997). Governmental agencies such as the U. S. Forest Service and the Environmental Protection Agency were created to protect and preserve the nation's resources (Disinger, 2001). Conservation education meant concern with the wise use and management of our national resources (Disinger, 2001). This form of environmental education became part of earth and life science studies in American schools during the 1920s, 1930s and 1940s (Gutek, 1997).

Care and concern for the conservation of natural environments and species are important elements of today's environmental education. Emphasis is placed on the development of environmental care and sensitivity by presenting a broader understanding of the web of life, and humanities place within it (Disinger, 1997). A positive environmental ethic enables individuals to make
thoughtful, constructive decisions concerning the environment.


Environmental education uses the outdoor setting as a backdrop to teach all subjects of the curriculum. Team activities are incorporated into the lessons to encourage cooperation and citizenship. Being outside and moving around within natural environments creates opportunities for hands-on learning and personal discoveries (Disinger, 1997).

The development of environmental education draws upon the ideas and concepts of two notable educational philosophers: John Dewey (1859-1952) and Theodore Brameld (1904-1987). Dewey believed that experience and nature cannot be separated from one another. The natural world is made up of earth, sea, sky, social conditions, happiness, suffering and everything that makes up the human environment. What humans experience everyday is part of nature. When a problematic situation appears in the natural stream of experience, consciousness is brought
into focus and creative intelligence is capable of development (Ozman & Craver, 2003). Learning by doing or experiencing in a real life, hands-on setting is one of environmental education’s key concepts. When people successfully solve a problem or navigate a difficult situation, they become confident and excited about the process of learning.

Dewey’s philosophy viewed nature as what one experiences. These experiences must be thought of in terms of their natural connections to the environment. Everything in nature is connected. He sought to connect thinking processes with social processes (Ozman & Craver, 2003). Environmental education teaches the importance of connectedness. Every part of nature and every living thing is a part of the web of life. The actions of one component will have an effect on all of the other components. The environmental actions and decisions of today will eventually affect the entire biosphere.

Theodore Brameld was future oriented and optimistic. His philosophy was holistic, referring to humanity in a worldwide sense. He called for the establishment of clear goals for sustainability and future survival. Brameld warned against dealing with global problems in a piecemeal fashion. Problems affecting the entire biosphere would
require all encompassing solutions. His future awareness called for a humane control of technology and more cooperation with nature (Ozman & Craver, 2003).

Environmental awareness and sustainability are important aspects of environmental education. Knowledge of earth’s biological diversity and humanity’s place within it builds a foundation and a starting point. This understanding becomes a place for an awareness and environmental sensitivity to begin. Decision makers possessing a knowledge and sensitivity for the environment have the ability to make positive and constructive progress towards global health and sustainability.

Defining Environmental Education

Finding a clear-cut definition for environmental education has been difficult. The concepts and methods of environmental education have a multitude of applications. Creating a comprehensive and universally accepted definition has proven to be perplexing (Disinger, 2001).

During a graduate seminar of the Department of Resource Planning and Conservation at The School of Natural Resources at the University of Michigan, Dr. William Stapp and his associates articulated a clear and concise definition: “Environmental education is aimed at
producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to solve these problems, and motivated to work toward their solution" (Stapp et al., 2001, p. 34).

Stapp et al. (2001) also organized the major objectives of environmental education into four goals:

1. To help individuals acquire an understanding that humanity is part of a larger system, consisting of humanity, cultures and the rest of the biophysical environment. Humanity has the ability to alter the interrelationships of the entire system.

2. To help individuals gain a broader understanding of the biosphere, both natural and man made, and its role in contemporary society.

3. To help individuals understand the environmental problems facing humanity, how these problems can be resolved, and the responsibility of citizens and government to work together toward their resolution.

4. To help individuals develop attitudes of care and concern for the quality of the environment, which will motivate them to participate in
solving current environmental problems and
prevent future damages.

Environmental education was further defined at the
first Intergovernmental Conference on Environmental
Education. The meeting was organized by UNESCO in
cooperation with the United Nations Environment Programme
(UNEP). Convening in Tbilisi, Georgia (USSR), the
Conference was in session from the 14\textsuperscript{th} to the 26\textsuperscript{th} day of
October, 1977 (Tbilisi Declaration, 2001). During the
course of the Conference, the Tbilisi Declaration was
drafted. Recognized as a landmark document in the field of
environmental education, The Tbilisi Declaration clarified
the characteristics of environmental education defining
its goals and objectives. The goals of environmental
education are:

To foster awareness and concern about, economic,
social, political, and ecological
interdependence in urban and rural areas; to
provide all individuals with opportunities to
acquire the knowledge, values, attitudes,
commitment and skills needed to protect and
improve the environment; and to create new
patterns of behavior of people, groups and
society as a whole towards the environment.

(2001, p. 15)

The objectives of environmental education are awareness, knowledge, attitudes, skills, and participation. These goals and objectives are still accepted today (Tbilisi Declaration, 2001).

The environmental problems of today are greater than at any other time of human history. In response to these needs, environmental education will continue to grow and evolve (Gutek, 1997).
Yucca whipplei has been re-classified as Hesperoyucca whipplei. Recent genetic studies have revealed that while Yucca whipplei is related to the yuccas, it is more closely related to the Hesperaloe (Agavaceae). Hesperoyucca whipplei is distinct from the rest of the Yuccas in its genetics, morphology, geographic locations, and pollinator characteristics. A new genus has been created to accommodate this unique group of plants (Clary, 2001). The new genus Hesperoyucca (Agavaceae) contains three species, Hesperoyucca newberryi, Hesperoyucca peninsularis, and Hesperoyucca whipplei (Clary, 2001; Flora of North America Editorial Committee, 2002).

Hesperoyucca differs from Yucca in its flower and seedpod structure, and the manner in which the seedpods break open (Clary, 2001; Flora of North America Editorial Committee, 2002). Hesperoyucca’s pollen is also distinct because it is produced in a cohesive mass, while Yucca’s pollen is produced as single grains (Clary, 2001).

The unique reproductive structures of the Hesperoyucca require a specialized pollinator, and the genus has only one, a yucca moth, called Tegiticula.
Tegiticula maculata and the Hesperoyucca share a tight mutualistic reproductive life cycle. They are exclusive to one another. Their exclusive reproductive relationship sets them apart from the rest of the yuccas (Clary, 2001).

Hesperoyucca whipplei exhibits a variety of forms. Formerly Hesperoyucca newberryi and Hesperoyucca peninsularis, being morphologically similar to H. whipplei were considered by many to be its subspecies. DNA analysis has now shown them to be individual species within the Hesperoyucca genus (Clary, 2001).

Yucca demonstrates many different growth forms and mixtures of these forms. Hains (1941) organized these diverse forms into five subspecies of Yucca based on leaf and inflorescence morphology, reproductive style, and geographic location. Currently, these subspecies are still recognized within the reclassification to Hesperoyucca. Further systematic studies and DNA analysis are required to accurately quantify the varied forms of H. whipplei’s subspecies.

Researchers studying H. whipplei use Hains (1941) subspecies classification or some form of it. For more accurate interpretation of the research literature and the
purposes of this paper, Hains (1941) subspecies taxonomy will be used to describe Hesperoyucca whipplei.

Hains (1941) defined five Yucca whipplei subspecies: parishii, whipplei (also called typica), ceaspitosa, intermedia, and percurusa. Parishii and typica exhibit a different life history than the other three subspecies in that they are monocarpic; they die after flowering once. Ceaspitosa, intermedia, and percurusa are polycarpic because they flower many times during their life span.

Parishii is the largest and tallest member of the H. whipplei subspecies. When in bloom its flower stalk can be anywhere from 7 to 21 feet in height. The length of its flower panicle can be as long as 11 feet, with the average being about 6.5 feet. The panicle may contain from a couple 100 to a 1,000 or more creamy white, and sometimes purple tinged, delicately scented flowers. The blossoms emit a light, pleasant citrus fragrance. Parishii blossoms from late March thru June. The basal rosette is made up of bluish green sword like leaves, which can be from 17 to 46 inches in length, with the average being about 29 inches long (Hains, 1941; Tirmenstein, 1989).

Parishii is solitary and does not produce any kind of offshoots. It takes from 7 to 10 years for the plant to reach maturity, after which it blooms once and dies as
soon as its seedpods have matured (Hains, 1941; Tirmenstein, 1989).

*Parishii* grows especially well on mountain slopes and alluvial fans. It grows on the western and southern front of the San Bernardino and San Gabriel mountains, where it occurs from 1,000 to 8,000 feet. At lower elevations it is a member of coastal sage and chapparal communities; at higher elevations it extends into ponderosa pine forests (Hains, 1941; Tirmenstein, 1989).

In its chapparal ranges *parishii* is a member of a fire prone community, and it has evolved certain characteristics to survive there. Of the five subspecies, *parishii* has the highest seed yield. Its seeds are heavier, able to survive higher temperatures, and they germinate faster and more often than any of the other subspecies (Keeley & Tufenkian, 1984; Tirmenstein, 1989).

Subspecies *typica* is also called *whipplei* in the literature, which can become somewhat confusing. For the sake of clarity, *typica* is used in this paper (Hains, 1941; Keeley & Tufenkian, 1984).

*Typica*, like *parishii*, is monocarpic. After 7 to 10 years of growth, it blooms and sets seed; then the entire plant will die. *Typica* grows on stony slopes, foothills, mountains, coastal plains, and on desert fringes. It
appears at elevations of 100 to 4,000 feet and can be found in the San Jacinto and Santa Ana mountains. It is a member of chapparal, coastal sage, and desert shrub communities (Hains, 1941; Tirmenstein, 1989).

Typica’s dense basal rosette is composed of bluish green sword like leaves that grow from 1 to 3 feet in length. It is a solitary plant with no offshoots. When in bloom, from March to June, its flower stalk can grow from 5 to 13 feet in height, and is crowned with a panicle of creamy white or purple tinged flowers. Its panicle can be from 1.5 to 7 feet long, with the average being about 3 feet in length. The flowers emit a delicate citrus scent (Hains, 1941; Shreve & Wiggins, 1964; Tirmenstein, 1989).

Typica closely resembles parishii, except that it is half the size of parishii, and its flower stalk appears to be more stout and its flowers more compact. Like parishii, typica lives in chapparal communities where intermittent fires are part of the ecosystem. Both of these subspecies have more leaves in their basal rosettes than their sister subspecies. This affords them more protection during a fire. Typica’s seeds are heavier, and can withstand much higher temperatures than ceaspitosa, intermedia, and percursa. Hains (1941) suggested that parishii and typica are so similar that the only characteristics that separate
them are size and geographic location (Hains, 1941; Tirmenstein, 1989).

Subspecies ceaspitosa grows in clumps of 3 to 100 or more rosettes. The secondary rosettes are attached to the base or caudex of the primary plant at soil level, branching on the surface of the ground. The secondary rosettes form early in life, and flowering does not begin until all of the rosettes are formed. Ceaspitosa's leaves are green to yellow green and more rigid than any of the other 4 subspecies. They can be from 12 to 40 inches long, with 28 inches being about average. The plant's crowded clump formation allows it to survive in harsh environments and helps protect it from the ravages of fire (Hains, 1941; Tirmenstein, 1989).

During late March and into June, several rosettes on an individual plant may produce flower stalks. The flower stalks may reach heights of 13 feet, but 7.5 feet is about average. The inflorescence of sweet smelling, creamy white blossoms may be from 1.5 to 6 feet in length. Average is about 3 feet long. After an individual rosette has blossomed and set its seed, it will die, though the rest of the plant lives on (Hains, 1941; Tirmenstein, 1989).

Ceaspitosa grows along the edges of the Mohave Desert from the San Bernardino Mountains to the Walker Pass
region. It can be seen on the slopes of the San Gabriel and San Bernardino Mountains at elevations of 1,800 to 4,000 feet. This subspecies occurs in California juniper woodlands, desert shrub, and chapparal formations (Hains, 1941; Tirmenstein, 1989).

Subspecies percursa produces offsets by means of underground rhizomes, which are attached to the stem in the root zone or below. Each rhizome will form a new individual from its terminal end. The plant forms large, usually open clumps with both rosettes and rosette clusters present. The new rosettes are considered clones of the original plant (DeMason, 1984; Hains, 1941; Tirmenstein, 1989).

Percursa blossoms and sets seeds from late March thru June as do the other 4 subspecies. Its flower stalk can be anywhere from 5 to 16 feet tall, with the average being about 9 feet in height. The panicle of creamy white, fragrant blossoms grows from 2 to 9.5 feet tall, with the average being about 4.5 feet. Several rosettes in a single group may bloom in one season. According to Hains (1941) the flowering branch dies back after blooming and setting seed, while the rest of the plant lives on for many more years. Tirmenstein (1989) indicated that the flowering branch does not die and may produce axillary rosettes.
Jensen (2005) suggested that *percurza* is the only subspecies where the single rosettes do not die after flowering.

*Percursa*’s blue-green leaf blades are shorter than the other subspecies, with the average length being about 19 inches long. This plant thrives in a more maritime environment than the other subspecies varieties. It grows on rocky mountain slopes and mesas, from sea level up to 3,600 feet elevation. It is a member of the coastal sage and chapparal communities, and can be found in the San Rafeal, Santa Inez and Santa Lucia Mountains of Santa Barbara and Monterey counties (Hains, 1941; Tirmenstein, 1989).

Being a part of the chaparral community, *percurza* is subject to intermittent fires. Since *percurza*’s rhizomes are underground, they are protected from damage by the overlying soil, and would most likely be able to re-sprout and survive after a fire. Post fire re-sprouting would be a much more important mode of re-growth for this subspecies because its seeds exhibit the lowest germination rates, lightest seed weight, and the seedlings are very easily stressed. California sagebrush and Tucker’s Oak are some of *percurza*’s ecosystem associates (Keeley & Tufenkian, 1984; Tirmenstein, 1989).
Hains (1941) described subspecies *intermedia* as an intermediate between *typica* and *ceaspitosa*. Keeley and Tufenkian (1984) and Keeley, Keeley and Ikeda (1986) described this plant to be a combination of the characteristics of *percursa* and *ceaspitosa*. Tirmenstein (1989) also suggested that *intermedias* morphology is a combination of the forms of *ceaspitosa* and *percursa*.

Subspecies *intermedia* forms a thick clump and lives a relatively long life, similar to *ceaspitosa*. However, *intermedia* does not begin to form its axillary buds until it is well matured, while *ceaspitosa* produces buds early in its development. *Intermedia*’s crowded clumps are smaller than *ceaspitosa*, and only one flowering stalk per year is produced, similar to *typica*. After the axillary rosette blooms, the leaves and flower stalk die, but the base of the stem and roots survive to sprout new rosettes (Hains, 1941; Keeley & Tufenkian, 1984; Keeley, Keeley & Ikeda, 1986; Tirmenstein, 1989).

*Intermedia*’s flower stalk can be between 5 and 15.5 feet in height, with the average being about 9 feet tall. The length of the panicle of creamy white flowers is from 5 to 7.5 feet, with the average being about 3.5. The length of the leaves can be from 13 to 40 inches,
averaging about 26 inches (Hains, 1941; Tirmenstein, 1989).

Intermedia grows in the Santa Monica and Santa Susana mountains of Los Angeles and Ventura Counties. It is an inhabitant of the coastal sage and chapparal communities. Intermedia is found from sea level up to about 2,000 feet (Hains, 1941; Tirmenstein, 1989).

A great deal of controversy surrounds the classification of Hesperoyucca's variety of forms and the combinations of these forms. Hains (1941) five subspecies classifications, based on growth form, reproductive style, and geographic location, have provided researchers with an informed and organized starting point.

Researchers working with Hesperoyucca whipplei have documented mixtures of characteristics between the subspecies. Demason (1984) planted percursa seeds, and recorded the progress of the seedlings. Some of her plants developed rhizomes, others developed axillary rosettes, some had intermediate rosettes, and there were some plants with combinations of all of these characteristics. From the seeds of one of the subspecies, she cultivated plants exhibiting the characteristics of the whole range of subspecies. Maybe there is no pure form, and all of the subspecies carry the genetic possibility to exhibit any or
all of *Hesperoyucca whipplei*’s forms. This would define a plant that could adjust to many different ecosystems, and it would explain its wide range of forms (Keeley & Tufenkian, 1984; Keeley, Keeley & Ikeda, 1986; Wilder, 1964).

Wilder (1964) suggested that there are three basic forms of *Hesperoyucca whipplei* subspecies: *typica* (*whipplei*), the solitary, monocarpic form; *ceaspitosa*, the form with axillary buds that become secondary rosettes; and *percursa* which produces rosettes through the growth of underground rhizomes. All other subspecies groups would be considered combinations of these three basic forms.

Clearly, in order to properly classify the subspecies variations within *Hesperoyucca whipplei*, further DNA studies are needed (Clary, 2001; DeMason, 1984). For the remainder of this writing, Hains (1941) classification will be used to gain a general understanding of the subspecies of *H. whipplei*.

Our local *Hesperoyuccas* are subspecies *ceaspitosa*, *typica*, *parishii*, and a certain percentage of *Hesperoyuccas* of mixed form (DeMason, 1984; Keeley & Tufenkian, 1984; Keeley, Keeley & Ikeda, 1986; Wilder, 1964). In late March and into June, the *Hesperoyuccas* sprout flower stalks with hundreds of flower buds on the top end. As
they begin to open, the bottom flower buds mature first. While the lower flowers bloom, reach maturity, and begin to fade, the flowers above are just beginning to open. This creates the effect of a rising plume of creamy white, delicately scented blossoms. Some *Hesperoyucca* have seedpods maturing on the bottom portion of the inflorescence, while the blossoms on the top have not yet opened (Udovic, 1981).

*Hesperoyucca*’s sweetly scented plumes of delicate white blossoms can still be seen in our remaining wildland areas. They will flourish as long as their habitat remains undisturbed.
CHAPTER FOUR

REPRODUCTION OF HESPEROYUCCA WHIPPLEI

While the individual subspecies of Hesperoyucca whipplei are distinct in many respects, in regards to their flowering behavior, they are all the same. All five subspecies blossom from late March thru early June. They all produce the same flower and rely on one species of yucca moth, Tegeticula maculata, for pollination. In turn, T. maculata depends entirely upon H. whipplei flowers for oviposition sites (Keeley, Keeley & Ikeda, 1986).

The lifespan and age at which the plant begins to blossom varies with each subspecies. The monocarpic varieties, parishii and typica, reach flowering maturity within 7 to 10 years. These two forms will die as soon as their seedpods have matured. The three polycarpic subspecies, ceaspitosa, percursa, and intermedia, will flower many times during their lives and can live much longer (Hains, 1941; Tirmenstein, 1989).

The monocarpic forms will expend all of their resources on a single reproductive episode. These varieties store the moisture and nutrients needed for reproduction in their basal rosettes. They will adjust the
expenditure of their available resources in a series of stages (Aker, 1982a).

The first stage in the regulation of resources is the determination of the number of flowers. When considering the entire range of subspecies, the monocarpics produce larger inflorescences with more flowers, resulting in more mature and viable seeds than the polycarpics (Huxman, 1996). The inflorescence must contain enough flowers to insure the attraction of a sufficient number of pollinating moths, without depleting the plants resource reserves. Many of the buds initiated by the plants never open. They are usually located on the upper portion of the inflorescence and at the ends of the branches. This indicates that they failed to open because they were balanced against the availability of resources or competition with developing seedpods and were terminated by the plant. Usually about 10% of the flower buds that are initiated fail to develop (Aker, 1982a).

The second stage is the number of pods reaching maturity (Aker, 1982a). Whipplei will not self-pollinate, so at this stage pollinator availability is important. The plant will initiate many more fruits than it will ultimately support. At this point, the plant insures that its reproductive capacities will be realized. Since the
species has only one pollinator, early in the season the plant will support all of its pollinated blossoms and immature pods. As the season progresses, the plant aborts any damaged, diseased, or excess pods, and utilizes its stored resources to develop the amount of pods or fruit it can support. Approximately 51% of the developing pods will eventually be aborted by the plant (Udovic & Aker, 1981).

The number of pods a plant supports, and develops into mature seeds, depends upon the stored resources available to that individual plant. Since the plant stores its resources in its basal rosette, the plants with the largest rosettes produce more pods that contain a larger number of seeds. An average of about 10% of the flowers on an inflorescence will develop into mature seedpods (Aker & Udovic, 1981).

During the floods of 2004-2005, many H. whipplei plants were observed that had been uprooted and displaced by the flood waters. In a matter of weeks they had all dried out and began to disintegrate. When blooming season arrived, a large number of these plants sprouted new leaves in the center of their dead rosettes. Their resurgence was short lived, because they had no root systems, but the desicated plants were using their stored
resources in a final attempt to blossom (personal observation).

The polycarpic varieties, *ceaspitosa*, *per cursa*, and *intermedia*, share the blooming season with the monocarpic forms. Their reproductive cycle is similar to that of the monocarpics, except that they reproduce clonally as well as sexually (Hains, 1941). They will live through many flowering seasons and produce many flower stalks, whereas the monocarpic subspecies experience only one reproductive episode. Consequently, the monocarpic varieties produce more seeds. Their seeds are heavier, and germinate more readily, and the seedlings they produce are robust and resilient. The seeds produced by the polycarpic forms are lighter and less viable. Their resulting seedlings germinate slower and are more easily stressed (DeMason, 1984; Keeley & Tufenkian, 1984; Tirmenstein, 1989).

The subspecies of *Hesperoyucca whipplei* all produce the same flower. Their blossoms are all hermaphroditic and self-incompatible. In the springtime, the plants sprout large asparagus-like flower stalks with a panicle of 100 to over 1,000 buds on the top end. The buds on the bottom portion of the stalk open first. As the buds mature, they open progressively upward on the stalk and outward on the branches (Udovic, 1981). The individual flowers stay open
for three to six days, depending on the surrounding temperature and humidity. The progression of the opening blossoms creates the effect of a rising plume of delicate and fragrant blossoms, preceded by unopened buds, and followed by wilted flowers and small, light green, developing pods (Aker, 1982a).

The structure of the blossom is one of the characteristics that separates *Hesperoyucca* from *Yucca* and defines them as a species (Clary, 2001). The creamy white blossoms are composed of six delicate petals, terminating in a three lobed capitate stigma. The characteristic shape of the flower stigma acts as a barrier to out-crossing with the yuccas (Webber, 1960), but hybridizing within the species occurs throughout the blooming season. *H. whipplei*’s distinctively shaped stigma requires a uniquely equipped pollinator. The species has only one, a yucca moth called *Tegeticula maculata* (Clary, 2001).

*T. maculata* and *H. whipplei* are mutually exclusive; one cannot survive without the other. *Hesperoyucca* is also cultivated in Europe, but must be hand pollinated to produce seeds because *T. maculata* does not exist there (Armstrong, 1999).

Pollination of the flowers is accomplished by the adult female moth only. She has a pair of long, curved,
prehensile appendages near her mouth called maxillary palpi. These are used to collect, form, and carry a ball of pollen that she will use to pollinate the blossoms. The male moth does not have these specialized palpi (Armstrong, 1999).

The adult moths emerge from the soil throughout *H. whipplei*’s blooming season. They will live for about one week (Udovic, 1981) and will not feed as adults (Aker, 1982b). *T. maculata* is active during the day, and is the only species of *Tegeticula* that is diurnal (Aker, 1982b).

The moths mate inside the open flowers. After mating, the females need a preoviposition period of several hours. They will rest amid the protection of the blossoms before venturing out to gather pollen (Aker & Udovic, 1981).

Following her rest period, the female moths will climb up on the stamen of one of the flowers, and using her highly specialized maxillary palpi, gather pollen from the anthers. She will collect pollen from a number of flowers, pack it into a ball, and hold it tightly against her thorax. During the collection process, she will not oviposite on any inflorescence where she has gathered pollen. She will carry her pollen ball with her from flower to flower during the impending activities of oviposition and pollination. Since she will not feed
during her short lifespan, the pollen she carries is used exclusively for pollination (Aker & Udovic, 1981).

When she has collected a sufficient load of pollen, she will rest briefly, then fly off. She will fly high, and travel relatively long distances, ignoring nearby inflorescences. This behavior suggests that the moths are minimizing the possibility that they might return to a plant where they had gathered pollen and self pollinate it. Since *H. whipplei* is self-incompatible, both the moth and the *Hesperoyucca* would experience reproductive failure should this occur (Aker & Udovic, 1981).

When she finally lands on her chosen inflorescence, the female moth will crawl in and out of the open flowers, searching for a desirable blossom to begin depositing her eggs. Fresh, recently opened blossoms seem to be preferred (Aker & Udovic, 1981). She will not oviposite in a flower that already contains an egg deposited by another moth. A moth seems to know when another moth has previously visited the blossom and left an egg there. Too many developing larvae in a single seedpod could create a large amount of seed destruction, causing reproductive failure for both moth and plant (Aker & Udovic, 1981). Researchers have seen evidence that *parishii* and *typica*, the monocarpic varieties, may have the ability to abort the
pods with too many larvae in favor of pollinated pods with fewer larvae that will yield more seeds (Keeley, Keeley & Ikeda, 1986).

After the female moth has selected a flower, she will insert her ovipositor into the ovary of the flower and deposit an egg. It will take her about 34 minutes to deposit her egg (Aker & Udovic, 1981). When the surrounding air temperature is warmer, she is able to complete the egg laying process somewhat quicker (Aker, 1982b). It is assumed that only one egg is deposited at a time, because it is rare that more than one larvae is found in a seed chamber or locule (Aker & Udovic, 1981).

Immediately after she deposits an egg into an ovule chamber, also called a flower ovary, she uncoils her palpi and passes them over the stigma, pressing some of her previously collected pollen into the flower's central stigmatic depression. This insures the pollination of the flower where her egg was deposited (Armstrong, 1999). Survival of the moth's offspring is dependent upon the pollination of the flower where the egg was laid. If the flower is not pollinated, the seedpod will not develop. If the seedpod does not mature, the growing larvae, which will need to consume a small number of the developing seeds, will not survive (Aker & Udovic, 1981). She may
attempt to deposit more than one egg in a chosen flower, but if she does, she will be careful to place it in a different compartment or locule of the flower ovary (Aker, 1982b). As the pollinated flower develops into a seedpod, each locule will become a separate seed chamber, and any more than one larvae in a locule would cause too much seed destruction (Aker, 1982b).

During the latter part of the flowering season, when fresh flowers are becoming scarce, the moths begin depositing their eggs directly into the ripening pods. This behavior is seen only in the last few weeks of the flowering season. The pods developing on the lower portion of the inflorescence are usually the most mature and least likely to be aborted by the plant. The moths seem to know this, because this is where they prefer to deposit their eggs (Aker, 1982b; Aker & Udovic, 1981).

The moth larvae hatches inside the green, developing fruit, or seed pod, during late spring and summer, and feeds on a small number of the maturing seeds. The seed capsule is composed of three sections or lobes, with each section containing two columns of seeds. The seed columns contain up to 38 seeds each, stacked like coins in a dispenser (Armstrong, 1999). In the column or locule containing the larvae, 6 to 14 of the seeds will be bound
together with silk, forming a feeding gallery for the pinkish colored larvae (Armstrong, 1999).

In late summer and fall, the mature larvae will emerge from the seed pods through exit holes and drop to the ground (Aker, 1982b). The larvae burrow into the soil and surround themselves with a cocoon made of silk and covered with sand grains (Armstrong, 1999). The larvae remain in their cocoons beneath the soil throughout the winter months. As the weather warms the larvae pupate and when blooming season begins in Spring, the adult moths begin to emerge from the soil (Armstrong, 1999).

Emergence of the adult moths is scattered throughout the blooming season (Udovic, 1981). Some of the larvae will not metamorphose; they will remain in diapause and emerge the following spring. They may remain in dormancy for two or more years (Arizona-Sonora Desert Museum, n.d.).

As winter approaches, *Hesperoyucca*'s three lobed seed pods will dry out and split apart, releasing the flat, black seeds into the wind. *Parishii* and *typica*, the monocarpic subspecies, having completed their lifecycles will die and begin to dry out (Armstrong, 1999; Hains, 1941).
The dead flower stalks are shaken by the wind, scattering hundreds of thin, black seeds onto the soil. With the arrival of seasonal rains, dozens of tiny *Hesperoyucca* seedlings, resembling blades of grass, will begin to appear (Armstrong, 1999). Rabbits, deer, and insects will eat many of the seedlings, and only a fraction of the original sprouts will survive. After the seedling has survived 8 to 10 months and has established a root ball and some spiked leaves, its chances for survival are greatly improved.
CHAPTER FIVE

NATIVE AMERICAN USES OF HESPEROYUCCA WHIPPLEI

_Hesperoyucca whipplei_ has many names. During recent times, it has been called the Spanish Bayonet, Candles of the Lord, the Chapparal Yucca, and the Praying Tree (Johnston, 1969; Saunders, 1920). Natives of Mexico have called it Quijote, a name derived from the Aztec word for Agave, quiotl (Cornell, 1938; Harris, 2003). The _Hesperoyucca_ was important to the Native Americans, and the tribes each had their own name for it. To the Cahuilla it was panu’ul (Bean & Saubel, 1972). To the Navajo it was yaybi-tsa-si, meaning yucca of the gods (Stark, 1991), and to many it was just called Yu-ca (Romero, 1954).

Every part of the _Hesperoyucca_ was useful to the Native Americans. The roots contain a concentrated amount of saponin, a natural compound with detergent properties. When pounded in water, the roots produce copious amounts of soap bubbles (Cornett, 1995). _Hesperoyucca_ soap was used to wash clothes, and as a shampoo and body wash (Cornett, 1995). The Hopi Indians added duck grease to the gentle soap to promote healthy, shiny hair (Johnston, 1969). The natural bubbles were used to wash and whiten sheep’s wool, prepare hides for tanning, and to clean...
enemy scalps (Johnston, 1969). The Native Americans used the Hesperoyucca soap suds as an all purpose cleaning compound.

Hesperoyucca soap was an important part of ritual cleansing in ceremonies. Yavapai warriors, returning from battle, purified themselves with Hesperoyucca baths (Cornett, 1995). The Pueblo Indians used the bubbles to wash babies and brides (Johnston, 1969). The Tewa and the Hopi accompanied all ceremonies of adoption and name giving with a washing in a bath of gentle Hesperoyucca suds. When an infant was named, before sunrise, on the twentieth day after birth, its head was washed by the paternal grandmother. Each member of the father’s family who gives an additional name, would touch the child’s head with the cleansing wash. The perspective bride was washed with the bubbles, by the groom’s mother, at the beginning of her bridal visit to the groom’s house. At the end of her visit, when she was about to return to her own clanhouse, the women of the groom’s clan used the Hesperoyucca soap to wash her hair before sunrise, and gave her a new name (Harris, 2003).

The fibers obtained from the leaves of the Hesperoyucca were a valuable commodity to the Native Americans. Hesperoyucca fibers were softer and finer than
those obtained from other yuccas. The soft white strands were often used as padding and to minimize the harshness of the other yucca fibers being used (Saunders, 1920).

To extract the natural threads, the harvested leaves were soaked, to soften them, and then pounded and rinsed repeatedly, until the pulp was gone (Saunders, 1920). Then the fibers were cleaned, combed out, and twisted into strands for weaving and sewing (Balls, 1962; Cornell, 1938).

_Hesperoyucca whipplei_ leaves yielded the finest quality of fibers. The fibers had many uses. They were woven into baskets, mats, cloth, blankets, nets, sandals, ropes, saddle blankets, and mattresses (Balls, 1962; Cornett, 1995). The nets were used to catch fish and small game. The Luiseno Indians made fishing lines from the _Hesperoyucca_ twine (Ebeling, 1986).

The soft fibers were especially useful in the weaving of cloth for clothing and blankets (Johnston, 1969). The folklore of the Zuni people, says that they used cloth made from _Hesperoyucca_ threads to clothe themselves when they emerged from the Underworld and came into the World of Light (Saunders, 1920).

Blankets were made by twisting and knotting _Hesperoyucca_ cords with strips of rabbit skin, and then
sewing them together with Hesperoyucca thread (Balls, 1962; Johnston, 1969). The Cahuilla used the fibers to weave saddle blankets on a loom. These blankets were very popular and provided a good income for the weavers (Bean & Saubel, 1972).

The Native Americans used the fibers to make cordage and nets to hang up pots, baskets, watermelons, and anything else that they wanted to keep off of the ground (Saunders, 1920). The thread was used to sew mats together to cover the inside walls of their dwellings (Balls, 1962). A needle and thread could be fashioned from a yucca leaf by first cutting a leaf, then pounding the green flesh off to expose the fibers. The sharp Hesperoyucca thorn makes a perfect needle, and the fibers or threads were already attached (Johnston, 1969).

The Hesperoyucca leaves were also used to make paintbrushes, designed to paint pottery, baskets, faces and bodies. The paintbrushes were made by cutting a leaf and chewing or cutting off the end, exposing the fibers which become the hairs of the paintbrush (Johnston, 1969; Stark, 1991).

The stalk, flowers, and seeds of the Hesperoyucca made an important contribution to the Native American’s diet. The Hesperoyucca blooms from late March until early
June, creating a nine to ten week time period when the Hesperoyucca was a prime source for food gathering (Bean & Saubel, 1972).

The plants produce food at three stages of their development. The first stage is reached when the stalk has almost reached full height, and the flower buds are just beginning to form. The second stage is when the flower buds have formed, and they are just beginning to open. The third stage is reached after the blossoms have opened (Bean & Saubel, 1972).

During the first stage, the immature stalk is tender and full of sap. At this point, it is said to be at its best (Willis, 2004). The tender stalk is cut, placed in a roasting pit with hot coals, covered with sand, and left to cook over night (Bean & Saubel, 1972; Saunders, 1920; Saunders, 1933). The baked stalk is said to taste a little like baked apple (Harris, 2003). After baking, it can be eaten immediately, or it can be dried, ground up and stored for future use (Stark, 1991). Navajo warriors carried the dried Hesperoyucca, along with grass seeds, and jerked venison as war rations (Johnston, 1969). To reconstitute the stalk, water is added to the powdered plant, and cakes are made (Bean & Saubel, 1972; Willis, 2004). The stalk can also be peeled, sectioned, parboiled,
and cooked like squash (Bean & Saubel, 1972; Cornell, 1938; Ebeling, 1986; Willis, 2004). It was also used as a laxative. The stalk was warmed, steeped in water, and then the water was consumed (Stark, 1991). Some tribes used the immature stalks to make an alcoholic ceremonial beverage, akin to tequila (Stark, 1991). Modern Native Americans are still enjoying the tender stalks. Except today, they are wrapped in foil and cooked in the oven (Bean & Saubel, 1972).

During the second stage of development, the stalk is fully developed, the buds have formed, and the delicate flowers are just beginning to open (Bean & Saubel, 1972). At this point, the fresh, recently opened blossoms, taste the sweetest. The delicate flowers were eaten fresh, boiled, roasted, or pan-fried with tomatoes, onions, and various spices (Balls, 1962; Bean & Saubel, 1972; Cornell, 1938; Ebeling, 1986; Romero, 1954; Saunders, 1920; Willis, 2004). The dense young flower heads were gathered, and pit roasted in stone lined pits (Balls, 1962; Ebeling, 1986). The roasted blossoms are said to have an apple flavor (Harris, 2003). The freshly opened flowers were also cooked like a vegetable in watertight woven baskets. Heated rocks were placed in the water that was covering the blossoms, and then stirred constantly so the rocks did
not damage the baskets (Stark, 1991). The finished blossoms taste like sweetpeas. When the blooming season was at its height, the young flowers were harvested, dried in the sun, and preserved for future use (Bean & Saubel, 1972).

During the third stage of development, the Hesperoyucca stalks are fully matured and the flowers are all open and in various stages of maturity (Bean & Saubel, 1972). By this time, the saponins have become concentrated in the stalk and flowers, causing them to be bitter to the taste. Saponin is a component of the Hesperoyucca’s sap and natural fluids. It is the important ingredient that gives the plant its detergent qualities, but when concentrated, saponin can be a toxic substance. Luckily, it is destroyed by heat during cooking, and it passes through the human digestive system without being absorbed (Willis, 2004). Conversely, saponin can be very poisonous to animals. Some American Indian tribes collected the concentrated juices from the plant, and dropped the liquid into streams and lakes to kill or stun the fish, making them easy prey (Willis, 2004).

By this stage of development the flowers can still be eaten, but they must be boiled three times, in a fresh pot of salt water each time, to destroy the bitterness (Bean &
Towards the end of the blooming season, the remaining flowers were gathered and dried for future use (Bean & Saubel, 1972).

With the arrival of Fall, the Hesperoyucca seedpods have matured, dried out, and are beginning to split apart. The Native Americans gathered the flat, black seeds, to be ground up and made into flour. Water was added to the flour, making a gruel, that could be eaten cooked or cold (Balls, 1962; Willis, 2004). The seed flour was a staple that could be saved and stored for long periods of time (Cornell, 1938). In preparation for storage, it was worked into a paste and spread on mats or flat rocks to dry. Later, the cakes were reworked and formed into blocks and dried again. The dried blocks were stored for winter staples, or used for bartering with other tribes (Stark, 1991).

The Native Americans discovered that the Hesperoyucca has many medicinal properties. They used it to relieve skin disorders and to treat the symptoms of arthritis. It was used by many tribes as a laxative (Jellin et al., 2002; Johnston, 1969; Saunders, 1920; Stark, 1991).

Hesperoyucca blossoms are currently considered to be a specialty food item. Natural food enthusiasts and gourmet restaurants incorporate the delicate flowers into
a variety of soups, salads and other entrees. The candied blossoms are used to decorate cakes and as a garnish for desserts and confections. Some examples of these recipes are included in the Appendix. These recipes expand the student’s understanding and appreciation of the Hesperoyucca.
Hesperoyucca extracts have many valuable uses, both historically and currently. The ingredients responsible for Hesperoyucca's useful effects, are plant steroids, called saponins (Jellin et al., 2002).

In the past, the American Indians relied upon the medicinal qualities of the Hesperoyucca saponins. Today, medical research is confirming the plant's curative properties (Jellin et al., 2002). Natural medicines made from Hesperoyucca extracts are being widely used as homeopathic treatments for arthritis, hypertension, migraine headaches, colitis, high cholesterol, and many skin problems (Jellin et al., 2002).

The natural plant steroids found within the Hesperoyucca enable it to live and thrive in harsh desert environments. When placed in the root zone of food crops, the Hesperoyucca compounds help the plants overcome many of the severe environmental conditions that are part of the Hesperoyucca's natural habitat, such as heat and water stress, compacted soils, poor water percolation, and salty, alkaline growing conditions (American Extracts, n.d.; Yale, 1976). The unique capabilities of the plant
extracts are especially well suited to applications in the agricultural industry.

Steroid saponin is a natural wetting agent. It reduces surface tension and allows water to percolate down into the soil where it becomes accessible to the plant’s root systems. Improved percolation conditions result in increased water uptake, greater seed germination, and the drainage of excess water from the root zone (American Extracts, n.d.; Yale, 1976).

Hesperoyucca compounds are frequently used to facilitate wastewater management. The microorganisms in sewage and wastewater treatment plants are often overloaded or hampered by the effects of toxic inputs. The addition of Hesperoyucca extracts to the mix alleviates these stresses and creates a more balanced environment for the microorganisms. The result is a more completely digested, and less malodorous end product (American Extracts, n.d.; Yale, 1976).

The commercial livestock industry has utilized Hesperoyucca extracts in the reduction of atmospheric ammonia levels in animal confinement buildings and feedlot areas. Elevated ammonia levels have been recognized as having negative effects on the health and performance of pigs, calves, and poultry. When the Hesperoyucca compounds
were added to the animal’s feed, or sprayed directly on
the litter or manure pits, the ammonia levels were
immediately diminished. The saponin’s mechanism of action
is the binding of the ammonia and its conversion into
other products (Headon & Dawson, 1990).

Feeding the plant extracts to feedlot lambs and
cattle resulted in greater digestibility of feeds, and
higher weight gains, with no negative side effects. The
cattle also seemed to deposit more lean tissue and less
fat while consuming the *Hesperoyucca* additives. Adding
*Hesperoyucca* saponins to the rations of feedlot animals
caused improvements in all of the economically desirable
traits (Goodall, 1980).

*Hesperoyucca whipplei* makes many valuable
contributions to modern society, and new applications for
this versatile plant are being discovered everyday. It has
provided many answers, and holds many more secrets yet to
be discovered.
CHAPTER SEVEN
DESIGN OF PROJECT

The initial research done during this project was conducted in the field. *Hesperoyucca whipplei* is a species local to our area. It occurs here in all of its subspecies forms, creating excellent field study opportunities. During the course of my fieldwork, I recorded my observations in the form of notes and photographs.

Studying the *Hesperoyucca* in its natural habitat prompted many questions. Each individual plant seemed to exhibit a unique form. They grew as clumps, in colonies, and as individuals. They could be found as small as a pineapple and as large as a century plant. To begin to answer my observational questions, I went online and began my search on the internet.

Information about the *Hesperoyucca* was plentiful online, but a large percentage of it was erroneous. *Hesperoyucca* had been previously classified as a *Yucca*. Confusing the *Hesperoyuccas* with the *Yuccas* created a profusion of misinformation on the web.

After an extensive online search, I organized the information I had retrieved and began to read through it. Much of it was old information and obsolete.
classifications. Some of it consisted of undocumented opinions and personal observations. I disposed of the irrelevant material and discovered that my search had yielded only a few reliable, substantiated articles. Using the references cited in these articles as a starting point, I continued my search at libraries and museums in the surrounding cities and counties.

The Palm Springs Public Library proved to be an excellent source of information on the Native American uses of the Hesperoyucca. The Seeley Mudd Library of Scientific Periodicals and the Rancho Santa Ana Botanical Gardens Library were my best sources of scientific information.

Observation and field study activities were carried on throughout the research process. Each article of new information led to a greater understanding of observations in the field.

After two years of research and observation, I felt confident in my understanding of the Hesperoyuccas. At this point, I organized my information and observations and began to write about what I had discovered.

The information in chapters three and four, as well as personal observations, was used to develop nature study lessons about the Hesperoyucca, designed to be taught in
the field (see Appendix). These lessons could be used by educators working with as young as third grade elementary students, and can be used with all age groups.

Native Americans ate the blossoms of the Hesperoyucca plant as noted in chapter five. As an aide for outdoor educators seeking to interest their students in uses of native plants, recipes featuring the Hesperoyucca are also provided in the Appendix.
APPENDIX

HESPEROYUCCA ACTIVITIES
When the flowers are fresh in the spring, having students taste the flowers expands their experience. Activities 1, 2 and 3 are all tested recipes that can be easily prepared.

ACTIVITY #1

Fried Hesperoyucca Petals

Ingredients

One flower stalk from a Hesperoyucca plant

One tablespoon canola oil

Two medium onions, chopped

Two fresh tomatoes, chopped

One cup water

Preferred seasonings

Preparation

Pull the petals from the stalk and wash them in salt water.

Add the oil, flower petals, onions and tomatoes together in a skillet.

Sautee, stirring gently, until the onions are soft.

Add the water, and simmer the mixture until most of the liquid is gone.

Season to taste.

The petals taste similar to cabbage (Smith-Kennedy, n.d.).
ACTIVITY #2

Crystallized Hesperoyucca Flowers

Ingredients

Fresh Hesperoyucca blossoms (clean and dry)

Finely granulated sugar

Egg whites (preferably egg white substitute)

Preparation

Line a cookie sheet with wax paper.

Brush flowers inside and out, with beaten egg whites.

Dip flowers in sugar.

Place flowers on cookie sheet.

Dry in oven at 150 degrees or less, with the oven door slightly open.

Store in covered containers.

(Arizona Department of Transportation, 1988)
ACTIVITY #3

Chilled *Hesperoyucca* Flower Soup

**Ingredients**

Four cups of cleaned *Hesperoyucca* blossoms (about 24 blossoms = one cup)

Two cups of chicken broth

One clove of garlic

One cup of plain yogurt

One cup of sour cream

Dill weed

**Preparation**

Boil the *Hesperoyucca* blossoms in the chicken broth for ten minutes.

Cool the mixture.

Puree in a blender with the garlic.

Add the yogurt and sour cream.

Whirl just until blended.

Chill the mixture.

Garnish it with a sprinkle of dill weed and fresh *Hesperoyucca* petals.

(Arizona Department of Transportation, 1988)
ACTIVITY #4

The Hesperoyucca in Winter

This activity is designed for third grade students, but it can be modified for use with other age groups, including adults. It especially supports the Content Standards for the State of California for the third grade level in the areas of Science, History and Social Science, and English and Language Arts. Observing the Hesperoyucca in its natural habitat gives the students the opportunity to learn through discovery and first hand experiences.

Background Lecture

Hesperoyucca whipplei can be found growing on mountain slopes, foothills and in desert fringe areas. It thrives in rocky, sandy, and well drained soils.

During the winter months, the green color of Hesperoyucca's spiny clusters are easy to see when the surrounding vegetation is dead and dormant. It blossoms and sets seed during the spring and summer, but the rosette, which is the main body of the plant, is green year round. Because the Hesperoyucca is easy to see during the winter season, it is the best time of the year to study the various forms of Hesperoyucca's subspecies.

The species Hesperoyucca whipplei contains five subspecies: parishii, typica, ceaspitosa, percura, and intermedia. The plants in all five subspecies exhibit the same spiny green rosette, but the number and arrangement of the rosettes varies among the subspecies.
*H. parishii* is the largest member of the subspecies group. Its bluish green, swordlike leaves can be as long as 46 inches in length. *Parishii* is solitary, producing no offshoots. It will be found as a single, large rosette. Sometimes, *parishii* plants can be found dead and drying out because it is one of the two monocarpic forms of the subspecies group. The monocarpic forms reach maturity after 7 to 10 years of growth and then die after blooming and setting seeds.

*Typica* is the other monocarpic form of *H. whipplei*. It produces no offshoots and will be found as a single rosette. It resembles *parishii* in all aspects except size: with *typica* being half the size of *parishii*. *Typica* may also be found dead and drying out.

*Ceaspitosa* forms crowded clumps of rosettes. The secondary rosettes are attached to the base of the primary plant at soil level, branching on the surface of the ground. *Ceaspitosa's* tight clumps may contain from 3 to 100 rosettes. Its spiky leaves are green to yellow green, and more rigid that its sister subspecies. *Ceaspitosa* lives a long life. Every year one or more of its rosettes will produce a flower stalk and set seed. Then the seed producing rosette will die while the rest of the plant lives on.

*Percursa* produces offsets by means of underground rhizomes. The rhizomes are attached to the main plant at the root zone and below. A new rosette or rosette cluster is formed from the terminal end of each individual rhizome. Because the underground shoots travel away from the plant, *percurusa* forms large, open clumps. Several of the plants rosettes may bloom during the spring and summer. After
blooming and setting seeds, the single rosette may produce new offsets. *Percursa's* blue green leaf blades are shorter than those of the other four subspecies.

*Intermedia* is hard to identify in the field because it has characteristics that resemble both *ceaspitosa* and *percursa*. *Intermedia* forms close, thick clumps similar to *ceaspitosa's*, but not quite as large. During the blooming season, only one of the plant's rosettes will produce a flowering stalk. After the rosette blooms, the leaves and stalk die, but the base of the stem and roots live and sprout new rosettes (Hains, 1941; Tirmenstein, 1989).

Materials

Each student needs a sketch pad and a pencil.

Procedure

While in the field, the students will be asked to sketch and label the *Hesperoyuccas* and *Hesperoyucca* groups as we observe and discuss them. Their notes and sketches will be the first addition to their field journals on *Hesperoyuccas*. We will carry on our class discussion throughout our fieldtrip.

Observation Questions

Where are the *Hesperoyuccas* found? Where are they in relation to the mountains? Where are they in relation to the desert?
What kind of soil are they growing in? Pick it up and look at it. Look at the soil particles. What size are the soil particles? What color are they? What about rocks? Is the soil rocky? What would you call this kind of soil?

Which subspecies of *Hesperoyucca* are you looking at? How many rosettes do you see? Is it a solitary rosette? Is it part of a group of rosettes? Are the rosettes clustered tightly together? Are they positioned loosely around a central rosette? Which one is the central rosette? How do you know it is the central rosette?

What do the leaves look like? What color are they? Feel them. Can you bend them? Beware of the thorns on the leaf tips. How long are the leaves?

Which one of *H. whipplei*’s subspecies are we looking at? Sketch and label a picture of the plant or group of plants you have discovered.
ACTIVITY #5

The Hesperoyucca in Spring and Summer

This activity is designed for third grade students, but it can be modified for use with other age groups, including adults. It especially supports the Content Standards for the State of California for the third grade level in the areas of Science, History and Social Science, and English and Language Arts.

Beginning in late March and extending into early June, the Hesperoyuccas can be seen in various stages of their reproductive process. On any day, during this time of the year, examples of every stage of reproductive development can be found among the wild plant populations. This phenomenon provides excellent field study opportunities.

Background Lecture

The Hesperoyucca’s blooming season begins in late March and ends in June. During this time, plants that have reached reproductive maturity will sprout a stalk, develop blossoms, and eventually produce seedpods.

In the first stage of the reproductive process, a large asparagus-like stalk will sprout from the center of the plant’s rosette. The stalk grows rapidly, and within a few days it can grow 10 or 15 feet in height.

After the stalk has reached its full height, buds begin to emerge on the top end. The buds extend from the top of the stalk, down toward the middle of the giant stem.
When the buds are fully formed, they begin to develop into blossoms. The bottom blossoms always open first. As the blossoms mature, they open progressively upward on the stalk.

Each flower stalk contains hundreds of delicate, sweetly scented blossoms. As soon as the first blossoms are open, *Hesperoyucca*’s sole pollinator, a tiny moth, can be seen visiting the blooms.

The *Hesperoyucca* and its pollinator, *Tegiticula maculata*, share a mutualistic (symbiotic) lifecycle relationship. *T. maculata* pollinates the *Hesperoyucca* flowers, and *H. whipplei* provides a place for the moths to lay their eggs.

The tiny moth is *Hesperoyucca*’s only pollinator, and is especially equipped for the job. Pollination is accomplished by the adult female moth. She has a pair of long, curved, prehensile appendages near her mouth called maxillary palpi. They are used to collect pollen, and to pollinate *Hesperoyucca*’s uniquely shaped flower stigmas. Without *T. maculata* to pollinate its blossoms, the *Hesperoyucca* could not produce seeds, and would soon become extinct. The tiny moth needs *H. whipplei* seedpods as a place to deposit and incubate its eggs. They are exclusive to one another, one cannot survive without the other.

*T. maculata* will pick a blossom and deposit an egg in the flower ovary. Then she will uncoil her palpi and pass it over the flower stigma pressing some pollen into the flower’s central stigmatic depression. As the pollinated blossom develops into a seedpod, the egg hatches inside and the moth larvae matures along with the seeds. The
larvae will eat a few of the seeds while they are developing, but not enough to endanger the _Hesperoyucca_’s seed production.

By the time the seedpods are fully developed and beginning to dry out, the mature moth larvae are preparing for the next phase of their lifecycle. They make tiny exit holes in the seedpods and drop to the ground. Then they burrow into the soil and surround themselves with a cocoon of silk and sand. They will remain in their underground cocoons until early spring when they will emerge over the course of _Hesperoyucca_’s blooming season (Aker & Udovic, 1981; Armstrong, 1999; Clary, 2001).

Materials

Each student needs a sketch pad and a pencil.

Procedure

During our fieldtrip, the students will be asked to sketch and label the _Hesperoyuccas_ as we observe and discuss them. Their notes and sketches will be added to their field journals on the _Hesperoyucca_.

Observation Questions

Sketch a picture of a _Hesperoyucca_ rosette that is producing a flower stalk. What does the emerging stalk look like? What part of the plant’s rosette produces the stalk?
Draw a picture of the *Hesperoyucca* flower buds. How many branches are emerging? Can you count the buds? Have any of the buds developed into flowers? Where are they located on the flower stalk?

Draw a picture of a *Hesperoyucca* blossom. What do they smell like? What color are they? How many petals do the blossoms have? How are the petals shaped?

Do you see any *Hesperoyucca* moths? Look closely because they are only 8 to 10 millimeters in length. If you stand still and watch an individual *Hesperoyucca* for a few minutes, you will probably see a moth.

Do you see any seedpods? Most of the seedpods that will grow to maturity will be found on the lower portion of the flower cluster. Small immature seedpods can be seen in the early weeks of spring. As the season progresses, almost all of the flower stalks will bear seedpods of various sizes. If you see any seedpods, what size are they? How many different sizes can you see on an individual plant? How are they arranged on the flower stalk? Sketch a picture of the *Hesperoyucca* and its seedpods.
ACTIVITY #6

The *Hesperoyucca* in the Fall

This activity is designed for third grade students, but it can be modified for use with other age groups, including adults. It especially supports the Content Standards for the State of California for the third grade level in the areas of Science, History and Social Science, and English and Language Arts.

When fall arrives, the *Hesperoyucca* have completed their yearly reproductive cycle. After their seedpods are fully developed, the rosette, stalk, and seedpods will die and dry out.

Background Lecture

After completing their yearly cycle, the *Hesperoyucca* flower stalks die and begin to dry out. The moth larvae developing in the seedpods have matured and are preparing for the next phase of their life cycle. They make tiny exit holes in the seedpods and fall to the ground. They burrow into the soil and surround themselves with a cocoon made of silk and sand. When spring arrives, the larvae will pupate and emerge as adult moths over the course of the *Hesperoyucca*’s blooming season.

The seedpods will not fall from the drying stalk. They will cling to it and dry out along with the rest of the dead stalk and rosette. As the pods dry out, they will split apart, revealing three sections, with each section containing two columns of flat black
seeds. The seasonal winds will shake the dead stalks and scatter the seeds onto the surrounding soil (Armstrong, 1999).

Materials

Each child needs a sketch pad and a pencil.

Procedure

While in the field, the students will be asked to sketch and label the *Hesperoyucca* as we observe and discuss them. Their notes and illustrations will be the final addition to their field journals on the *Hesperoyucca*. We will carry on our class discussion throughout our fieldtrip.

Observation Questions

Observe the dead *Hesperoyucca* rosettes. Is it a single rosette, or is it a member of a cluster of rosettes? During our past field trips we have discussed *Hesperoyucca*’s five subspecies. We know that two of these forms are solitary. When we discover a solitary dead rosette, we know that the entire plant has completed its lifecycle. It has to be either subspecies *typica* or subspecies *parishii*. When we discover tight groups of living rosettes with dead rosette members, it means we have discovered subspecies *ceaspitosa* or subspecies *percursa*. These two subspecies will continue to live even though individual members may blossom, set seeds, and then die. Sketch a picture of the rosette, or group of rosettes we are observing.
Look at the seedpods. Pick one from the dried stalk. Look at the three lobes. Where did the seed capsule break open? Did all of the pods break open in a similar manner? Look at the columns of seeds. How many columns are there? Shake the seedpod until a few seeds fall into your hand. What do they look like? What color are they? Describe their shape. Draw a picture of the open seedpod. Draw a picture of a seed. Look closely at the outside of the seedpod. Do you see any holes? Every mature seedpod will have at least one tiny hole made by an exiting moth larvae. After you find the escape hole, look for the larvae’s abandoned feeding gallery. There will be a small gap in one of the seed columns where the moth larvae hatched and developed. The tiny larvae fell to the ground, burrowed into the soil, and surrounded themselves with a cocoon. They will pupate in the spring and emerge while the *Hesperoyucca* are blooming.

After you have finished examining the seedpod, drop it to the ground along with the loose seeds. Some of the seeds we have examined may grow into *Hesperoyucca* plants in years to come.
REFERENCES


