Pipe Spring National Monument

Vegetation Management Plan
Phase II

May 2010

UtahStateUniversity
Department of Landscape Architecture
and Environmental Planning

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Introduction

The following report provides treatment recommendations and protocols for the management alternatives selected by Pipe Spring National Monument in 2009. Management alternatives were selected based on the potential impacts described in phase I of the report. Recommendations are founded on research studies conducted on the monument, PISP archival material, scientific references, discussions with PISP staff and other experts, site reconnaissance, and best professional judgment (see references).

The Pipe Spring National Monument (PISP) staff has delineated in scoping sessions related to this project, six vegetation management/land use zones within the monument (Intro Figure 1.1). The organization of this document is based on the following zones:

- Visitor Zone (VZ) 7.4 acres
- Historic District (HD) 9 acres
- Shrubland/Grassland Zone (SGZ) 14 acres
- Hillside Zone (HZ) 5.6 acres
- Administrative Zone (AZ) 4.acres
- Tribal Zone (TZ) 2.7acres

Existing Conditions Monument-Wide

Visitor Zone

The Visitor Zone landscape is the most disturbed within the monument. Little remains of the topsoil, topography, or hydrology. Consequently, most existing vegetation is early to mid-successional in species composition. The existing community is lacking in species diversity and age diversity when compared to relatively undisturbed shrub steppe communities in the region.

Historic District Zone

The Historic District Zone is primarily a cultural landscape characterized by introduced shade trees, native desert shrub steppe and pinyon/juniper woodland. The native desert shrub steppe community has been disturbed by historic activities associated with ranching, as well as more current NPS activities. The community has a deficient perennial grass/annual forb understory and no perceivable biological soil crust. The area bordering the Hillside Zone to the north is dominated by juniper/juniper woodland species with a shrub, perennial grass and annual forb understory. As noted in the PISP Avian Inventory Report, junipers observed in the NE of the HDZ may be following a successional pattern through which desert shrub steppe is over time replaced by pinyon/juniper communities (Johnson, Holmes, and Stuart 2004, 30).

The introduced trees in this zone are clustered near the fort and around the ponds. Relict Siberian elms to the west of the fort are contributing historic features that are in decline, with seedlings/saplings growing in their shadows. The cottonwoods and *Ailanthus* within and adjacent to the ponds have died or have been in decline over the past 15 years, matching trends seen throughout the monument. Seeps from the ponds support cultivated roses and herbaceous riparian species. Further north, near the chicken house, are the remnants of *Populus alba* and barren areas where *Ailanthus* once grew.

Hillside Zone

The Hillside Zone is comprised of the pinyon-juniper plant community, one of most predominant habitat types adjacent to the monument. Within the monument, while there is some diversity in age classes, there is a distinct lack of mature pinyon pine and Utah juniper.

Shrubland/Grassland Zone

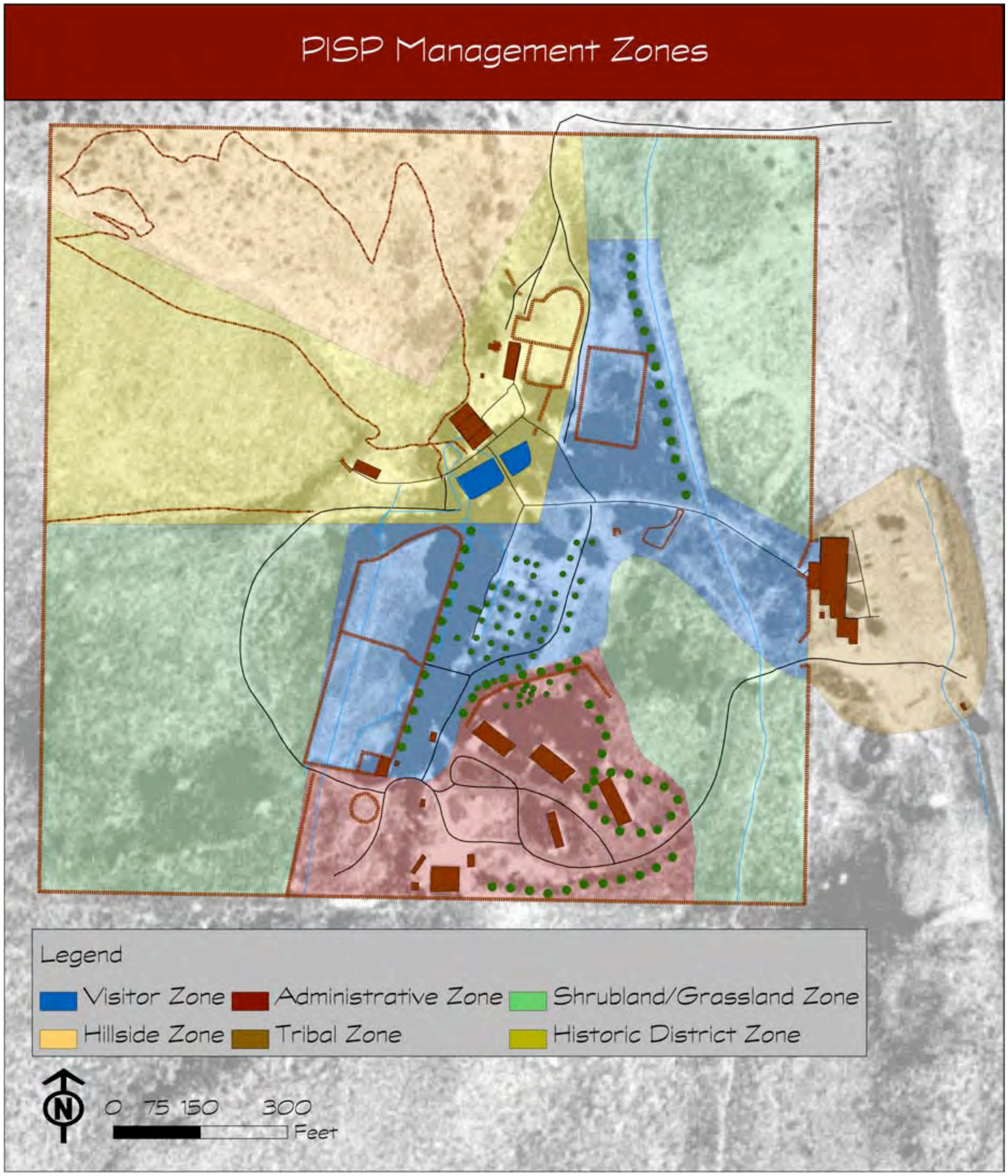
In general, the Shrubland/Grassland Zone plant communities are degraded. Grasses and forbs are minimal, replaced with dominant shrub species. Consequently the pre-settlement pattern of grassland interspersed with shrub species is no longer evident (Alexander 1998). Biological soil crust exists in a few isolated locations but is generally absent from this zone. The riparian plant community in the SW corner of the SGZ has been stressed by drought and lack of spring water which used to flow from the irrigation ditch across the corral and into the arroyo.

Administrative Zone

Structures, roads, parking, utilities, lawn, shrubs and shade trees give the Administrative Zone the characteristics of a suburban development. The introduced plantings are sprinkler irrigated and are in general in good condition. *Ailanthus* has invaded several planting beds on the southwest corner of the AZ. The lawn panels are in decline. They are an unnatural food source for cottontail rabbits, whose population on PISP exceed regional norms and degrade some of the plantings in the VZ.

Tribal Zone

The condition of existing vegetation on tribal land east of the entry road has not been studied. The lawn and shade trees east of the visitor center, in the Tribal Zone (TZ), are in good condition. Trees in the parking lot appear stressed and several decadent trees were recently removed.



Intro Figure 1.1: *Map of Pipe Spring National Monument Management Zones*

Desired Future Conditions Monument-Wide

- Establish a landscape that to the greatest extent possible, complements, and reduces conflicts with the depiction of a 19^{th} century landscape associated with Mormon pioneer settlement within the Historic District.

- Natural resources will reflect a variety of successional ecosystems – from desert grasslands to overgrazed ranchland – from pre-European contact, 19^{th} century conditions to present conditions.

- Maximize use of spring water for cultural and natural resources

- Minimize use of culinary water (pumped well water) for cultural and natural resources

- Maintain integrity of vegetation as related to the cultural resources of the monument

- Maintain/ enhance habitat for long and short distance migrating birds and other native species

- Potentially control rabbit and other rodent populations until optimal vegetative conditions are reestablished.

- Replace/ remove exotic *Ailanthus* selectively, and exotic elms outside of Historic District.

Management Recommendations

Visitor Zone

Action 1C: Revitalize the decadent poplar hedgerow along the corral by selectively thinning the existing hedgerow by > 50%, removing every other tree plus any that are hazardous, and saving as much understory vegetation as possible. The stumps of cut trees are not treated and the dominant sucker is saved, cutting all others, and is then pruned to replace the removed decadent tree.

VZ Image 1.1: *Condition of the poplar hedgerow in fall of 2009*

Treatment Background

Historic Overview

Historically, it is unclear when the poplar hedgerow was planted. The first mention of cottonwoods in the PISP CLI is during the Woolley period, though specific locations are not mentioned (USDOI 1997). In a detailed 1932 sketch by Heaton, plums, cottonwoods, and *Ailanthus* are shown growing at the far south end of the irrigation ditch, and only plums are shown growing in the present location of the hedgerow. In 1933, however, the Civil Works Administration planted numerous trees irrigated with a new 'ditch and flood' system (USDOI 1997). The poplars may have been established at this time. In the 2008 Vegetation Classification and Mapping Project, both *Populus nigra* and *Populus alba* are documented along the irrigation ditch and pond areas (USDOI 2008), although presently *Populus nigra* does not appear to be present along the corral.

Species Overview

Black Poplar (Populus nigra)

Varieties of black poplar are native to Europe, Asia, and North America. In their native habitat, black poplars are a riparian species, but they are also found in less favorable growing conditions. The species is fairly adaptable, tolerating stony, poor, or arid soils. Like most poplars, *P. nigra* requires full sunlight. Depending on the variety or cultivar and on soil conditions, black poplars can reach heights around 100', slowing in growth after 30-40 years and reaching full maturity at 80-100 years of age. Characteristic of the species, black poplars are generally short-lived and fragile, with crown die-back moving from the top down (Poplars and Willows 1979, Bialobok 1976).

Populus nigra are most easily distinguished from other poplar species by their trunk and bark. Beginning at the base of the trunk moving towards the crown, the species' smooth trunk becomes cracked, gnarled, wrinkled and twisted at an early age. The nodulous gnarls produce burl wood, a popular wood amongst craftsman, not found in hybrid *P. nigra* varieties. As the tree matures, the bark thickens and darkens from a yellow or white gray to a dark gray or black color. The surface becomes rough and develops vertical fractures and ridges. The crown of *P. nigra* is often broad and densely branched. Long shoots produce deltoid leaves with finely serrated edges and short shoots produce longer, smaller deltoid shapes (Poplars and Willows 1979, Bialobok 1976, Bogdanov 1965).

White/Silver Poplar (Populus alba)

White poplars are non-native, fast-growing but short-lived trees. *P. alba* can reach 60'-100' tall and 40'-50' wide, growing slowly in the first year and then rapidly for up to 50 years. Like *P. nigra*, *P. alba* can tolerate arid conditions but requires strong direct sunlight to thrive (Bialobok 1976).

Populus alba can be easily identified by its two-toned leaves. Although highly variable in shape, the underside of its lobed leaves are coated in a white fuzz that produces a "sparkling effect" when caught by the wind (USDOI 1994). The trunk of *P. alba* can be large and is a smooth green-gray or white gray, darkening, thickening and developing vertical fractures from the base up at 15-20 years of age (Bialobok 1976).

Both *Populus alba* and *Populus nigra* are able to reproduce prolifically through root sprouting, making them excellent candidates for coppicing techniques (Kuhns, pers. comm. 2009).

Management Overview

Coppicing, the practice of regenerating a plant by cutting down the parent and encouraging the growth of sprouts, is an old silviculture practice dating back as far as the earliest civilizations. In nature, the prolific production of sprouts in response to injury, poor health, and death, is most likely an adaptive response to fires capable of destroying the above-ground portion of the plant (Smith et al.1997).

The offspring produced through coppicing are genetically identical to the parent tree and usually very similar in appearance (Stroempl 2005, Smith et al. 1997, Nyland 1996). The mature trees produced vegetatively by sprouting are usually not as straight or as morphologically predictable as trees produced sexually through seed dispersal. Sprouts do, however, grow much more quickly than seedlings of the same age (Smith 1997).

Although in silviculture practices multiple sprouts may be allowed to reach maturity, the process of selecting a single sprout to replace the parent tree is called singling. There are two major forms of coppicing that differ by the species-specific location from which the sprouts emerge from the parent tree:

Stump Sprouting

Stump sprouting is the most common form of regrowth, occurring widely amongst woody plant species. When the parent tree is felled, regulatory hormones called auxins are redirected to dormant buds located under the bark of the tree’s stump, triggering growth in the form of shoots. Stump sprouts originate as either “stool shoots” from the top of a cut stump, also called the stool, or as “coppice sprouts” that emerge from the bark on the side or at the base of the stump (VZ figure 1.1) (Stroempl 2005).

Although stump sprouting is commonly used as a form of coppicing, it does have several limitations. The success of sprouting is proportional to the age of the parent tree. As trees mature, the bark often becomes thicker, making it more difficult for the shoots to break through. The connection between the dormant bud and the tree’s pith, important to the growth of the shoot, is also more likely damaged or broken in mature trees (Smith 1997). Generally, stump sprouting is most successful in trees younger than 40 years (Nyland 1996).

Stump sprouts are also prone to crooked growth, as they must curve away from the trunk of the parent tree and at the same time towards the light. They may also easily develop rot or decay. Rot can be avoided, however, by selecting the lowest growing shoots, closest to the root collar or base of the stump (coppice sprouts), rather than those growing from the top of the stump (stool shoots). Although stool shoots may grow straighter, coppice sprouts often develop more independent root systems, not inheriting the rot of the parent tree, and are more stable and less prone to breaking as the stump decays (Nyland 1996). The advantage of stump sprouting is that the emergence of sprouts from around the parent tree's stump more accurately reproduces the spatial distribution of the parent stand.

Stump Sprouting Treatment

The best time to promote stump sprouting is during the tree's dormant season, from late fall through early spring, or before buds open. During this period carbohydrate storage is maximized, providing the most energy for new sprouts (Smith 1997, Stroempl 2005).

During the dormant season the tree should be felled with a well-sharpened chainsaw (the instrument used should minimize damage to the bark of the tree). Ideally the stump is then flush-cut as close to the ground as possible and at a slight angle for water drainage. This will reduce the risk of rot and promote straighter shoot growth. Any unhealthy or undesirable established shoots should also be manually removed at this time.

Soon after cutting the parent tree, in the presence of direct sunlight, a cluster of new shoots should emerge from the top, sides, and/or base of the stump. The shoots are likely to be numerous and dense. Although many of these shoots will perish through fierce competition for resources, selective manually thinning as early and often as possible in the second and third year of growth will reduce competition and encourage more robust growth. Shoots should be selected based on form (straightness, irregularities, single-shoot and not V formed), health and vigor (disease and height), location (as close to the ground level as possible), and spacing (aesthetic, light availability and least competition) (Stroempl 2005).

Root Sprouting

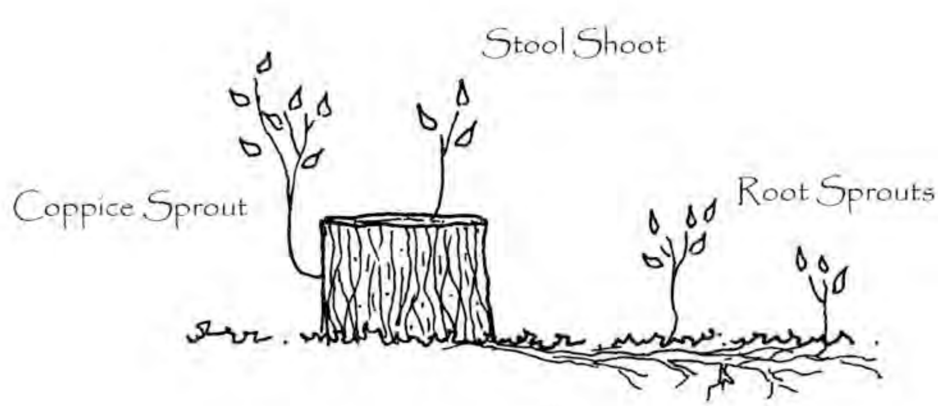
Much less common than stump sprouting, certain tree species such as *Populus alba* and *nigra* also produce new shoots from the parent tree's root system. These shoots emerge when the above-ground portion of the tree is killed, sending stored energy into the root system, or when shallow roots are bruised or injured. Root suckers grow singly, rather than in clumps, and usually develop a root system independent from the parent tree. This is a benefit to these offspring, as they do not inherit the root decay or disease of the original tree and grow straighter since they do not have to adjust to the stump or competing shoots. Unlike stump sprouts, root suckers proliferation is independent of the age of the parent tree and can be encouraged even in older trees (Nyland 1996, Stroempl 2005, Smith 1997).

Although the root suckers are superior to stump sprouts in many ways, they produce stands that are less faithful to the spatial arrangement of the parent stand. Unlike stump sprouts, which grow within inches of the parent stump, root sprouts can emerge over the entire spread of a tree's root system. As a result, a stand of root sprouts will be less predictable and appear more natural, similar to a stand produced sexually by seed dispersal (Nyland 1996).

Root Sprouting Treatment

Root sprouts are easily encouraged by the felling of the parent tree or by injury to the shallower surface roots. No special treatment of the stump is required, but the removal of soil and organic matter from the surface roots can promote growth by allowing more sunlight to reach the emerging sprout. Like stump sprouting, root sprouting is best during the tree's dormant period in the late fall through early spring (Nyland 1996, Smith 1997).

Although competition between root suckers is less aggressive than between stump sprouts, only the best sprouts should be allowed to continue past the first few years of growth. Sprouts should be selected based on the same parameters of form, health and vigor, location, and spacing as stump sprouts. More attention must be given to the spatial distribution of the shoots, since they will be more widely dispersed and dissimilar to the parent population (Nyland 1996).



VZ Figure 1.1: *Sprout types used in coppicing treatments*

Recommended Treatment

Growing Replacements

Populus alba and *Populus nigra* are able to reproduce through both stump and root sprouting, providing PISP management with several options for replacing the declining stand. Generally, root sprouts are stronger candidates as replacement trees than stump sprouts because of their straighter form, independent root system, and resistance to rot. The less predictable nature of their spatial arrangement, however, may pose some problems in retaining the historic character of the existing stand. It is therefore recommended that the felled trees be prepared for both stump and root sprouting through the methods described in the management overview. This will give PISP greater flexibility in selecting offspring.

VZ Image 1.2: *Some areas of the existing stand are too dense to promote the growth of healthy trees. Reducing the stand density will improve the health and longevity of new trees*

Allowing both stump and root sprouts to emerge will provide more options for selecting the most vigorous sprouts and the most desirable spatial arrangement. Once the sprouts appear, the desirable replacements can be selected from both the stump and root sprouts, giving preference to root sprouts. If one tree fails to produce healthy sprouts in an appropriate location, a second (root) sprout from an adjacent tree may be able to replace both its parent and its neighbor. PISP staff will have to make these aesthetic and functional decisions on a tree by tree basis as sprouts emerge.

Additional Notes

- Although environmental conditions, such as wind, likely caused the extreme eastward lean of the mature poplar trees in the current hedgerow, the offspring may not produce the same effect.
- Irrigation may have to be redirected to run along the new sprouts until they are well established or until climatic conditions are favorable.
- There are several areas where trees are growing within a foot or two of one another, increasing competition for light and water and promoting branch death (VZ Image 1.2). PISP should consider replacing only some of the mature poplars,

thinning some of these high density areas. A lower density stand would produce healthier trees, even if at some historic or aesthetic cost.

- In all cases where root or stump shoots are selected to preserve the genetic identity of declining historic trees, the adult tree should be evaluated for root diseases (appendix 3). These diseases can be transferred to vegetative produced offspring, potentially resulting in the death of the offspring and loss of historically significant genotypes. Alternative methods for propagating genetically identical offspring in the case of root disease or as an additional measure are available (For additional propagation options and stump removal techniques see appendixes 1 and 2).

Phasing for Removal and Replacement

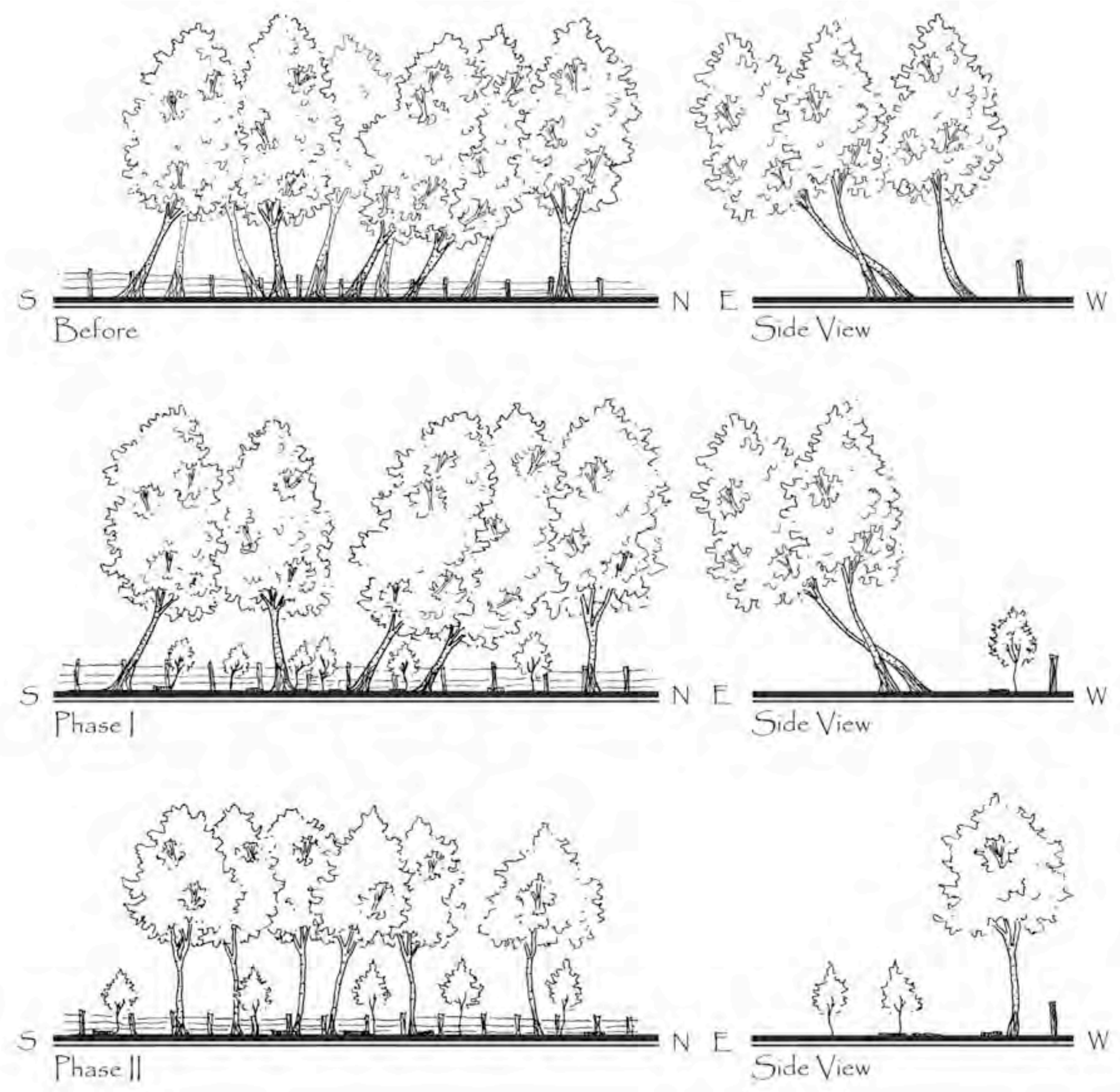
Generally there are four factors that will determine the phasing for the removal and replacement of the existing stand: light, competition, health, and ease of removal (Smith 1997). Successful coppicing requires direct sunlight to catalyze the production of sprouts. Ideally, trees should be removed in such a way as to provide sunlight for the new sprouts. Competition and health withstanding, this could be accomplished by removing the western most trees (adjacent to the corral) first, moving inwards towards the plums and the orchard (VZ Figure 1.2). Most of the trees along the drainage are leaning heavily towards the east, therefore removing the western most trees will provide sunlight to the sprouts of those western trees, and remove the shade from the eastern trees during the next removal phase. The western most trees also appear to be declining more rapidly than the eastern trees, and many are dead (VZ Image 1.1) giving their removal an additional aesthetic priority.

VZ Image 1.3: *The extreme eastward lean of the trees necessitates the removal of the western most trees first*

Competition plays a strong secondary role in successfully reproducing through coppicing. If trees were removed at random from throughout the stand, the remaining mature trees would likely draw energy and other vital resources away from the new sprouts of adjacent coppiced trees. It is best, therefore, to remove clumps of adjacent trees at one time. The west-to-east phasing will, to some extent, accomplish this. It will also allow some of the character of the area to remain by allowing a façade of easterly trees, visible from within the monument, disguise the trees that have been removed from behind. Once the new sprouts reach an age where they are a visible presence, or when they begin to shade the area where the trees to the east of them must sprout, the second removal phase can begin (VZ Figure 1.2).

Unfortunately, a third factor must also be taken into account that may disrupt the phasing detailed above. Certain trees appear to be declining much more rapidly than others and may have to be removed before their designated time in the planned sequence. PISP staff will have to determine when a tree has reached a critical state of decay and must be removed for the safety of staff and visitors, or for aesthetic improvement. According to Mike Kuhns, Utah State University Forestry Extension, trees with 10% or less live crown are unlikely to coppice well (ideally at least half the crown is alive). In this situation the sprouts of another adjacent tree may be used to replace the unproductive tree (Kuhns, pers. comm. 2009). See appendix 3 for more information on assessing tree health.

The final factor, ease of removal, may be a serious complication to the phased removal plan. As a result of the extreme lean of the poplars towards the east (VZ Image 1.2), the first row to be removed will be disposed towards falling on top of the remaining trees as they are felled. The trees will either have to be carefully felled in pieces, starting from the crown and working down in small sections, or particularly difficult trees may have to be taken down after adjacent eastern trees. This will have to be decided on site on a tree by tree basis by PISP staff.



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VZ Figure 1.2: *Phased removal of poplar tree line and replacement through coppicing. During Phase I the western most trees are removed and allowed to coppice. Once phase I trees establish, the eastern most trees are removed in phase II*

Visitor Zone

VZ Image 2.1: *Ailanthus grove west of administrative housing*

Action 2: Selective removal of scattered *Ailanthus* trees throughout Visitor Zone. This action includes the removal of all *Ailanthus* from the administrative zone and thinning overgrown stands in historically compatible areas.

Treatment Background

Species Overview

Ailanthus altissima, also known as tree-of-heaven, shumac, stinking sumac, stink-tree, copal tree, and Chinese sumac, is an exotic invasive tree found throughout most of the United States. A native to central china, *Ailanthus* was first introduced in the United States in Philadelphia during the late 18th century as an ornamental shade tree and street tree capable of thriving in the urban smog of the industrial revolution. A second west-coast introduction occurred in 1850s by Chinese immigrants who imported the culturally and medicinally important tree to California. Fast growing and easy to establish, *Ailanthus* quickly became a staple of early settlement, allowing the tree to proliferate from coast to coast (PCA 2009, USDA 2000, Burch 2003). *Ailanthus'* significance in the landscape at Pipe Spring National Monument is derived from the Mormon settlers' affinity for the tree and its historic cultivation within the pond structures and in other locations within the monument.

Today *Ailanthus altissima* is considered a noxious invasive in thirty states, including Arizona (PCA 2009). It is a fast growing deciduous tree that can establish and easily thrive in inhospitable conditions and poor soils. *Ailanthus* is tolerant of almost any condition, with the exception of full shade, and has no serious vulnerabilities to insects or disease. *Ailanthus* are prolific seed producers and regenerate quickly and abundantly through sprouting and root suckering, easily replacing short-lived adults in exponential numbers. These traits, along with the tree's allelopathy[1], allow *Ailanthus* to easily outcompete other desirable species and establish in large homogeneous stands (PCA 2009, USDA 2000, Burch 2003).

[1] Allelopathy refers to a trait of certain plants processing biochemical toxins that can inhibit the establishment and growth of other plant species.

Commonly mistaken for sumac or walnut trees, *Ailanthus* can be identified in the winter by its thin, smooth gray bark and brittle, blunt light brown branches, and by its 1’-4’ long compound leaves with mostly smooth leaflets in the summer months. Female trees also display large hanging clusters of conspicuous red seeds for much of the year. Although relatively short-lived, a single *Ailanthus* tree may grow up to 80 feet tall and greater than 3 feet in diameter. Perhaps its most distinct characteristic, however, is the strong and unpleasant nutty odor emitted by seed clusters and damaged branches or leaves (PCA 2009, USDA 200, Burch 2003).

Ailanthus is a dioecious tree that reproduces both sexually and asexually. Sexual reproduction occurs between male and female individuals, producing up to 300,000 seeds per female tree each year. During the summer, from June to September, energy is put into leaf and shoot growth, as well as seed formation in female trees. *Ailanthus* seeds (samaras) mature in late summer, dispersing by wind during the fall, winter and spring months. Seeds begin to germinate in early May and into the summer, producing seedlings that may reach up to 3’ in height during the first year (USDA 2000).

Asexual reproduction can be aggressive, producing copious fast-growing root suckers and sprouts. Root suckers can establish far from adult tree, producing new trees up to 6’ tall within a single year. Dead trees that have been cut, felled or treated with herbicides often retaliate with prolific sprouts from the stump or roots suckers from even the smallest remaining root fragments. These new trees can grow 10’-15’ per year and may continue to emerge 1-2 years after the initial treatment (USDA 2000).

Management Overview

Ailanthus altissima is an aggressive tree that is exceedingly difficult to manage. Many management techniques successfully kill the trunk and crown of the tree, but leave the tree’s root system intact and able to regenerate through sprouts and root suckers (Pannill, pers. comm. 2009). Generally, there are four treatment types that can be used to manage undesired plant species: biological, manual, mechanical, and chemical. Currently there are no biological treatments available for *Ailanthus altissima* (Pannill, pers. comm. 2009).

Manual Removal

Manual removal, by pulling or digging, is possible only for very young seedlings which have not yet established deep taproots. This treatment does not apply to root suckers, which look similar to seedlings but are fused to an adult tree’s lateral roots. During manual removal, it is critical that no roots or tree fragments remain, as these will establish new trees through root suckering. Manual removal is easiest when the soil is moist, after a period of saturating rain (USDA 2000)

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Mechanical Removal

Mechanical removal, which includes cutting and girdling, is usually unsuccessful when applied to *Ailanthus*, but can be successful in the long-term through years of aggressive and persistent labor. It is often said that for every *Ailanthus* killed, ten attend its funeral… mechanical removal poses a serious risk, as trees often respond by sprouting or root suckering, replacing the original tree by copious new trees (USDA 2000).

Felling

Felling is best applied to small populations in June and early July when food storage in the tree's roots is depleted from summer leaf, shoot, and seed growth, reducing the energy available for sprouting. Late July and August or late May are considered the next best months for cutting. It is also important to cut trees as young as possible, before a large root system supporting sprouts and root suckers is developed. Female trees should be targeted first, reducing the potential seedbank of the population. Cutting may be successful in minimum of 2-3 years only through persistence and frequent (monthly) treatments throughout the growing season until sprouting and suckering begins to slow. Under ideal growing conditions, however, this treatment could produce a larger, stronger stand of *Ailanthus* in the same period of time (Pannill, pers. comm. 2009, USDA 2000).

Girdling

Girdling is an alternative mechanical treatment often applied to medium-large *Ailanthus* trees. Girdling kills individual trees without felling them, benefiting wildlife by leaving dead wood or snag habitat. Girdling cannot be applied in areas where standing dead trees are hazardous or unaesthetic, such as along paths or in public spaces. Girdling effectively severs the tree's nutrient and energy circulatory system, but it may take up to 2 years before the tree drains its remaining energy supply and succumbs to the treatment. To girdle a tree, the bark, cambrium and phloem must be severed over a large enough area around the circumference of the tree, essentially carving out a collar. Girdling is a fairly technical process, and incorrectly girdling trees can be hazardous and encourage root suckering and sprouting. Like cutting, even well executed girdling may encourage root suckering and resprouting, creating a more serious situation (USDA 1999, USDA 2000). For more technical information on girdling, see USDA 1999.

Chemical Treatments

Chemical treatments, or herbicides, are the most consistent and effective treatment. Although they are more aggressive and pose greater potential environmental and human health risks, applied correctly, herbicide application is the most efficient and labor-saving method with the least risk of population proliferation and expansion through suckering and sprouting. In some instances, less frequent chemical treatments may be less invasive and environmentally harmful than frequent long-term site disturbance through alternative treatments (USDA 2000, Pannill, pers. comm. 2009).

There are four common chemical treatments used to manage *Ailanthus* populations: foliar spraying, basal bark spraying, cut-stump treatments, and the hack & squirt method. There are particular herbicides that are most affectively used for each method. For each of these treatments, the directions, warnings, and safety precautions from the selected herbicide's manufacturer should always be consulted and followed. Climatic conditions should be carefully noted before application, as many chemicals have optimal temperature ranges, absorption times (before rain, for example) and susceptibility to wind dispersal. Dyes are also available as additions to herbicide mixtures. These dyes allow the applicator to see where spray has been applied, avoiding excess herbicide and accidental overspray affecting desirable species. Specific herbicides are discussed in the herbicide overview below.

VZ Image 2.2: *Foliar spray application. Note the blue dye used to see the application (Miller)*

Foliar Spraying

Foliar spraying is perhaps the easiest chemical treatment, but it is only applicable when the entire crown of the tree is accessible. It should also be avoided when desirable plants are in very close proximity and where dead trees are hazardous or unaesthetic. During foliar spraying herbicide mixed with water and a non-ionic surfactant is applied to all of the tree's leaves and shoots with a herbicide sprayer (VZ Image 2.2). Foliar spraying can be used as both a primary treatment and as a supplementary treatment to curb sprouting and root suckering following other treatments. Foliar spraying uses a larger volume of herbicide than other treatments, but at a very diluted concentration (USDA 2000, Calzarette, pers. comm. 2008).

Foliar spraying must be done after the tree has fully leafed out. It is important to reduce the treatment's impact on the environment and surrounding vegetation by carefully spraying only the leaves of the target tree and by completely coating the leaves with herbicide without oversaturating them and causing drips (USDA 2000).

Recommended Herbicides:

Triclopyrs (Garlon® 3A, Garlon® 4). Joe Calzarette, Natural Resources Program Manager for Antietam National Battlefield, MD, recommends Garlon® 3A, which kills the tree more slowly than Garlon® 4 (per. comm. 2008). A faster death initiates a self-preservation mechanism, allocating all of the tree's energy to the roots for sprouting and suckering.

Other Herbicides:
Roundup® /Accord®, Cimmarron®/ Escort®, Crossbow®

Basal Bark Spraying

Basal bark treatments are affective on trees up to 12" in diameter in locations where standing dead trees are not hazardous or unaesthetic. In this treatment herbicide is mixed with oil (fuel, kerosene, or mineral), and sprayed onto the lower 12"-18" of the trunk, completely covering the bark around the full circumference of the tree and any emergent roots (VZ. Image 2.3). Unlike foliar spraying, basal bark spraying has a much lower risk of affecting surrounding plants. The herbicides can, however, reach desirable plants through the soil if an area is sprayed heavily. It is also a fairly easy method that does not require cutting. The greatest disadvantage of basal bark treatments is that a greater volume of herbicide is needed to cover the entire lower trunk than is needed in other treatments, depending on the size of the tree (USDA 2000).

VZ Image 2.3: *Basal bark treatment with blue dye marker (Dow Agro Science 2010)*

Basal bark treatment is most effective in late winter and early spring as well as mid to late summer but can be used year round. When applying herbicides, the trunk must be free of debris and dry. Rainfall following the application will not affect the treatment. Foliar spraying should be used to destroy any root suckers and sprouts following the treatment. Dead trees should not be removed for at least 6 months after the treatment (USDA 2000).

Recommended Herbicides:

Triclopyrs (Garlon® 3A, Garlon® 4).
Garlon®4 may be more affective than 3A. For this application the herbicide must be oil-soluble and mixed with an oil diluent (recommended 80% oil, 20% herbicide). There are

also mineral or vegetable oil-based diluents available that are designed for basal bark treatments in sensitive areas. It is recommended that PISP consider these diluents.

Other Herbicides:
Pre-mixed triclopyrs designed for basal bark treatments such as Pathfinder® II, are also available.

Cut Stump Treatment

VZ Image 2.4: *Cut stump treatment with blue dye marker (Miller)*

Cut stump treatment is a highly effective but labor-intensive method in which the stump of a felled tree is treated with a concentrated herbicide, spreading into the roots and preventing suckering and sprouting (VZ Image 2.4). This method is ideal for treating trees that must be fully removed (felled), especially larger trees, but may also be used on very small trees. This method uses less herbicide than basal-bark or foliar treatments because a concentrated herbicide is applied (Calzarette, pers. comm. 2008). Cut stump treatment affects adjacent vegetation by the process of felling, but because the herbicide is applied directly to a small surface of the stump it is less likely to reach desirable plants. The herbicide may, however, kill other *Ailanthus* trees (suckers and sprouts) as it is transported through shared root systems (UA 2006, USDA 2000, Pannill, pers. comm. 2009).

The herbicide must be applied to the outer 1/3 of the cut surface, covering the entire circumference, within five minutes of cutting (longer if an oil mixture is used). The herbicide is easily applied with a spray bottle or paintbrush. Hand-held spray applicators are also available. Trees that have previously been cut may still be treated with the cut stump method after a second cutting (UA 2006, USDA 2000, Calzarette, pers. comm. 2008).

The summer growing season is the most effective time during which to apply cut stump treatments, though the trees should be checked for bird nests before felling (UA 2006). Trees selected for cut stump treatment should be examined for connectivity to desirable *Ailanthus* trees, as a treated sucker may kill a desirable adult through shared roots

(Pannill, pers. comm. 2009). Foliar spraying should be applied to root suckers and sprouts that emerge after the treatment.

Recommended Herbicides:
Triclopyrs (Garlon® 3A, Garlon® 4). Joe Calzarette, Natural Resources Program Manager for Antietam National Battlefield, MD, recommends Garlon® 3A, which kills the tree more slowly than Garlon® 4 (pers. comm. 2008). A faster death initiates a self-preservation mechanism, putting all of the tree's energy into the roots for sprouting and suckering.

Other Herbicides:
Other herbicides applied in cut stump treatment may be active within the surrounding soil and are not recommended for PISP.

Hack and Squirt Method

VZ Image 2.5:*Hack and squirt method with a blue dye marker (Miller)*

The hack and squirt method requires herbicide to be injected, or applied, to a series of cuts in the bark of the tree (VZ Image 2.5). The herbicide is then carried through the vascular system of the tree, killing the upper portion and inhibiting sprouting and root suckering. This method should be used on larger trees (at least 2" in diameter) that can stand dead without creating a hazard or affecting site aesthetics.

Hack and Squirt may more affectively kill roots systems than cut stump treatments (USDA 2000). Along with cut stump treatments, the hack and squirt method uses less herbicide in a higher concentration than other treatments (Calzarette, pers. comm. 2008). Although root suckering and sprouting is inhibited during the growing season, foliar treatment will likely be necessary in the fall (USDA 2000). .

The hack and squirt method requires that a tree be punctuated by a series of downward angled cuts into the tissue of the tree made with a hand-axe. The cuts should be made at 1'-2" intervals around the entire circumference of the trunk at any height. It is recommended that 1 cut be made for each inch in diameter, plus one more cut. It is important to leave un-cut tissue between cuts, preventing a self-preservation response that sends nutrients to the roots of the tree. Other cut methods, such as frilling and girdling, are also used in hack and quirt treatments but are not recommended for treating *ilanthus*. A concentrated herbicide is then applied directly to the cuts with one or two squirts from a spray bottle or other had-held applicator. The herbicide should coat the cut without dripping. The herbicide should be applied within 1-2 minutes for the maximum effectiveness. Hack and squirt treatments are most affective during the summer growing season, especially in the fall, but can be used less effectively in the winter (USDA 2000).

Recommended Herbicides:
Triclopyrs (Garlon® 3A, Garlon® 4). Joe Calzarette, Natural Resources Program Manager for Antietam National Battlefield, MD, recommends Garlon® 3A, which kills the tree more slowly than Garlon® 4. A faster death initiates a self-preservation mechanism, putting all of the tree's energy into the roots for sprouting and suckering.

Other Herbicides:
Other herbicides applied in cut stump treatment may be active within the surrounding soil and are not recommended for PISP.

Recommended Treatment

Although manual removal may be used for small seedlings, it is recommended that chemical treatments are used to manage *Ailanthus* populations.

The following guidelines can be used to select an appropriate treatment:

Conditions for use:

Foliar Spraying

- All leaves are accessible
- The tree is small or can stand dead
- Some potential impact on understory species is allowable
- Treatment can be applied in the late spring through the summer

Chemical Use: high
Ease of Application: Very easy

Basal Bark

- Tree is <6" DBH
- Tree is small or can stand dead
- Some potential impact on understory species is allowable
- Treatment can be applied in late winter- early spring or mid-late summer, though year-round use is acceptable.

Chemical Use: High
Ease of Application: Very easy

Cut Stump
- o Complete removal of the tree is desired
- o Tree is of any size
- o Location permits safe felling
- o Tree is clear of desired bird species nests
- o Treatment can be applied during the summer

Chemical Use: Low volume, high concentration
Ease of Application: More difficult (felling)

Hack and Squirt
- o Tree is > 2" dbh
- o The tree can stand dead
- o Foliar treatment can be applied following the treatment, late summer
- o Treatment can be applied most affectively during the fall and summer growing season, but also may be used in the winter.

Chemical Use: low volume, high concentration
Ease of Application: Moderate- more difficult (size dependant)

Treatment Timeline

_____Optimal treatment season,
_ _ _ Acceptable treatment season

	Early Spring	Late Spring	Early Summer	Mid Summer	Late Summer	Fall	Late Winter
Foliar			______	______	______		
B.B.	______	_ _ _	_ _ _	______	______	_ _ _	______
C.S.	_ _ _	_ _ _	______	______	_ _ _	_ _ _	_ _ _
H & S			______	______	______	______	_ _ _

Other Specifications:

- The apparent lack of female *Ailanthus* trees at the monument suggests that individual trees in groves were asexually produced and consequently share a common root system. Any of the above chemical treatments are systemic, and will likely affect not only the target tree, but also adjacent trees sharing the root system. It is therefore not practical to selectively thin a stand without accepting some unintended *Ailanthus* casualties. Non-chemical treatments for trees larger than seedlings are likely to proliferate *Ailanthus* and are not a recommended alternative. Phil Pannill, N.C.T.C. Land Manager for the U.S. Fish and Wildlife Service and an *Ailanthus* expert, suggests two alternative treatments that could be tested in small areas where thinned stands are desired:

  - Garlon® 4, which may be less mobile within the tree, applied through a basal bark treatment may reduce the effect of the treatment on adjacent trees.
  - Garlon® 3A applied through a cut stump treatment prevents sprouting. This treatment will not prevent root-suckering, requiring a later application of foliar spray, which could damage adjacent trees.

- The recommended herbicides are triclopyrs, systemic herbicides with low soil mobility. These herbicides are also appropriate for riparian and aquatic environments, such as adjacent to drainages and irrigation ditches. Triclopyrs are selective, killing only broadleaf and woody plants, and are perhaps the most popular and successful choices for the treatment of *Ailanthus*. They have been used successfully in the Mid-Atlantic, where most *Ailanthus* research is currently conducted (USDA 2000). The plant matrix surrounding the *Ailanthus* groves at PISP includes desired native species and possibly biological soil crust. In the experience of Phil Pannill, the recommended herbicides, Garlon® 3A and Garlon® 4, do not significantly affect non-target species.
- If PISP should desire alternative herbicides in the future, it is important to recognize that some are more likely to affect surrounding plant communities. In order of decreasing potential damage to adjacent vegetation are the following herbicide families: picloram, imazapyr, dicamba, metsulfuron methyl, triclopyr, glyphosate (Pannill, pers. comm. 2009).

Selection of Trees for Thinning

Pipe Spring has decided to retain a selection of *Ailanthus* trees as representative of the historic significance of the species to early Mormon settlers and of the historic vegetation characteristics of the monument. The following guidelines can be used to selectively thin and control existing *Ailanthus* populations:

Considerations for Removal:

- *The tree is unhealthy and/or unsightly*: *Ailanthus* trees are by nature extremely brittle and short-lived, infrequently reaching full maturity. Even so, certain trees may be more easily identified for removal, including those that have lost major branches, have significant storm damage or other injuries, trees that appear to be water deficient (droopy or dead leaves) or those that demonstrate uncharacteristic growth patterns (twisted or overlapping branches, unusually crooked trunk etc,). For more information on assessing tree health, see appendix 3.

- *The tree is crowded*: To maximize a healthy stand of *Ailanthus*, crowded trees should be selected for removal. The number of trees thinned is dependant on the desired aesthetics, screening functions, and desired individual tree sizes. Although a dense stand can affectively screen views, thinner stands will produce larger trees and potentially more attractive stands.
- *Encroaching trees*: *Ailanthus* is highly invasive, and can easily spread to healthy native communities, and it is therefore desirable to maintain (or minimize) the current extent of the *Ailanthus* groves. The current and historic boundaries should be referenced and maintained, removing peripheral trees as needed. Irrigated areas, such as the orchard, are at particular risk.

VZ Image 2.6: *Ailanthus* have spread into residential planting beds

- *The tree is female*: Female *Ailanthus* trees can produce up to 300,000 seeds per year and should be priorities for removal, preferably before seed dispersal. Although *Ailanthus* will still spread asexually, removing female trees will curb sexual reproduction. Note: at this time there do not appear to be any female trees in the monument. Reproduction is asexual.
- *Ease of removal*: During thinning, when all other conditions are equal, trees can be selected for removal based on ease and safety. This is especially important when using methods producing standing dead trees or for which felling is required.
- *Context*: Trees that are growing in important native habitat, competing with desirable native species should be removed. *Ailanthus* are drought-tolerant, hardy trees that do not require additional irrigation. Trees near irrigation ditches that feed desirable native species warrant consideration for removal.
- *Historic Character and Aesthetics*: Trees that are important to the historic character and authenticity of the site, especially within the Historic District Zone, may be conserved. Trees that block important historic views should be removed, while those that screen historically incompatible features should be conserved (VZ Image 2.7).

VZ Image 2.7: *Ailanthus* contribute to the historic vegetation around the ponds

Visitor Zone

Action 3: Replace *Ailanthus* trees at south end of the hedgerow with a mixed cottonwood/willow planting and extend the existing ditch.

Treatment Background

Species Overview

Ailanthus

See VZ action 2, S*pecies Overview*

Salix exigua

The coyote willow, also known as sandbar willow, gray willow, narrow-leafed willow, dusky willow, and pussy willow, is a tall riparian shrub of great cultural and ecological significance in the United States. Typically *Salix exigua* reaches heights of 3'-15', forming large masses of cloned root sprouts, usually in areas with a bare gravel or sand substrate and stable high water table (USDA 2002).

Ecologically, coyote willow is a valuable riparian species used to stabilize banks, prevent erosion, and provide wildlife forage and habitat. It is often found as a pioneer species in association with native cottonwoods (*Populus fremontii*), a strong identifying feature of riparian communities in the west. Eventually *Salix/Populus* give way to later successional communities dominated by species such as sagebrush, usually following sediment accumulation. As habitat and forage, *Salix exigua* is valuable to many ungulates, rabbits, and birds. It may also be browsed to some degree by livestock, including sheep, goats, and cattle (USDA 2002).

Coyote willow has a long cultural history as one of the most important plant species to numerous Native American groups. The Paiute were amongst those groups that depended on the willow for a plethora of household items, shelter and medicine. Important everyday items including baskets, jugs, hats, cradles, and cooking-racks were made of scraped willow shoots. Characteristic Paiute homes were framed with coyote willow, and sheltered roofs were constructed with thatched willow roofs. Even the early, organic version of aspirin was taken in the form of willow bark tea (USDA 2002).

Populus fremontii

The Fremont poplar, or Arizona cottonwood, is large riparian tree native to the American southwest. Reaching heights of 39'-114' and a spread of 20'-40', this poplar grows very quickly under ideal conditions, including a deep, stable water source and well drained gravel or sand substrates. *Populus fremontii* is a significant tree for both its ecological function and cultural history (USDA 2003).

Many Native American groups used virtually every part of the Fremont poplar for sustenance, medicine, and the production of goods. *Populus fremontii* provides habitat and forage for numerous bird species, ungulates, rabbits, beavers, and porcupines. It can also be grazed by most domestic livestock (USDA 2003).

Like the coyote willow, the Fremont poplar provides services such as bank stabilization. Although they are both pioneer species, *Populus fremontii* can shade out willow groves in 15-20 years. The Fremont poplar is a prolific seed producer, germinating with annual inundations in the spring and early summer. Although propagation through seeding is challenging, *Populus fremontii* can be grown from hardwood and root cuttings or transplanted from containerized saplings (USDA 2003).

Management Overview

Three sequential activities are required to complete action 3, including:

- Removal of all *Ailanthus* trees
- Redirection of the irrigation ditch and site grading to produce a retention basin
- Planting of willows and cottonwoods

Recommended Treatment

Removing the Ailanthus

The removal of the *Ailanthus* must be comprehensive and thorough so as to ensure that *Ailanthus* does not outcompete the willow and cottonwoods and repopulate the site. This will require the complete removal of each tree, including its root system, which can produce copious clones of the parent tree, even once the adult is deceased. The stumps and root systems can be removed during the excavation and grading of the site to form the retention basin (see note below). Care should be taken to remove and contain all *Ailanthus* debris, including roots, branches, leaves, and fruit to prevent the spread of new trees to the disposal site. Although it requires the use of strong chemical, a cut stump treatment could be used before the stump removal, killing the root system and eliminating some the risk of an incomplete removal (see note below). Foliar spray treatments will likely be necessary for several seasons to remove new trees sprouting from missed roots (see note below). Covering the site with a opaque material, such as black plastic, for several weeks up to a year, can also reduce the number of new sprouts.

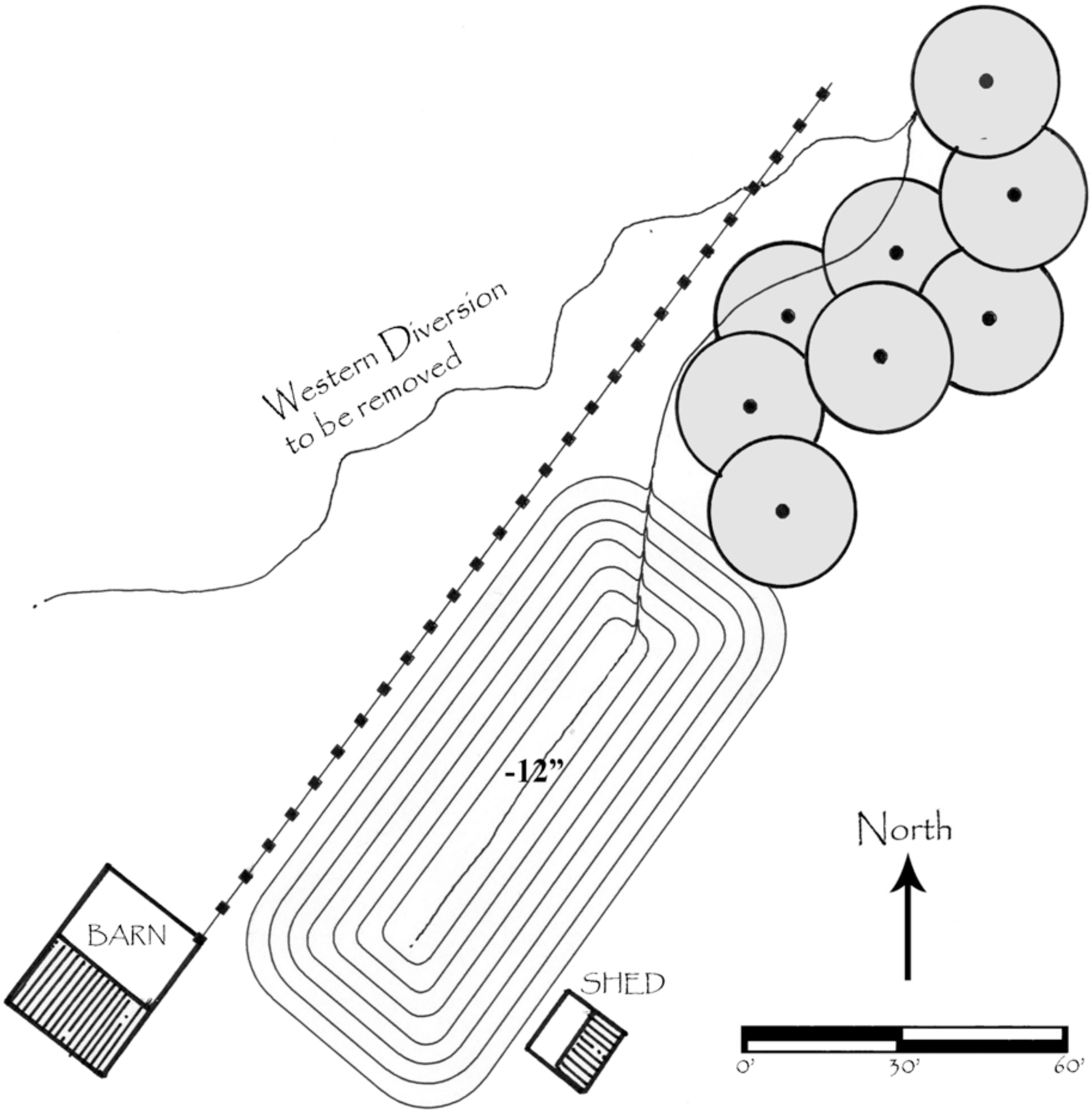
Note: For details regarding the removal of the *Ailanthus* see VZ action2, *Management Overview: Foliar Spray* and *Cut Stump Treatment.*

For more information on stump removal, see appendix 1.

VZ Image 3.1: *Current Ailanthus grove and proposed location for cottonwood and willow plantings*

Creating a Retention Basin

Constructing a subtle, roughly 12” deep, retention basin will establish the moisture-rich growing conditions required by coyote willows and Fremont poplars by capturing the overflow spring water from the poplar hedgerow. This water is currently diverted west across the south corral into a native wash, where vegetative evidence suggests that most of it is lost to infiltration before reaching the wash. A small 2”-4” deep gravity-driven channel appears to have already spread to the upper half of the *Ailanthus* grove. This naturally formed ditch can be used as the feeder to the retention basin and the branch of the channel currently flowing into the west corral should be removed (VZ Figure 3.1).



VZ Figure 3.1: *Schematic view of proposed retention basin. Contours are at 2" intervals, reaching a depth of 12"over a 4% slope. The existing drainage ditch is shown starting at the divergence. The western branch, leading into the west corral is to be removed. General location of existing poplar tree line shown in gray. The shape of the basin should be naturalized in an irregular form, rather than the formal shape indicated on the schematic drawing. Note: Scales and locations of objects are generalized due to possible GPS data variability.*

Planting Willow and Cottonwood Habitat

Willows

Coyote willows are easily propagated from root and stem cuttings. Willow plantings are much more likely to succeed if local genotypes adapted to the site conditions are used, recommending that, if possible, the willows growing in the southwest of the monument be used to populate the retention basin. If propagation is unsuccessful, containerized willows from a local nursery can be used, preferably a nursery with plants grown in the same region, elevation, climate, soil type, and hydrologic regime as Pipe Spring (USDA 2002, 2003). Coyote willow poles are also available to public agencies through the NRCS Plant Materials Center in Tucson, AZ. These plants provide a diversity of local genotypes representing the center's service area, increasing the long-term adaptability and resilience of the plantings (USDA 2002, 2003).

The NRCS Plant Materials Center at Los Lunas and the U.S. Fish and Wildlife Service have developed a planting technique for establishing willow and cottonwood communities (USDA 2002, 2003).

"*Steps for Successful Pole Plantings*:
Select sites as close to the area as possible to conserve genetic diversity. Try to match donor site and revegetation site in terms of soils, elevation, hydro-dynamics, permanent groundwater table, and soil salinity (which should be low).

• Select willow cuttings from a local, native stand in healthy condition. Prune no more than 2/3 of plants in an area. Willow cuttings for pole plantings should generally be at least 1/2 inch in diameter or larger. Select the longest, straightest poles available. Use only two to four-year old wood. The total length of the poles needed depends upon the water table depth (see #7 below).

• Measure water table fluctuations for at least 1 year, preferably longer, to determine the lowest water table depth. Take a reading at least once a month, preferably more often during the driest months of the year.

• Cut poles while dormant during January and February. Remove all side branches except the top two or three.

• Prepare cuttings by trimming off the top to remove the terminal bud, allowing a majority of the energy in the stem to be sent to the lateral buds for root and shoot development.

• Soak poles in water for at least 5 to 7 days before planting.

• Dig holes to the depth of the lowest anticipated water table. Sites where the water table will be within one foot of the ground surface during the growing season are better suited for willows than cottonwoods.

• The cuttings should extend several inches into the permanent water table to ensure adequate moisture for sprouting. At least 1/2 to 2/3 of the cutting should be below ground to prevent the cutting from being ripped out during high water flows, usually, at least 2 to 3 feet should be below ground. It should also be long enough to emerge above adjacent vegetation such that it will not be shaded out.

• Place cuttings in the hole the same day they are removed from the soak treatment. Set the butt as close to the lowest annual water table elevation as possible.

• Electric hammer drills (Dewalt model DW530) fitted with one-inch diameter, 3-foot bits were used to plant thousands of coyote willows in New Mexico. With one drill, two people installed 500 willow per day to a 3-foot depth. A power auger or a punch bar can also be used.

• Coyote willow pole cuttings were generally planted on 10 to 20 foot centers in New Mexico. Areas with a shallow water table (4-6 feet) were generally planted with a higher number of pole cuttings to enhance overall survival of the project; in this case, coyote willow was planted on 1-foot centers or even closer. Often understory species were planted under the canopy of pre-existing overstory (cottonwoods, tree willows) since they are often observed occupying this niche.

• It is critical to ensure the soil is packed around the cutting to prevent air pockets. "Mudding" (filling the hole with water and then adding soil to make a mud slurry) can remove air pockets.

• When necessary, install tree guards around the poles to protect from beavers, other rodents, or rabbits. Coyote willows tend to be fairly resistant to pruning from beavers, so tree guards may not be necessary.

• As buds begin to swell (usually in April or May), wipe them off the lower two-thirds of the pole. This will reduce evapotranspiration water loss and stimulate root growth.”

Note: Trials of the above procedure have produced a survival rate of over 80% when poles are cut and planted between November and February.

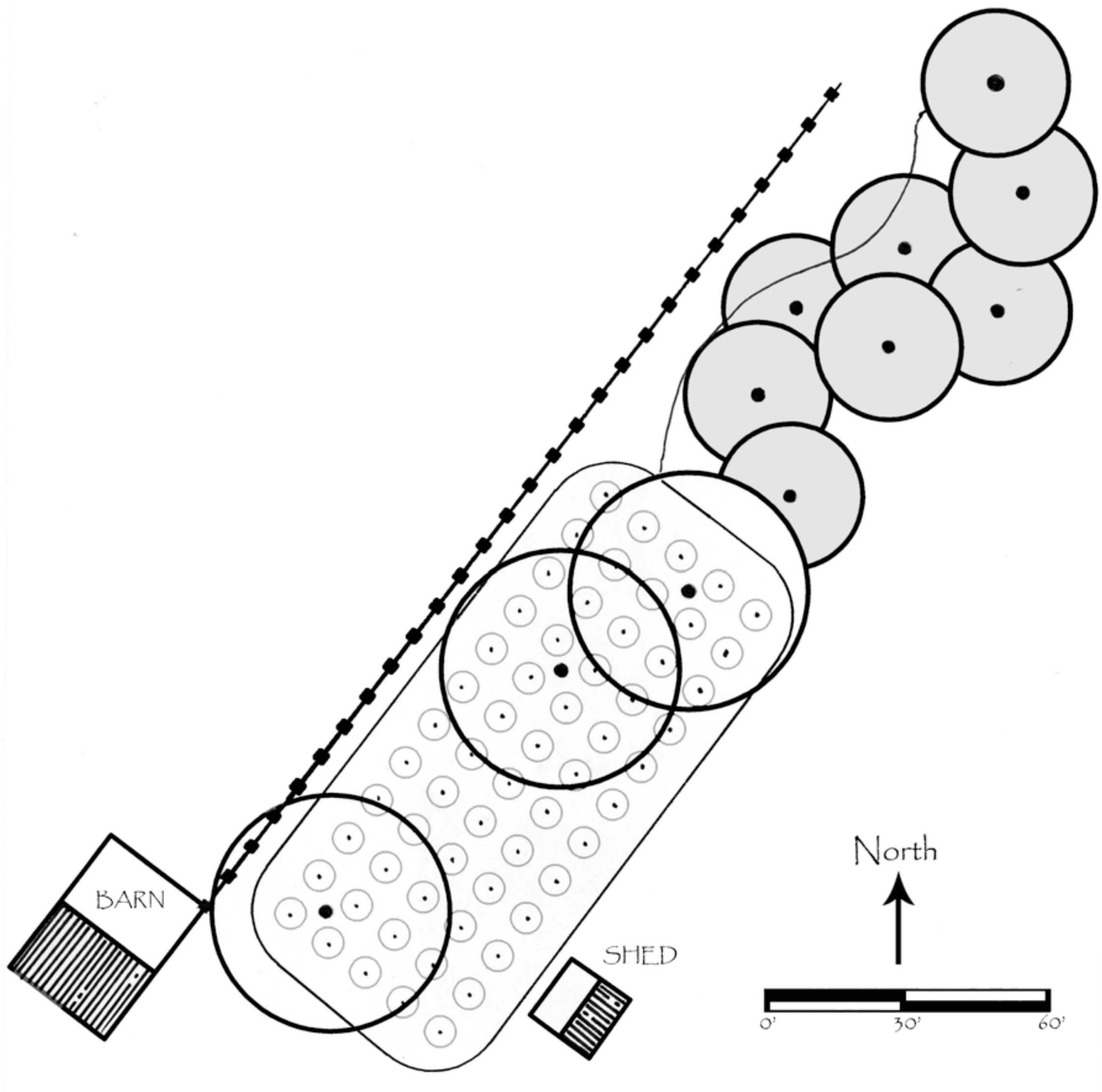
See VZ Figure 3.2 for a prototypical planting plan

Cottonwoods

Unless local cottonwood cuttings are readily available, Pipe Spring should select containerized *Populus fremontii* that have been grown in the same region, elevation, climate, soil type and hydrologic regime as the monument, or as closely matched as possible. For both the willow and cottonwood plantings, the site soil may need to be amended to produce ideal growing conditions. Both species prefer deep, well drained soils, preferably with a gravel or sand substrate.

The cottonwoods should be strategically placed to block views of administrative structures from the west cabin and rim trail views (VZ Image 3.2). The placements shown in VZ Figure 3.2 are based upon fieldwork conducted while the *Ailanthus* were leafed-out and from photos taken during the winter, after leaf loss. It is recommended that the positions be adjusted by an additional field survey once the *Ailanthus* have been removed, observing ideal locations from the west cabin and ridge trail.

VZ Image 3.2: *View of the Ailanthus grove from the west cabin. Cottonwoods should be strategically placed to screen views on administrative structures*



VZ Figure 3.2: *Schematic planting plan of new willow/cottonwood habitat. General location of existing poplars is shown in gray. Three cottonwoods are located within the basin, placed to block undesirable views from the west cabin and ridge trail. An understory of coyote willow, placed 10' on center, (should depend on the depth to the water table,. as indicated in text above) is shown below the cottonwoods. The spacing of the willows may be adjusted to accommodate available resources. The willows may be planted in a more naturalized arrangement, although even on a grid (for expediency and efficiency) they will eventually fill the space irregularly. Note: Scales and locations of features shown are generalized due to possible GPS data variability.*

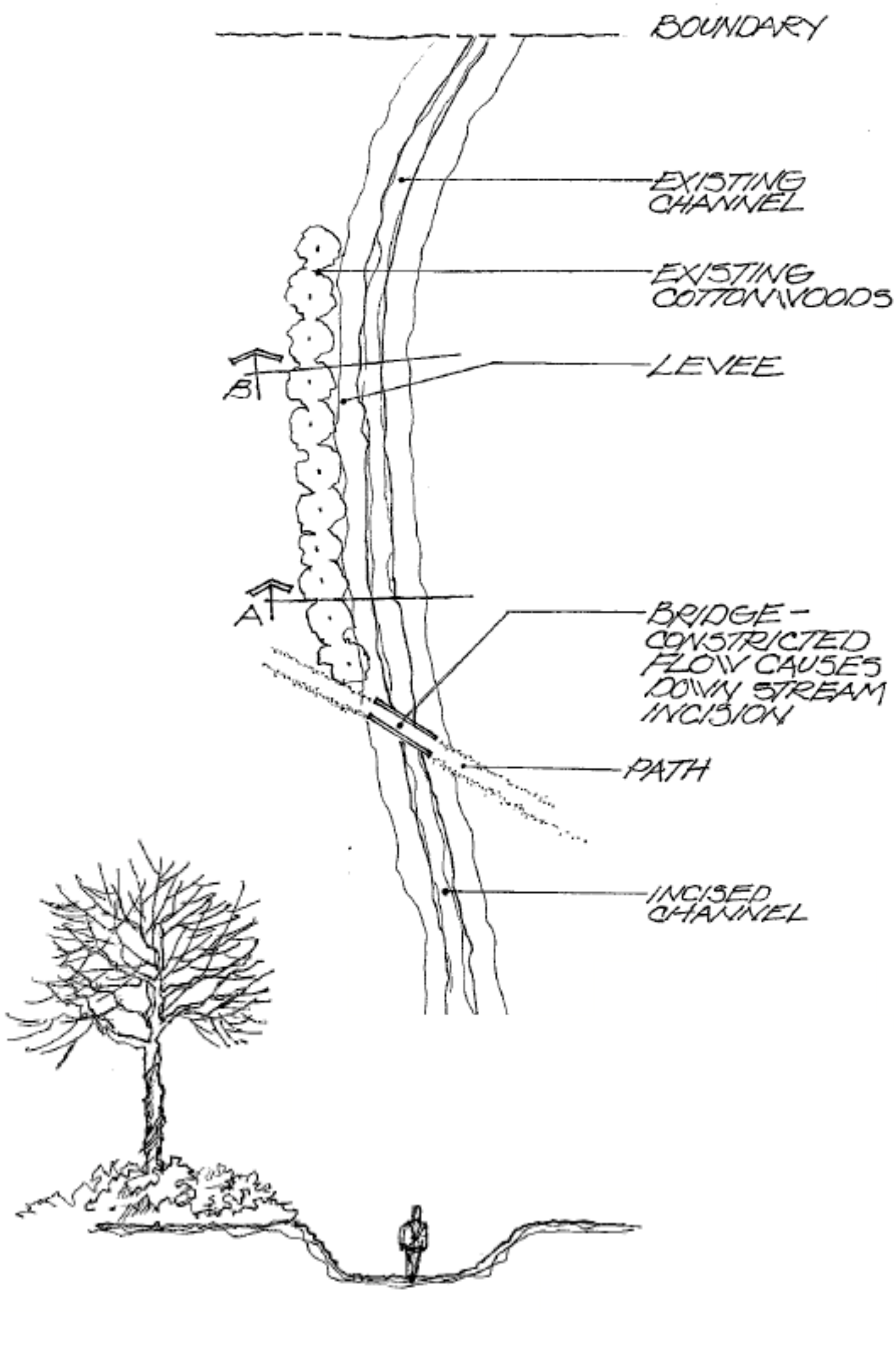
Visitor Zone

Action 4: Realign the flood ditch and redesign the cross section to enhance its ecological function and appearance, while retaining designed flow capacity.

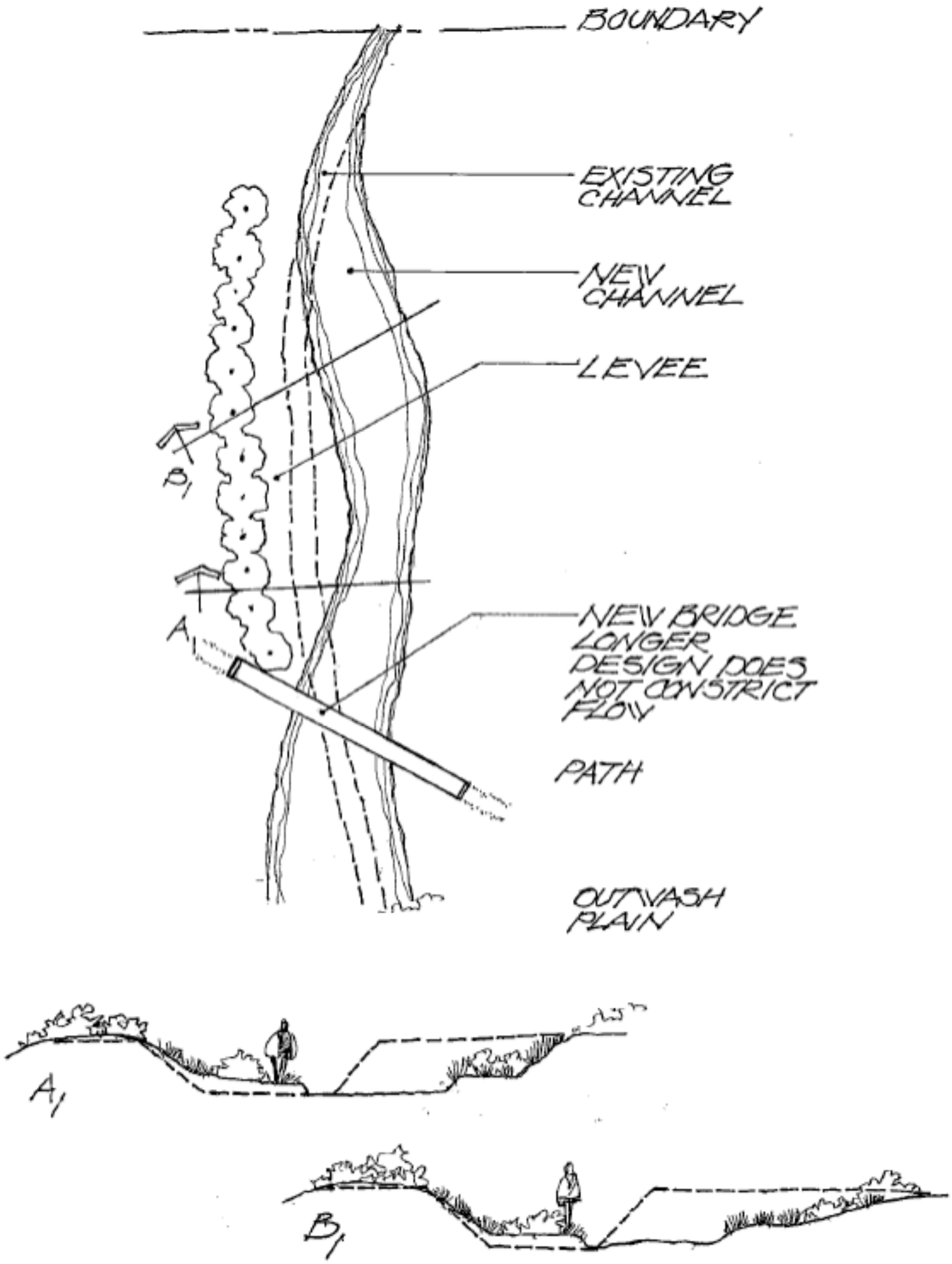
Recommended Treatment

The flood ditch is located just west of the visitor center and east of the Paiute camp and eastern corral. It runs north and south across the entire length of the monument.

The actual reconfiguration of the channel requires a more detailed survey and hydrologic engineering than can be accomplished by this report. Schematic studies from *Pipe Spring National Monument Vegetation Management Plan Phase I Alternative Actions*, 2009 are included below.



VZ Figure 4.1: *Existing channel – plan and section (not to scale) – note uniformity and depth of channel*



VZ Figure 4.2: *Proposed channel – plan and section (not to scale)*

Visitor Zone

Action 5: Save and revitalize plums along the walkway north and west of the orchard, and currant thickets along the walkway north of the orchard.

Treatment Background

Species Overview

Ribes aureum

The Golden Currant belongs to the genus *Ribes*, which includes currants, gooseberries, and jostaberries. Although *Ribes* are usually thought of as fruit crops, producing edible berries, *Ribes aureum* are also an ornamental species with desirable blooms (VTCE 2009).

Currants are generally cool climate plants, but can thrive in warmer climates if an appropriate microclimate is provided. Temperatures over 85 degrees Fahrenheit usually results in some wilting, but high summer temperatures can be mediated by the provision of partial shade, mulch, and an adequate water supply. Currants are tolerant of a range of soils, but prefer well drained silt to sandy loams with an organic matter content less than 1% and a pH within 5.5-6.5 (VTCE 2009).

Plum Species Ambiguity

Information relating to the identity of the plums is inconsistent and ambiguous. According to the Vegetation Mapping and Classification Report, the “edible berry shrubland’s” primary association is “*Prunus virginiana*-(*Prunus americana*)” with *P. americana* (American plum) described as the dominant species (USDOI 2008). Although presently there is no evidence of choke cherries (*P. virginiana*) growing in the monument, it is possible that some or all of the plums are American plums.

The most import disputed identity is that of the historically significant Pottawattamie plums. Various accounts of the Pottawattamie provide inconsistent information relating to species identity, origin, and presence of the plum at Pipe Spring.

The Administrative History of PISP, which provides the earliest mention of plum trees, indicates that the Winsor family planted two varieties of plums in the family orchard (USDOI 2007). Subsequent references are much later, beginning in 1927, when Leonard Heaton, custodian of PISP, planted numerous fruit trees throughout the monument (USDO 1997). In the 1960s Grant Heaton and Ray Mose planted a row of plums behind the administrative housing, and in 1971 additional plums were ordered for an interpretive orchard by Superintendant Tracy (USDOI 2007). Although the use of historic varieties is alluded to during the monument's interpretive period, the first direct mention of a specific species or variety is in the monument's 1977 Resource Management Plan which states that "The silverleaf cottonwoods, English elms, black locusts, ailanthus, Carolina and lombardy poplars, and Potawatomi plums, along with various other fruit varieties of which the original trees are gone, were all imported by Mormon pioneers to Pipe Spring." (USDOI 1997). Although the report indicates the Potawatomi plums were at this time no longer extant, it does go on to recommend that historic varieties be replaced, leaving the question of the present plum composition no further answered (USDOI 1997).

Prunus americana

Prunus americana, is most commonly known as the American plum or Wild plum, though a surfeit of common names can be found referring to the species, including the sandhill plum, osage plum, river plum, sand cherry, thorm plum, wild yellow plum, red plum, august plum, goose plum, hog plum, and sloe (USDA 2003).

At the turn of the century, it could be argued that the American plum was both the most prevalent and important plum species, giving rise to copious native plum varieties of commercial value (Waugh 1901, USDOI 2009). A native North American species, *Prunus americana*, was valued by many Native American groups and European explorers as an abundant source of food and materials. Among the groups with the strongest ties to the species are the Plains tribes, including the Pawnee, Kiowa, Comanche, Omaha, Teton, Dakota, Lakota, Comanche, Crow, Assinibon, and Kiow. In addition to consuming the fruits of the American plum, these groups also used the species to treat wounds and cankers and as a part of their ceremonial material culture (USDA 2003).

Ecologically, *Prunus americana* provides important avian nesting and brooding habitat and is a preferred forage of mule deer. It is also useful as a windbreak and to stabilize erosive areas (USDA 2003).

This species of *Prunus* is a large shrub or small tree, ranging from 3' to 34' tall. The leaves of the American plum are alternating, slightly toothed, shiny and green with some hairs below. The fruit is generally a reddish-purple color, oval, and o.75"-1.25" long. Although the American plum transplants readily, it is difficult to root from cuttings. Hardwood cuttings offer the most promising method, though the process is technical and may require access to greenhouse facilities (USDA 2003).

Prunus munsoniana (Pottawattamie plum)

The origin, botanical name, and spelling of the Pottawatamie plum remain unclear. According to the Capitol Reef National Park's fruit species descriptions (appendix 10), the “Potawatomi” plum is native to the middle Mississippi and Missouri watersheds and is described as “*Prunus munsoniana”*. A Fruitful Legacy, however, describes the “Pottawattamie” plum, popular in the 1930s, as an American variety derived from *Prunus Americana* (American plum) and *Prunus angustifolia* (Chicasaw plum). The Munson plum (*P. munsoniana*) is listed as a different variety (USDOI 2009). A comprehensive guide to North American plum varieties and cultivation published in 1901, includes the “Pottawatomi” plum as a variety of *Prunus angustifolia* (Chickasaw plum). The publication also insists that despite several popular alternative spellings, the correct spelling for the plum is “Pottawattamie” (Waugh 1901). Although they differ in the botanical origins of the species, the descriptions of the Pottawattomie from both sources corroborate that they are referring to the same species (see descriptions below).

According to the 1901 publication:

“Pottawattamie- Fruit medium to large, ellipsoid, with a long, slender stem; bright red, with small yellow dots and white bloom and a faint suture line; skin, rather inclined to crack; flesh firm, yellow, fine quality, cling. Midseason or a little later. Originated in Tennessee. Introduced by J.B. Rice of Council Bluffs, Iowa, in 1987. One of the best known Chicasaws, and deservedly popular. Probably the hardiest of the group. ‘It will not prove hardy north of the forty-second parallel except in favored spots.”---Budd, Iowa Bulletin 19. Professor Goff, in preparing Wisconsin Bulletin 63, received twenty reports of Pottawattamie. These generally called the variety productive and a good seller, but inferior in quality. The name as been diversely spelled, but the spelling here given in correct (pp. 199).

According to Capitol Reef N.P.’s fruit species guide

“Potawatomi (*Prunus munsoniana).* This plum is native to the middle Mississippi and lower Missouri watersheds, but was apparently translocated to the Colorado Plateau and Great Basin either by Mormons or miners. In southern Utah, it is restricted to hedgerows and vacant lots in small Mormon villages, rarely reaching beyond these anthropomorphic landscapes into truly wild habitats. Sometimes spelled Pottawattamie, or simply called the wild or hog plum, its horticultural potential first came under the notice of J.B. Rice of Council Bluffs, Iowa in 1875, who named it after one of the counties of his home state, thereafter making it available to nurserymen in many other states.

The fruit are variable in both color and size, ranging from seven-eights of an inch to an inch and an eighth inches in diameter. In shape, they are round to oval, and slightly compressed. There is a very shallow cavity on one side of them. Their skin color runs from a clear currant-red with thin bloom, to pale yellow and white. Over this basal color are a few whitish dots clustered about the apex. The skin of this plum is tough, cracking under conditions of high heat, separating readily from the flesh of the fruit. The stem of each fruit is slender, three-quarters inch long, and weakly adheres to the fruit itself. The flesh of this plum is deep yellow, juicy, tender and melting. The plum pit or stone clings closely to the flesh, is five-eights by three-eights inch in size. The pit is flattened, smooth, somewhat oval and turgid. Its dorsal suture is faintly grooved.

The trees are really dwarfish, multi-stemmed shrubs at maturity, seldom more than seven feet tall, and often forming hedges that average less than five feet in height. They are vigorous in their branching, and especially productive when receiving irrigation tailwaters, or growing alongside a ditch or a road. They are considered to be among the hardiest of the native plums, growing without danger of winter injury to tree or bud far into cold winter climes.

The Potawatomi is lauded in *The Plums of New York* as “possibly of greater cultural value” than any other wild American plum, for the flavor of its flesh is “of high quality…, the texture of the fruit being especially pleasing in eating, and though melting and juicy, it keeps and ships very well because of a tough skin. It escapes both the curculio and the brown-rot to a higher degree than most of its kind…” Elderly Mormons claimed that as children during the Depression, they survived on this fruit more than any other grown in their villages of Mt. Carmel, Caneville, Henrieville and Torrey at that time. As Lulu More of Henrieville Utah told us,

> *‘We didn’t have much food in those days when I was growing up…There Were no big orchards around here then, so when us kids could find them Potawatomi plums, it was a real treat.’”*

Dr. Mary Barkworth, a professor at Utah State University and taxonomist, believes that the Munson Plum and Pottawattamie plum as the same species, *Prunus monsonia*. She suggests that they are possibly different cultivars or that the nomenclature has been confused through time. Dr. Barkworth further suggests that specimens be taken or examined on site to determine the exact identity of the plums, specifically looking for the presence of glandular teeth, which are present in *P. munsonia* but not *P. americana* (Barkworth, 2010 pers. comm.).

Management Overview

The plum and currant thickets west of the orchard and along the walkway have been allowed to grow and spread naturally over a long period of time, producing overgrown, crowded, and aged thickets in need of rejuvenation. Generally two pruning methods are used in plum production in order to maintain healthy and productive plants (Morton Arboretum 2004):

Heading Back

Heading back is a method used to control the size and shape of an established, healthy plant. Branches are trimmed back to a bud or lateral branch. Heading back is done after the plant's new growth is finished for the season.

Renewal

Renewal is used to gradually restore the health and form of an old and overgrown shrub. Typically the renewal cycle is three to four years, removing a third of the plant's canes each year and then removing the oldest (4 year old) canes and replacing them with new canes in subsequent years.

Regular Maintenance

In addition to the pruning methods described above, a regular maintenance routine should be established to remove dead, damaged or misshapen canes. Maintenance pruning should be done throughout the year, especially after storms or drought. Any removed canes can be replaced by new canes during the next growing season.

Recommended Treatment

General Recommendations for Currants and Plums

Primary pruning should be done in the late winter, before the buds begin to swell. If the plant is stressed or has years of overgrowth, no more of a third of the plant should be pruned in one year.

The location and site conditions where the fruit hedges currently grow are generally favorable to plum and currant species, but could possibly be enhanced with more knowledge of site chemistry. Soil test pits conducted by PISP, show that the electrical conductivity (EC) of the soils along the west corral range from 2.37-2.79 dS/m (see test pits 6 and 11 in appendix 16). According to Dr. Black, these levels are near the high end for fruit crops and may require a leaching treatment. Dr. Black recommends that the EC of the irrigation water be determined in order to locate the source of the problem and determine a treatment, such as leaching, through which the soil is inundated with an appropriate water source, flushing it out (Black, pers. comm. 2009).

The plums located along the west corral tree line benefit greatly from the western shade provided by the poplars. The removal of the poplars along the west corral (see VZ 1C) may adversely affect the plums until the trees mature enough to provide afternoon shade. Some of the plums in the monument are in direct afternoon sunlight (east of the orchard) and seem to be fairing well, an optimistic sign that the plums will survive the poplar removal.

Currants

VZ Image 5.1: *Currant thicket located along the main trail*

The currants appear to be in fair condition but in need of regular maintenance (VZ Image 5.1). According to Dr. Brent Black, Utah State University fruit crop specialist, the best treatment for the currants is renewal pruning. Each year one third of the oldest canes on each bush should be removed. Ultimately, after a 3-4 year cycle every cane will be 3 years old or younger. The oldest canes are identified by diameter and condition. Heading back may be used once the hedgerow has passed through the cycle and needs only general pruning to maintain its size and shape.

Plums

Taxonomic Identification

Presently little and conflicting information exists regarding the identity of the plums. It is unclear whether or not any of the plants are of the historic Pottawatomie variety and whether or not they were grown from grafted stock. It is highly recommended that a taxonomist be consulted to shed light on this information in order to select the appropriate treatment.

Treatment (General)

Plums purchased from nurseries are often not pure stock, but have been grafted onto the base of another species or variety (Black, 2009 pers. comm.). A grafted bush can be identified by a union seam near the base of the trunk where the two plants merged. At the union some swelling may be noticeable, and the appearance of the bark will abruptly change.

If the plum is grafted, it is desirable to maintain only growths emerging from above the union. These canes will be true to the species or variety that was originally planted. Any canes below the graft union and from root shoots are offspring of the root stock (or host plant) and should be removed.

If a graft union is not visible or the plants are known to be pure, pruning should focus on removing much of the new growth and reducing the overall density of canes while maintaining the main trunk of the plant.

VZ Image 5.2: *Plum thickets located west of the orchard. The yellowing of the leaves is a sign of iron chlorosis*

VZ Image 5.3: *Signs of insect damage*

Some of the plum bushes exhibit possible signs of iron chlorosis, a yellowing of the leaves (VZ Image 5.2), and a mite infestation producing fine white webs and causing leaves to shrivel and fall (VZ Image 5.3). An integrated pest management specialist should be consulted to determine the causes and treatments for these issues (see references section for suggested contacts).

Treatment of Historic Plants

If any of the plums are positively identified as the historic Pottawattomie variety, efforts must be made to retain the genetic integrity of the plants and prioritize their growth over other varieties.

Evidence of Grafting

Essential to the preservation effort is identifying whether or not the plums have been grafted (see previous discussion). If there is evidence of a grafting seam, any shoots or plants emerging from below the seam will not be of the Pottawattomie variety and should be removed. These shoots or plants are derived from the root stock species and crown species, often exhibiting characteristics of both species or varieties (Hill 1985). Annual pruning will be required to maintain only plants from the Pottawattomie crown of each plant.

Preserving Historic Genotypes

If Pottawatomie plums are present, there is an opportunity to preserve the historic genotypes of the plants by propagating a small nursery stock. If the plums are not grafted, young root suckers can be removed and grown as a replacements for deceased plums and non-historic varieties. If the plums have been grafted, propagation must be derived from the true Pottawattomie variety above the graft union, excluding root suckers. Propagating plums from cuttings can be challenging. See appendix 2 for more information on the “layering technique”.

Visitor Zone

Action 6A: Create a native vegetation plot south of the monument trail between the monument boundary and flood drainage channel.

Note: Action 6A was established in October, 2008. Pipe Spring worked in conjunction with Zion National Park botanists and revegetation staff to develop the design, construction and management protocol for the plot. As of fall 2009 the plot has successfully produced a healthy population of native grasses.

VZ Image 6.1: *Progress of the revegetation plot in October 2009*

Treatment Background

Species Overview

Species Planted in 2008

- *Sporobolus contracus*, Spike Dropseed (potted)
- *S. airoides*, Alkali Sacaton (potted)
- *Aristida purpurea*, Purple 3-Awn (potted)
- *Stipa comata*, Needle and Thread Grass (potted and seeded)

- *Hilaria jamesii*, Galletta Grass (potted)
- *Elymus elymoides*, Squirreltail (potted and seeded)
- *Yucca utahensis*, Utah Yucca (potted)
- *Oryzopsis hymenoides*, Rice Grass (potted and seeded)

Management Overview

Zion National Park has provided Pipe Spring with a comprehensive design and management protocol based on expert knowledge and experience. Pipe Spring anticipates monitoring the plot for 4-5 years, and will then reassess its protocol.

A plot approximately 100’x120’ was cordoned off by a 4 foot hardware cloth fence above ground and two feet below, to prevent rabbit and rodent depredation, and planted with just under 500 plants. Potted plants were aligned with irrigation tubing, ensuring that each plant is irrigated. Additional species, including *Oryzopsis hymenoides* from the increase field at Los Lunas, *Stipa comata, and Elymus elymoides*, were broadcast seeded over the site. A surface drip irrigation system extends to all of the interior plants. Emitters were placed randomly along drip lines, providing an equivalent number of emitters and plants on each line. A fine layer of mulch has been applied to the entire plot. Visitors are engaged in the site by using an ADA compliant walkway and by interpretive signage along the main monument trail.

Dr. Chris Call, a grasslands restoration specialist and professor at Utah State University, and Dr. Mark E. Miller, biologist with the U.S. Geological Survey, were consulted to provide any supplemental knowledge and address several smaller issues as requested by Pipe Spring administrators (Call, pers. comm. 2009, Miller, pers. comm. 2010). This portion of the management plan provides these supplemental materials (For the full description of the plot design and implementation see appendix 2).

Recommended Treatment

Overview of Species Selection Process for Revegetation

The steps below describe the basic process of selecting appropriate plant species and community composition (Dr. Mark E. Miller 2009, pers. comm.). See appendixes 5-9 for an expansion of the following steps, NRCS Ecological Site Descriptions, USDA VegSpec reports and other information pertinent to grassland revegetation.

1. Determine the soil type.
2. Determine the type of 'ecological site' that is associated with the particular soil of interest.
3. Examine the appropriate ecological site description, and rangeland productivity and plant composition table to determine the appropriate vegetation.

4. Use population data to determine relative seed requirements for each species

Irrigation

Dr. Call recommends that Pipe Spring continue to irrigate the plot for several years, but in order to ensure that the plants do not become dependent, the irrigation system should be left in place only for occasional use in subsequent years, depending on climatic conditions and new plantings. It is recommended that Pipe Spring examine seasonal rainfall trends and distinguish weeks or months in which precipitation consistently falls below average. It may be necessary to add supplemental irrigation during these time periods as a proactive measure (Call, pers. comm. 2009).

Mulching

Although Pipe Spring has used a very finely chipped mulch, Dr. Call suggests the staff carefully monitor the effect of the mulch on seedling emergence. The seed sizes of the grasses and forbs used in the plot range from very large Indian rice grass seeds to the tiny seeds of spike dropseed. If it is too thick or coarse, mulch can prevent a broadcasted seed from finding a safe site, and an established seed from sprouting and emerging from beneath the mulch. Dr. Call suggests that Pipe Spring evaluate the coarseness of the mulch used and the thickness at which it is applied (Call, pers. comm. 2009).

Although the mulch is preventing the strong southwest winds from disturbing the soil and seeds, it is not a natural component of a grassland ecosystem and may warrant removal at some later stage once the plot has reached an aesthetically pleasing density.

Rodents

Heteromyid rodents share a symbiotic relationship with native arid grassland and shrub steppe communities, and are one of the most important ecological components in many systems. This group of rodents cache seeds as a form of food storage, which in turn, provides safe sites where many of those seeds are able to establish and grow. Although currently the grassland plot is fenced in as an attempt to prevent rabbit and gopher activity during the establishment phase, rodents could become a useful part of the system if the fence is removed later

VZ Image 6.2: *Dipodomys Merriami, Merriam's Kangaroo Rat. A Heteromyid rodent the aids in the establishment of Indian Rice Grass (http://commons.wikamedia)* in the restoration process (Call, per. Comm.; Longland 2001; Longland 2009).

Pipe Spring may want to consider a small mammal survey in order to understand the rodent population in the monument and gauge their potential in grass revegetation within the plot (if the fencing is removed) and in other sites throughout the monument. Rodents can easily be studied using small live-traps baited with peanut butter and placed in various habitat types throughout the monument. Recording the presence or absence of rodent species may indicate whether there is a healthy population that could assist in revegetation and could possibly recommend certain sites within the monument for additional revegetation projects.

Visitor Use Zone

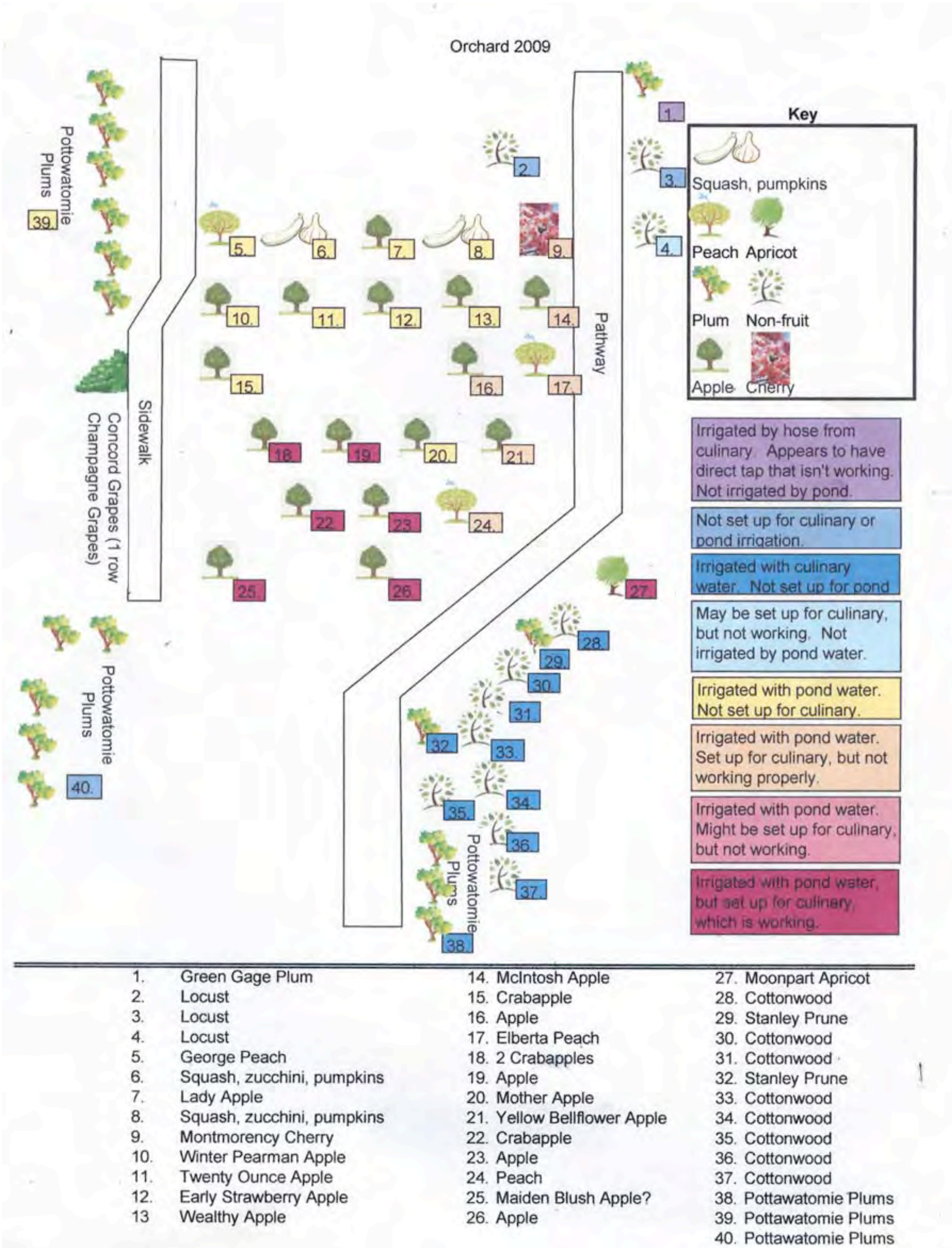
Action 7: Revitalize Orchard.

Treatment Background

Chronological History of the PISP Orchard

The following chronology is compiled based on research summarized in the 1997 CLI (USDOI 1997).

1863	Whitmore cultivates grape, peach, apple and other fruits
1872	The Winsor family plants peaches, apples, and two varieties of plums.
1888-1889	Mrs. Min Adams, PISP resident during the Woolley era, states that there was “a good sized fruit orchard on south of the ponds”.
1926	Leonard Heaton, NPS custodian of PISP, plants peach trees, grapes, gooseberries, and currants.
1927	Leonard Heaton plants 54 apple and plum trees south of the fort
1964	PISP is developed as a “living history” site
1971	Fruit trees are ordered to be planted to develop visitor demonstration areas.
1973	NPS constructs an orchard and garden south of the fort ponds in order to recreate the historic scene. The design is informed by very limited historic data.
1972	A new well and pumping station are constructed and gravity-flow irrigation systems are abandoned. The location of the orchard is no longer dependant on historic gravity-flow systems and the orchard. The
1973	Operations Evaluation Report states that “locations and size of gardens are suspect, modern irrigation is incongruous and varieties of crops planted probably are not historically accurate”.
1970s	Late in the decade more attention is given to the selection of historic crop varieties.
1979-1989	During Superintendent Bill Herr’s administration, additional fruit trees of historic varieties are planted and irrigated by underground pipe irrigation systems.
1980s	Many fruit trees are planted and provided with underground irrigation, abandoning the historic surface flow system.
Present	South of fort ponds, an orchard of 22 fruit trees, including apples, peaches, cherries, and apricots are planted in a grid. The grid is square, with wider spacing between rows than between individual trees. Plums, grapes, and currants are planted in small grouping along the perimeter of the orchard and interpretive trail. The date for the establishment of the existing orchard has not been determined.

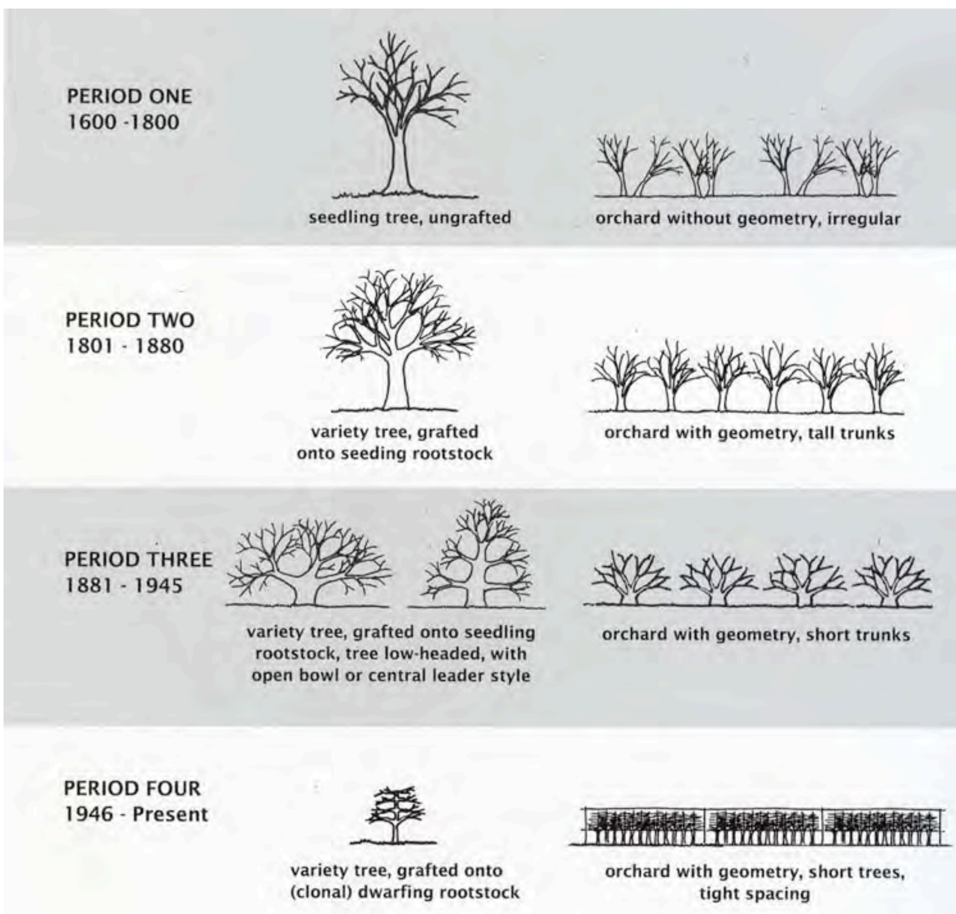


VZ Figure 7.1: *2009 orchard configuration and species composition (Stone 2009)*

Historic Context for the PISP Orchard

The book "Fruitful Legacy: A Historic Context of Orchards in the United States", provides the following summary of the evolution of fruit orchards in the United States (USDOI 2009, p. 4):
:

- 1600-1800 European fruit trees were introduced and planted for both subsistence farming and pleasure.
- 1801-1880 Collectors and entrepreneurs developed fruit technology, and regionalism.
- 1881-1945 Orchard development focused on commercialization, technology, and regionalism.
- 1946-Present Orchard production intensified and dwarf trees became commonplace.



VZ Figure 7.2: *Diagram of the four periods in the history of American orchards (USDO 2009, from Dolan 2006)*

Using this breakdown, the orchards planted during the period of significance at Pipe Spring (1863-1895) fall within two different evolutionary periods. Orchards of the Whitmore, and Winsor eras fit within stage two, *1801-1880: Fruit Diversification and Migration*. Those planted during the Woolley era fit in stage three, *1881-1945 Orchard Specialization and Industrialization.* The two stages are summarized below to provide a contextual overview of orchard practices typical during the period of significance.

1801-1880: Fruit Diversification and Migration

Overview of Defining Features and Developments:

- Shift from cider and livestock-quality fruit to edible fruits (in smaller quantities, even in remote western farms).
- Grafting and planting (vs. sowing) becomes standard
- Cider apple orchards continue to sow seeds
- Abundant varieties are developed to produce edible, flavorful fruits. Varieties become local and national symbols
- Early commercial orchard development and spread by settlers traveling west
- Little pruning or other management practiced
- Use of seedlings rather than seeds affords a shift from irregular orchard forms to more geometric forms
- Tree form continues to be defined by tall trunks and natural forms, allowing livestock to graze on orchard floors.

Narrative of Historic Context (1801-1880)

The “golden age of pomology”, the second major era in American orchard development, is a period defined by blossoming national pride engendered by the development of copious fruit varieties with flavors and forms unique amongst the fruits of the world. The adaptability of these American varieties soon gave grafted trees a leading role in small farm orchards, replacing unpredictable seed stock and allowing farmers to consistently reproduce flavorful, edible fruits.

Emerging as leaders in the development of new varieties, were apples and peaches. While the nation was producing abundant, highly localized apple and peach varieties, pears remained unpopular and difficult to grow in much of the country. The development of true American varieties of pear, however, prompted an explosion of interest in pear breeding from 1820-1860, until the fire blight epidemic struck pear orchards nation-wide.

Two other achievements, the development of pesticides and the completion of the Transcontinental Railroad, changed the way in which orchards were managed during the later half of the century. The devastating effects of widespread disease in the late 1800s afforded science and technology new roles in fruit production. Prior to the availability of pesticides in the 1880s, hand control methods and livestock were the primary means of controlling insects and disease. Trees were manually scraped or washed with soap to remove surface infestations and shrouded in smoke to kill moths.

Although the Transcontinental Railroad prompted the development of commercial orchards throughout the west, many small western orchards were still lagging behind the rest of the nation. Much of the lag was a result of the 1862 Homestead Act, which by providing a property title to those who improved and cultivated their land within five years, resulted in an abundance of inexpensive and hastily planted orchards, which once established, were abandoned for five years. The consequence was a harsh western landscape punctuated by small formless orchards of randomly placed, unkempt, seed-grown trees with very few true varieties. However, once the five year probation period was completed more permanent residents often improved the crude subsistence orchards by incorporating more trees of true varieties.

One of the greatest influences of the era was Andrew Jackson Downing, Jr., author of "The Fruits and Fruit Trees of America", 1847. Downing's influence extended well beyond his death, at least fifty years after the publication of the first edition of his book, and reached farmers as far west as the Mormon settlements in Utah.
Specifically, the popularity of several techniques and practices in farm orchards (but not gentleman's orchards) demonstrate Downing's authority:

- A lack of pruning. Downing did not endorse pruning beyond what was necessary to remove dead wood (VZ Images 7.1,7.2, and 7.3).
- Wider spacing than was commonly practiced at the time. Downing recommended a 30' grid for apple and pear orchards, and a 16'-20' grid for peaches, cherries, and plums.
- Full sized trees. Dwarf varieties, although available in some nurseries, were not endorsed by Downing (VZ Images 7.1,7.2, and 7.3).
- Grafting close to the ground. This practice helped hide the unsightly graft union.
- "heading high". This refers to height and shape of the tree, maintaining a tall trunk (up to 6') and keeping the fruit out of the reach of animals browsing the orchard floor. This tree form was more easily managed in the late 1800s with the development of specialized equipment such as tall picker's tripod tree ladders. (VZ Images 7.1,7.2, and 7.3).
- Single variety orchards. Downing recommended that single varieties be planted in rows, reducing the labor of harvesting and producing an orderly form.

According to " Fruitful Legacy " (USDOI 2009, p. 54):

> " For the next 50 years, as the many editions of ["The Fruits and Fruit Trees of America"] were published, the typical apple and pear orchard

would have a 30-foot grid spacing, with very large, almost entirely unpruned trees, bearing high canopies on three-to-six-foot tall trunks."

VZ Images 7.1, 7.2, and 7.3: *Photographs of trees exhibiting characteristics typical of 1801-1880 period. Note the tall trunks and large, unpruned forms (USDOI 2009, USDOI 2009, USDOI 2009, from Dolan 2001, 2006)*

1881-1945 Orchard Specialization and Industrialization

Overview of Defining Features and Developments:

- Orchards maintained by horticultural practices advanced by university research
- USDA forms in 1870s, promoting scientific advancement in orchard management, including pesticides, mechanical irrigation, and tractor-powered equipment
- The federal government becomes that dominant leader in the new commercial orchard industry
- Orchard form is defined by more regular spacing and wide row spacing to allow equipment to move through the orchard
- Tree form altered by pruning trees into central leader and open bowl forms, creating shorter trunks and excluding most livestock from orchard floors.
- The number of varieties available plunges from the hundreds to tens

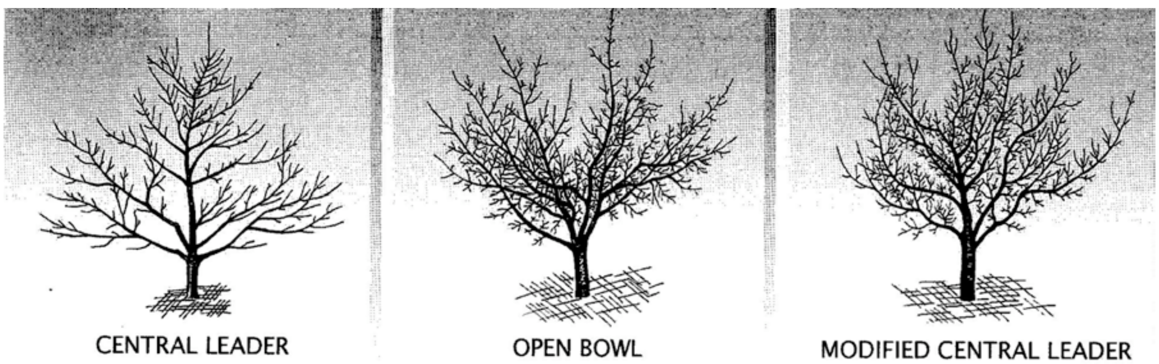
Narrative of Historic Context (1881-1945)

Described as the Industrial Revolution of the fruit industry, this period ushers in the modern era of orchard development. Increased dependence on new technology and devastating losses in the diversity of fruit varieties were accompanied by transfer of control to the federal government and a standardized, professional orchard industry. In the western part of the country the number of apple orchards grew, fueling a competitive rivalry between the two coasts.

VZ Image 7.4: *Low-headed apple tree planted in 1899 in the Flat Top Orchard, Moses Cone Estate, NC (USDOI 2009, from Dolan 2001)*

The shape, size, and management of orchards and their trees also shifted during this era to forms conducive to a more standardized, commercial industry. Downing's "high-headed" tree forms were replaced by "low-headed" forms early in the 20th century (VZ Image 7.4). At trunk heights of 18"-36", the low-branching trees were more easily maintained and harvested, excluding livestock (with the exception of poultry) from grazing the orchard floors. Fences, hedges, and other barriers designed to exclude livestock became a part of the orchard structure.

New pruning techniques accompanied the low-headed tree forms, allowing, for the first time, the size of the tree to be controlled. The two most popular techniques, still used today, produced “central leader” and “open bowl” styles (VZ Figure 7.3). Central leader (or pyramidal) pruning produces a “scaffold” of well- spaced branches, leaving space for light penetration between layers, or whirls, of nearly horizontal branches moving up the tree, and producing stronger crotches and more blossoms. The second style, open bowl (or vase) style, allows light to reach all parts of the tree by removing the central leader, creating an open center, and training 3-5 shoots as major “scaffold” limbs. Although it produces weaker crotches than the central leader style, the height of the tree can more easily be controlled by an open bowl pruning technique.



VZ Figure 7.3: *Diagram of three tree pruning styles popular in orchards in the 1881-1945 period (USDOI 2009, based on Tukey 1964)*

VZ Image 7.5: *Historic photograph showing rectangular spacing in a low-headed apple orchard in the 1910s, near Canon City, CO (USDOI 2009, from the Denver Public Library)*

As technology advanced, the tractor replaced livestock as the primary means of transporting farm equipment. An adapted orchard form followed, replacing the 20’-30’ square peach and plum orchards of the past century with rectangular shapes. Wider spacing (20’) between rows accommodated wider, low-headed tree forms and allowed equipment to navigate the orchard grid, but close spacing (15’) between trees within a row maximized the orchard’s yield (VZ Image 7.5). Apple and pear orchards were also more widely spaced, providing room for the low-headed trees and increased yields.

Irrigation also took a more technological turn approaching the turn of the century, though irrigation systems were typical of only western arid or semi-arid orchards, and were rarely found in the eastern part of the country. The hand-dug, open irrigation ditches characteristically associated with Mormon settlements were used at this time, as were converted miner's ditches used by settlers traveling along the Oregon and California Trails. Even commercial orchards were irrigated with ditches hand-dug by laborers. Technology in the industrial orchard age gave rise to more advanced systems lined by concrete or clay tile. Rather than moving water as sheet flow, the new systems incorporated a series of secondary ditches controlled by wood gates, delivering a controlled flow of water to individual trees. Ultimately the ditches were enclosed and converted to steel pipes run by pumps. Many of the advancements in irrigation were fueled by federal and private initiatives to irrigate the west.

The third era in orchard development closed with the loss of large numbers of orchards following the Dustbowl and Great Depression. During these events and afterwards, the CCC became a major player in both removing abandoned orchards and recreating historic orchards for the National Park Service. According to "Fruitful Legacy", the majority of old fruit trees, predominantly long-lived species such as apples, pears, oranges, and cherries, and historic orchards in the NPS are from this era (USDOI 2009, p. 110).

Selecting a Reference Period

As a first step, Pipe Spring's administration must select a reference period for the design and management of the orchard. This does not necessarily require selecting a specific date but could simply refer to one of the two general periods in orchard history that correspond to the monument's period of significance. Many factors may play a role in selecting the most appropriate period, including existing conditions, maintenance requirements, support of contributing and significant features, interpretation, and practicality. Once a period has been selected, however, administrators can ensure that the orchard is managed to provide a consistent and clear interpretation for visitors.

After early references to the subsistence orchard and later 'living history' orchard established on site, the history of the orchard at Pipe Spring becomes ambiguous. In its present configuration, however, the orchard more closely resembles forms typical of the latter part of the monument's period of significance (VZ Image 7.6). The orchard contains several true varieties on an organized grid with rows of trees spaced wider than the trees within each row. The tree forms are short-headed (low trunks) and pruned. Irrigation is provided by an open earthen canal from the two ponds south of the fort, which is then channeled through secondary canals down each row and to each tree. Water is controlled at each row and tree by sandbags (VZ Image 7.8, 7.9). All of these characteristics are consistent with the later part of the monument's period of significance and the third period in orchard development in the United States.

VZ Image 7.6: *View of the orchard at Pipe Spring from below the ponds, 2009*

Many of the decisions to be made by the monument's administrators will depend on the selected reference period for the reconstruction. There is precedent for representing multiple periods within a single orchard when it has obtained historic significance during multiple periods, such as the orchard at the Adams National Historic Site, which represents several generations of association with Presidents John and John Quincy Adams (USDOI 2009). Although within such a small orchard multiple reference periods could detract from the interpretive quality of the orchard, Pipe Spring may choose to temporarily represent multiple periods as it transitions from the orchard's current configuration to either an earlier period's design or a more historically accurate version of its present design.

As disciplines such as history and anthropology recognize, there is frequently a lag time associated with culturally diffused phenomena. Often a trend that appears to predominate in a country or region has not reached all local cultures. Isolation, transportation, emigration, local cultural values, local economics and other factors often interfere with the synchronized and homogeneous adaptation of cultural phenomena. The histories related in the previous section represent general trends within a given time period. Although a breadth of locations and scales are represented, the specific context for the development of orchards at Pipe Spring may not be accurately represented by national trends. Pipe Spring is unique in both its oasis setting within an extremely remote and harsh environment and its use as a tithing yard by the LDS church. The provided trends should supplement facts gleaned from historic records and documentation of the monument's orchard and those in its vicinity.

Action 7A: The spacing and distribution of fruit trees in the present orchard does not create a strong visual grid. Downsize and fill in the existing orchard with additional fruit trees representative of the historic period (apple, peach, apricot, and plum).

Recommended Treatment

Two primary references inform the following recommendations for actions 7A, 7B, and 7C. The previously cited publication "Fruitful Legacy", authored by Susan Dolan, is a comprehensive reference providing a history of orchards in the United States and technical information for registering orchards in the National Register of Historic Places. The book has recently been published by the Olmsted Center for Landscape Preservation and will be available this year. Contact Charlie Pepper, Deputy Director of the OCLP, for more information (see references).

VZ Image 7.7: *An orchard located in Capitol Reef National Park (Capitol Reef National Park 2010)*

Wayne Hanks, manager of Capitol Reef National Park's orchards, provided additional valuable information regarding orchard restoration. Capitol Reef was selected as a primary reference because of its attention to historic detail, geographic proximity and climatic similarities with PISP (VZ Image 7.7). The orchards at Capitol Reef are designed based on historic data ranging from 1884-1946, overlapping in part with Pipe Spring's period of significance (1863-1895). Additional resources and historic orchard restoration projects are listed in the references section.

Spacing and Species Distribution

Wayne Hanks, manager of the Capitol Reef orchards, recommends a spacing of 20'-24' between trees, which is consistent with the PIPS orchard's present 20' spacing. These measurements have been selected for the Capitol Reef orchards based on research conducted by the park's cultural resources staff, though many of the park's orchards date into the mid 20th century. According to "Fruitful Legacy", the many farmers adhering to the guidelines promoted by Andrew Jackson Downing Jr. would have spaced their trees on a 20'-30' square (average) grid during the early part of the Pipe Spring's period of significance, though narrower spacing was more common of the commercial orchards of the period. Near the turn of the century, during the later part of the monument's occupation, trees were spaced more regularly at an average of 15', with wider rows 20' apart.

According to the Capitol Reef National Park Cultural Landscape Inventory, pioneer orchards were often composed of a mix of species, rather than the single-species groupings used in modern orchards. This information is consistent with "Fruitful Legacy" which describes the numerous local varieties available and valued by farmers in the early to mid 19th century, though Downing did recommend single variety orchards. Later in the monument's period of significance, single species orchards became more common. Specific forms were associated with these orchards such as rectangular (vs. square) plum and peach orchards.

Once Pipe Spring has established a reference period, the existing orchard can be transitioned or adjusted to meet the historic qualities described above.

Species

Species selection for an historic orchard can be complicated due to the loss of so many historic varieties. Many nurseries and organizations do, however, provide heirloom varieties. Capitol Reef may prove to be a valuable resource for plant materials and information. Hanks has established a relationship between Capitol Reef National Park and Dave Wilson Nursery, California. Together, they have preserved and propagated a number of historic varieties from historic remnant trees within Capitol Reef and surrounding communities. The nursery collects cuttings on-site during the winter, grafts the cuttings at their facilities and sends them to Capitol Reef. Although copious heirloom species can be ordered from specialized nurseries in the East, the tree varieties grafted in California are descendants of the trees brought to the locality by early settlers.

Ranger Hanks has suggested the PISP contact Capitol Reef and the Dave Wilson Nursery to discuss the possibility of obtaining local, historic cuttings from Capitol Reef's stock. See references for contact information.

For more information on historic varieties see the following references:

- For a detailed summary of Capitol Reef's historic fruit varieties see Appendix 10 *Capital Reef National Park: List of Fruit and Nut Varieties, Including Heirlooms*.

- For a detailed narrative describing the history of varieties in the U.S. see “Fruitful Legacy” (USDOI 2009).

Form and Pruning

The reference period selected by Pipe Spring will play a large role in the form and pruning of the orchard trees. Early orchards from roughly 1800- 1885 were “tall-headed” and left unpruned. These trees were usually tall, with trunks of up to 6’, and irregular in shape and form. This form would require very little maintenance, apart from removing dead limbs, and could complement the rugged nature of the monument’s pioneer landscape.

The later style, after 1885, was much more formal and maintained. According to Hanks and “Fruitful Legacy”, trees in these pioneer orchards were generally pruned to one of three shapes: Open Vase, Modified Leader, and Standard. The pruning was not dramatic, and simpler than many modern pruning methods. For a detailed description of the two most popular forms, Open Vase and Modified Leader, and how they are achieved see appendix 11.

Additional Elements

Additional elements present in many orchards during Pipe Spring’s period of significance include livestock, (cattle and chickens), and barriers such as fences and hedges. These components are not recorded in the monument’s historic documentation, with the exception of a currant hedge surrounding the garden during the time it was adjacent to the orchard. If a later reference period is selected, the monument could include these elements by recreating a currant hedge around the southern and eastern boundaries of the orchard, not obstructing visitor views but providing additional screening of the housing area and adding definition to the orchard space. The monument’s chickens could be allowed to graze the orchard floor once a cover species is established.

Action 7B: The ground surface below the orchard is prone to invasion of exotics, making it difficult to maintain. The lack of ground cover may be causing a concentration of salt in the soil. Plant a cover crop in the orchard.

Recommended Treatment

Historically, both alfalfa and orchard grass were commonly used as a cover crop below pioneer orchards (Wayne Hanks, pers. comm., USDOI 1997). Alfalfa was grown by necessity, providing forage for large animal stock, and habitat for important pollinators such as bees (Wayne Hanks, pers. comm.). A Cover crop may also function as a soil stabilizer and regulator of temperature and nutrient and water uptake.

Although alfalfa is historically compatible, it establishes slowly and may require a temporary nurse crop. Hanks uses alfalfa is some small areas, but generally recommends orchard grass as a more effective cover crop. According to Hanks, orchard grass is used in most of Capital Reef's orchards because it is fast growing, easily maintained (mowed four times a year) and is not a food source for wild animals. Given Capitol Reef's arid climate and alfalfa's high water demands, Hanks grows it only areas where it can be used for cattle forage. In light of the few outweighed benefits of alfalfa, and Pipe Spring's need to conserve water and reduce herbivory, orchard grass appears to be a more effective choice.

Action 7C: Maintain surface flow system utilizing gravity flow from pond for historical interpretation, retaining the existing pressurized system as back-up in the event of low spring outflow. Note: This item has been changed from Phase I of the report. "Maintain" has replaced "reconstruct" in order to amend incorrect observations in Phase I of the report.

Recommended Treatment

At present the orchard is irrigated by earthen ditches directing water from the ponds to channels along each row, collecting in circular berms around each tree. Flow is controlled by sand bags used to dam water and divert it into channels (VZ Images 7.8 and 7.9). In addition to maintaining the current surface flow system, the irrigation channels may be reconstructed by combining the channels in each row into a single terrace. The design would terrace the entire orchard by row. Pipe Spring is currently pursuing this option and believes that irrigation terraces will improve the efficiency of the system and deter rabbit herbivory (Bornemeier, pers. comm. 2009). The University of Arizona currently uses the terrace system for its historic entryway and could be a source of additional information (Johnson, pers. comm. 2010).

VZ Images 7.8 and 7.9: *Present irrigation system at PISP. Note the use of sandbags to control flow and water detention around individual trees. Future plans include expanding each row into a single flooded terrace*

Visitor Zone

Action 8: Widen all concrete walks in the VZ from visitor center to the fort.

Recommended Treatment

Action VZ 8 is proceeding this summer (2010) using stimulus funding. See AZ 2 for information on porous concrete as an alternative to traditional concrete paving.

Visitor Zone

Action 9: Phased removal of the cottonwood tree line on the west side of the flood ditch

Recommended Treatment

Cottonwood Removal

The *Populus alba* growing along the flood ditch should be removed as each tree reaches a critical state of decline. This critical state should be determined by aesthetics, safety and tree health on a tree by tree basis. For more information on assessing tree health, see appendix 3.

Follow the procedures described in VZ 2 for cut stump treatments to remove selected cottonwoods and for foliar treatments to curb root suckering and regeneration.

Naturalizing and Screening

As the *Populus alba* are removed some limited screening of the Red Hills community will be lost. Screening may be reestablished by either planting pinyon and juniper trees directly adjacent to the visible housing and allowing the flood ditch to naturally revegetate with junipers, or by supplementing established junipers* along the flood ditch with junipers planted in naturalistic clumps. A combination of both treatments (planting adjacent to the housing and along the flood ditch) may also be used. In either case, established junipers must be protected and conserved during the removal of the cottonwoods. Junipers are very slow growing species and establishing a screen, either adjacent to the housing or along the flood ditch, will not produce immediate results.

*The natural composition of the woodland below the ridge appears to be almost entirely junipers, with pinyon pines appearing only at the higher, ridge-top elevations.

Planting Adjacent to Red Hills Housing

Although pinyon pines planted along the flood ditch do offer some screening from the interpretive areas below the ponds, a naturalized clumping pattern will not screen the houses from every perspective as visitors move around the visitor zone, and the Red Hills housing complex will still be visually intrusive as viewed from much of the historic district zone.” It is therefore recommended that establishing a pinyon-juniper screen directly adjacent to the housing be prioritized (see TZ 1). Once the housing is directly screened, the replacement of the cottonwoods with junipers will no longer be necessary, aside from providing additional screening. The flood ditch can then be revegetated naturally by the surrounding junipers, conserving the effort and water that would be necessary to plant additional trees.

Supplementary Plantings along the Flood Ditch

If the Red Hills homes cannot be screened directly, additional juniper plantings may be necessary along the flood ditch to provide some screening from the visitor zone (VZ Figure 9.1). Taking into account established junipers, a natural clumping pattern based on the surrounding woodland should be used as a template for planting additional trees (VZ Figure 9.2 and VZ Image 9.1). The young junipers may need drip irrigation until they are established.

Figure A

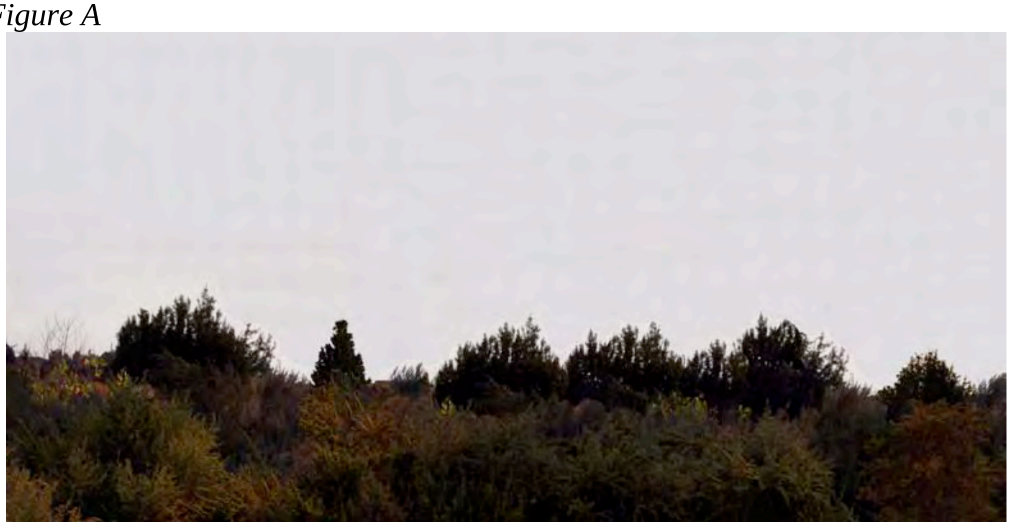


Figure B

VZ Figure 9.1*: View from visitor zone demonstration area before (Figure A) and after (Figure B, visual simulation) cottonwood removal and supplementary juniper planting*

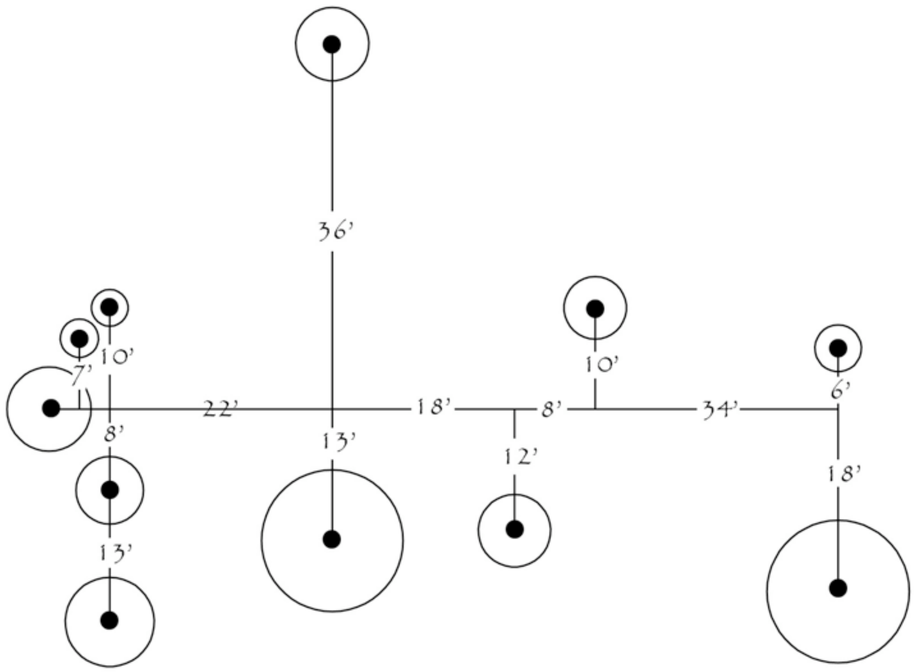


Figure A

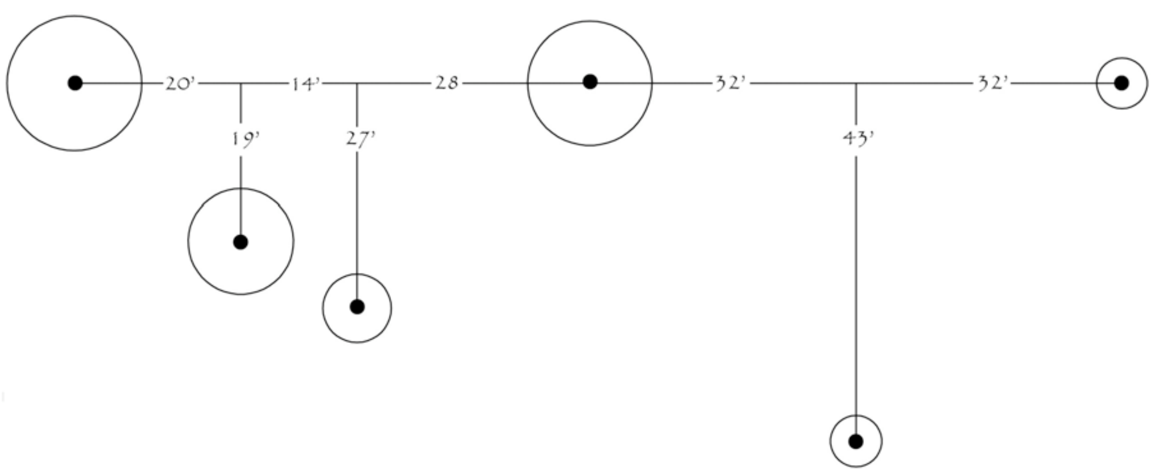


Figure B

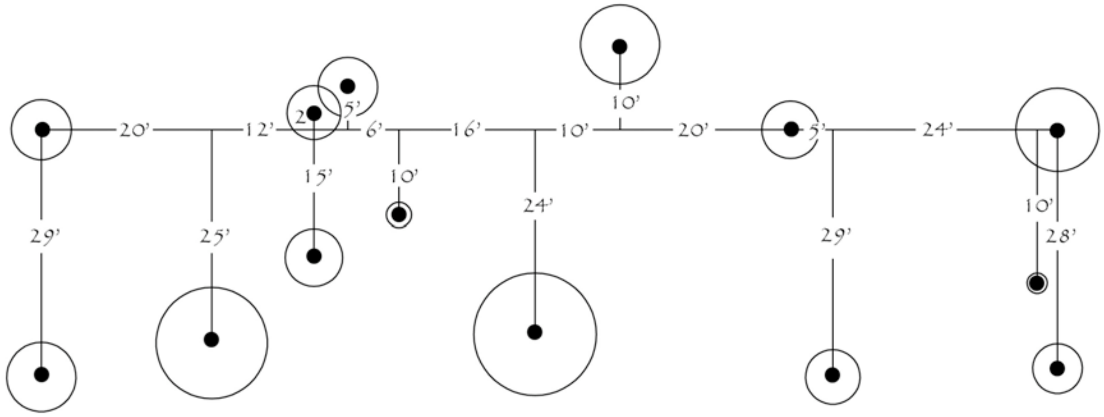


Figure C

VZ Figure 9.2: *Transects of junipers taken at three locations, moving from the lower elevation woodlands adjacent to the main park road to the higher elevation woodlands north of the chicken house and east cabin. Relative size composition and distances between juniper trees (shown as circles) are shown. Note: None of the trees surveyed were pinyon pines. This species appears to be growing only at the highest elevations on top of the plateau but may be substituted for added diversity or interest if site conditions (soils and temperatures) are compatible*

VZ Image 9.1: *Natural pinyon-juniper community composition at higher elevations surrounding Pipe Spring*

Visitor Zone

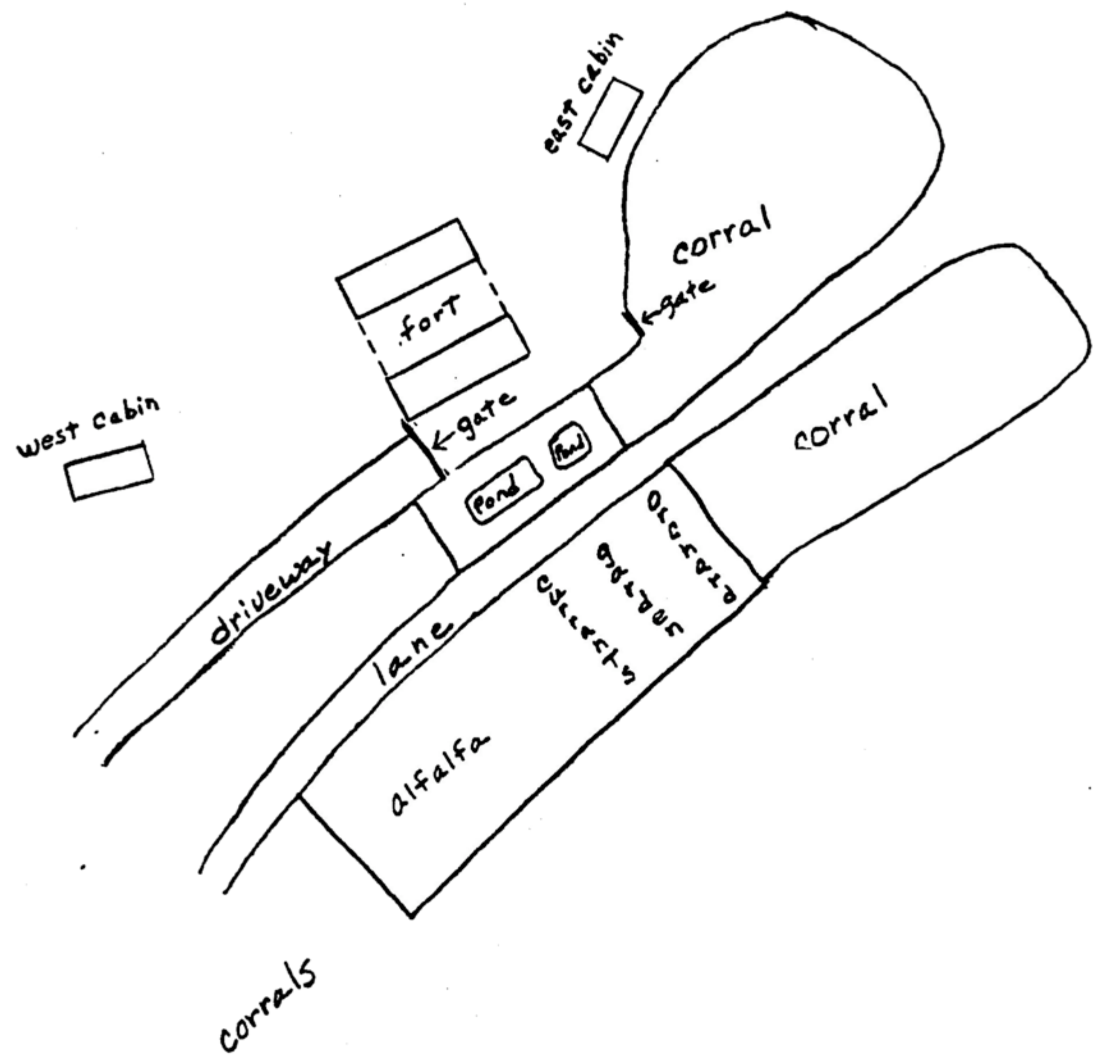
Action 10: Consider relocation of demonstration garden to historically accurate location below ponds.

Treatment Background

Chronological History of the PISP Garden

The following chronology is compiled based on research summarized in the 1997 CLI (USDOI 1997).

1863	James Whitmore and Robert McIntyre built a dugout and within a couple of years, cleared eleven acres for crops, a small vineyard, and orchard.
1870	Winsor sends his son Anson Jr. to establish a garden…
1873	The Winsor family locate their garden south of the two ponds and just west of the orchard and surround it with currant bushes. In the garden they grow tomatoes, corn, potatoes, squash, and pumpkin.
1888-1889	Mrs. Min Adams mentions that there was a "good sized fruit orchard on south of the ponds also the garden was down that way"
1971	A flood destroys the garden and washes out several fruit trees and the drainage channel. Numerous fruit trees, grape vines, and garden seeds are ordered to be planted for demonstration areas.
1973 (circa)	With very little historic data to guide their efforts, an orchard and garden were cultivated south of the fort ponds in an attempt to recreate the historic scene. Thanks to a new well and pumping station, the location of the garden and orchard was no longer dependent on the historic gravity-flow system from the natural springs.
1973	The operations Evaluation Report stated that "locations and size of gardens are suspect, modern irrigation is incongruous, and varieties of crops planted are probably not historically accurate".
Late 1970s	The garden area was eventually relocated to its current site, east of the corrals, at a higher elevation than the historic gravity-flow system could ever have accommodated.



VZ Figure 10.1: *Map of Pipe Spring based upon Dilworth Woolley's description as it looked in 1886*

Recommended Treatment

Redesign

Very little information pertaining to the design of the garden can be gleaned from the available research. One known historic element is a hedge of currants surrounding the garden in the late 19th century (USDOI 1997). Recreating the current hedge would serve several purposes (VZ Figure 10.2, 10.3). In addition to providing an historic interpretation, the currant hedge would give spatial definition to the garden and provide a screen behind which a low fence could be hidden to prevent rabbit and rodent herbivory. Kept below eye-level, the currents would allow more visual access to the garden than the tall fencing presently used.

Relocation

According to the sketch of Pipe Spring based on Woolley's description (VZ Figure 10.1), the currant orchard is the west of its 1886 location. There is, however, adequate space to the east of the orchard for the relocation of the demonstration garden, which, although not reproducing the exact historic relationship between the orchard and garden, would place the garden adjacent to the orchard and in a much more logical position lower in elevation than the ponds. Moving the garden to this location would allow for at least partial use of a historic gravity-flow irrigation system, creating a richer interpretive experience for visitors. Outflow from the pond could be augmented with well water added to the ditch system to provide adequate water for surface irrigation. This location would also provide some additional screening of the administrative area, especially if taller crops, such as corn, are strategically placed.

Two mature locust trees are growing in this location, producing some filtered shade in part of the proposed garden. There are, however, vegetable varieties that grow well in shaded conditions and could be placed beneath the trees.

Establishing a Boundary

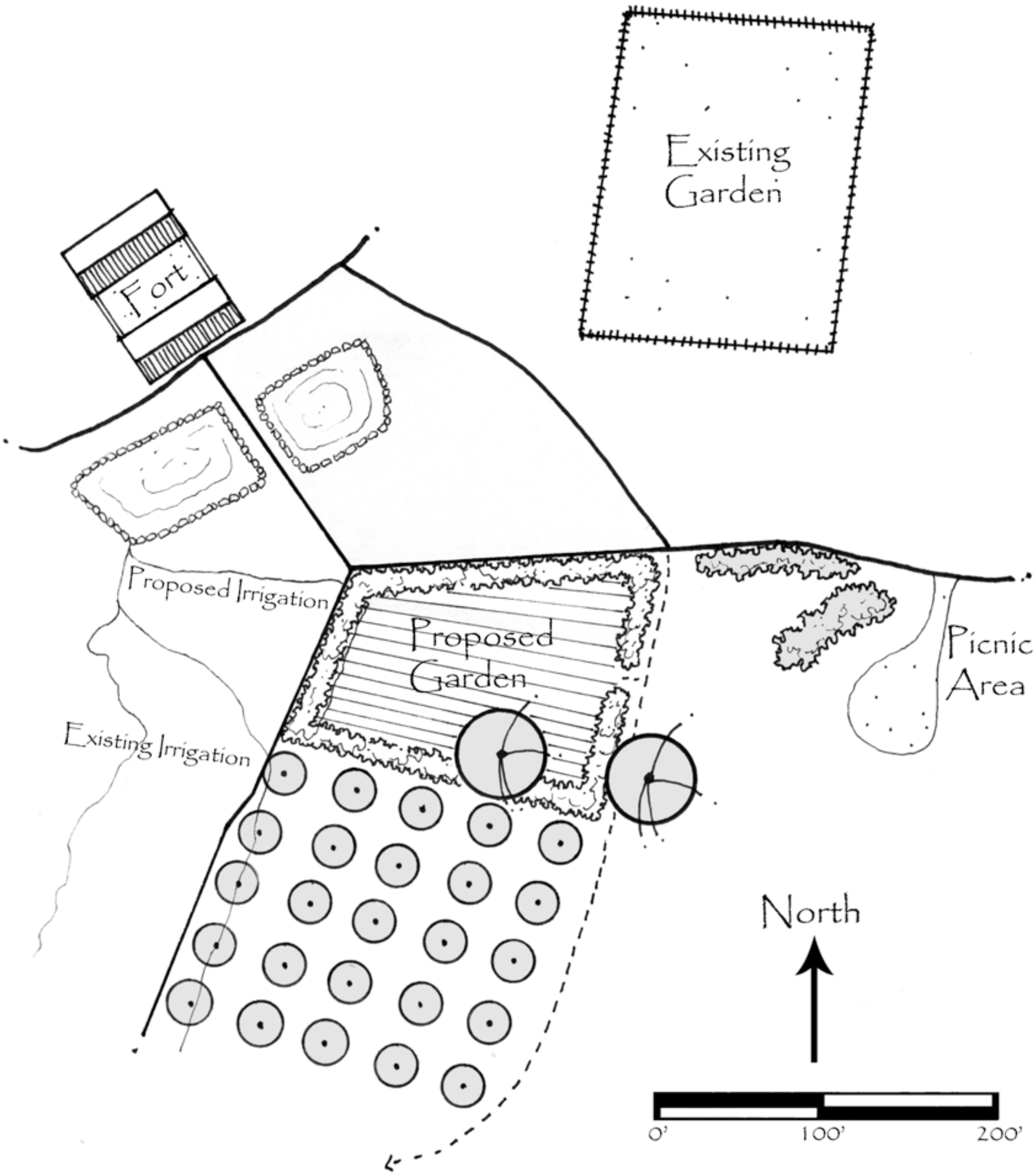
VZ Figures 10.2 and 10.3 show two relocation scenarios. In the first (VZ Figure 10.2), the garden is located adjacent to the orchard and bounded by the existing dirt administrative path. This scenario produces unity with the orchard but does decrease the size of the existing garden by roughly 1/5.

The second scenario (VZ Figure 10.2) expands the size of the garden (slightly exceeding its current size), extending the boundaries past the administrative path towards the picnic area. This extension could effectively tie in the plum and currant thickets already established near the picnic area. These plants are currently isolated from the rest of the orchard, appearing out of context and detracting from the delineation of distinct interpretive spaces.

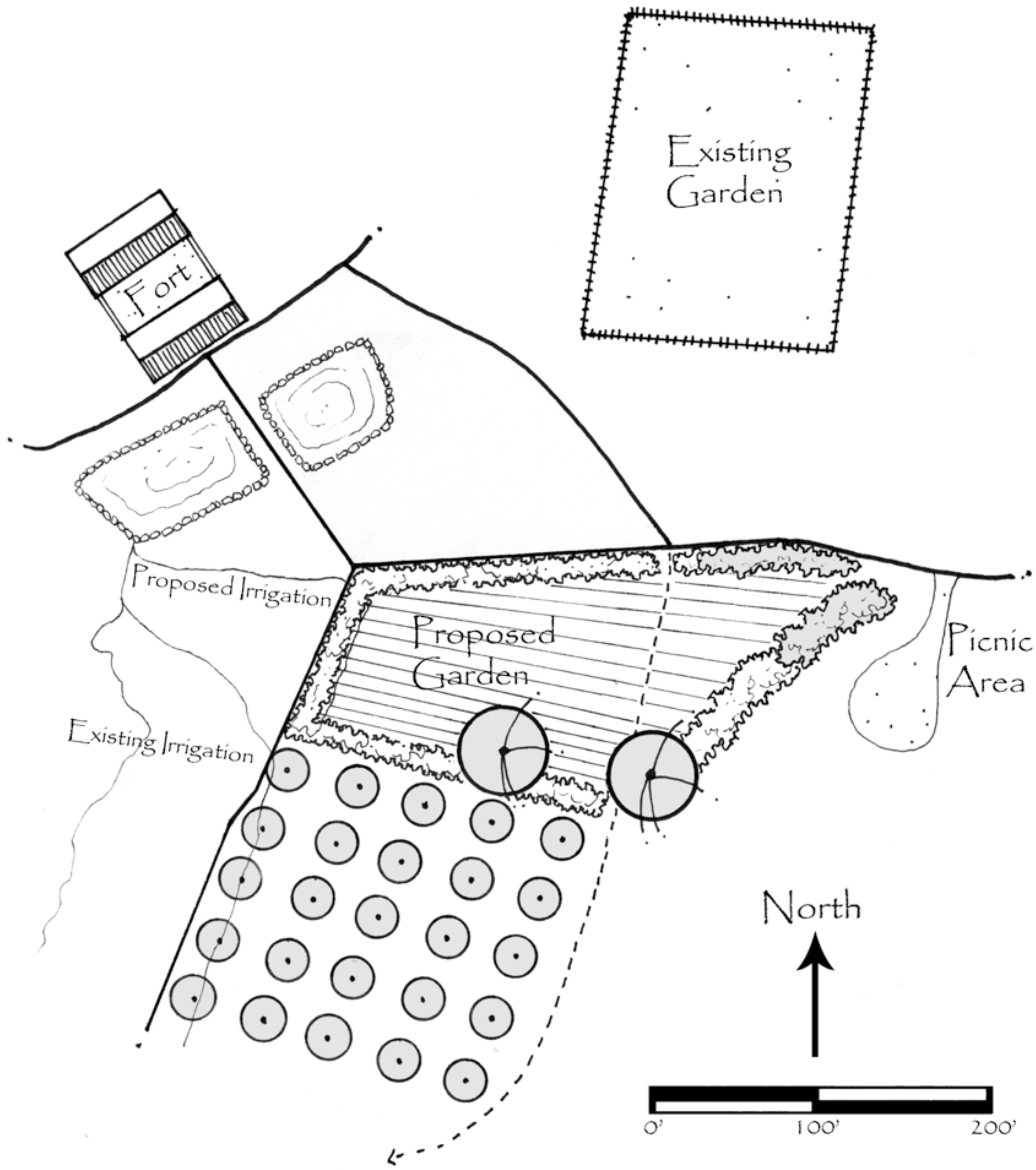
Recycle and Reuse

The proposed location for the garden currently supports an area of dense shrub steppe species, including sagebrush, rabbitbrush, and four-winged saltbrush. These plants could possibly be used to revegetate other areas of the monument, including the picnic area and the current Piaute camp site (VZ 12, SGZ 3). Sagebrush can be successfully transplanted, however, smaller seedlings are much more likely to survive and are less difficult to transplant (Evens 1990).

The wooden posts currently containing the garden could also be reclaimed and used in the repair of fencing around the corrals and other parts of the monument or cut into smaller pieces and used to direct water and create shade in grassland revegetation sites (appendix 5, VZ6, VZ11, SGZ 1 SGZ 2).



VZ Figure 10.2: *Proposed demonstration garden relocation: Scenario 1. Figure shows proposed current hedge surrounding the relocated garden. Irrigation is provided by extending the existing ditch down-slope to the new garden. The dirt administrative path is shown as a dashed line. Existing plants are shown in gray (orchard trees are representative, not accurately placed). Two mature locusts are located within and adjacent to the proposed garden and currant/plum thickets are located adjacent to the picnic area*



VZ Figure 10.3: *Proposed demonstration garden relocation: Scenario 2. Figure shows proposed currant hedge surrounding the relocated garden and extending to the existing currant/plum hedge adjacent to the picnic area. Irrigation is provided by extending the existing ditch down-slope to the new garden. The dirt administrative path is shown as a dashed line. Existing plants are shown in gray (orchard trees are representative, not accurately placed). Two mature locusts are located within and adjacent to the proposed garden and established currant/plum thickets are located adjacent to the picnic area*

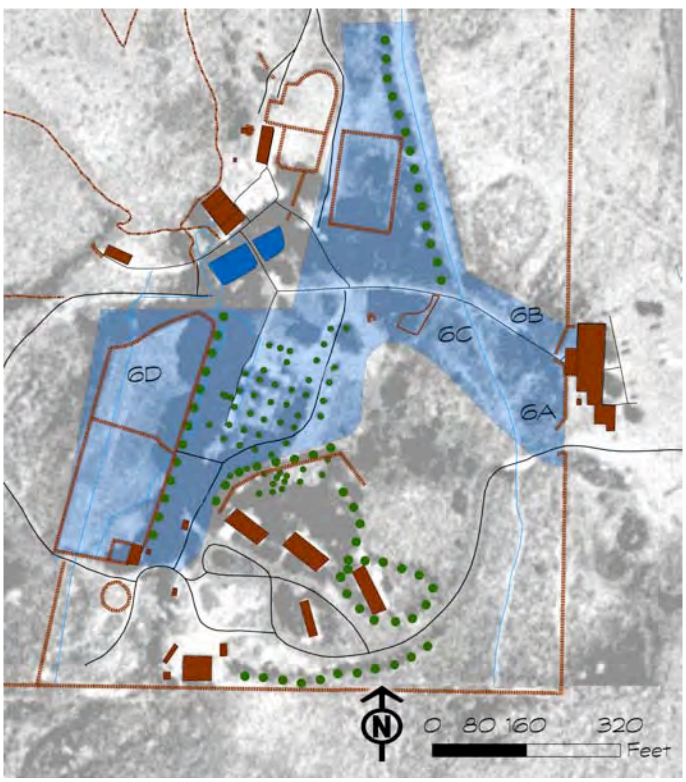
Visitor Zone

Action 11: Reestablish native plant community characteristics through selective thinning of shrubs and grass/forb reintroduction. If successful, this option may be applied throughout the monument.

Recommended Treatment

VZ action 11 may be applied to small areas within the visitor zone. Unlike the intensive grassland restoration plot (VZ 6), the restoration recommended in this action is less formal and management intensive. VZ action 11 restores a native grass/forb shrub steppe community, thinning existing shrubs but not removing them from the species composition. If the restoration is successful it may be applied to the entire monument.

Location



VZ Figure 11.1: *Location of recommended restoration sites. Visitor Zone shown in blue. (Adapted from phase I report, 2009)*

Restoration activities should begin in areas with high visitor visibility in order to maximize the interpretive value of the project. Within the visitor zone, three general locations are appropriate in terms of ecological setting and visitor interpretation. These areas have been designated in VZ action 6 in Phase I of the management plan (VZ Figure 11.1). Location 6C has been excluded due to the establishment of a grassland plot east of the drainage and subsequent opportunity for an interpretive transition (see below).

In addition to their interpretive value, sites 6A, 6B, and 6D will not disturb the monument's healthy plant communities. Dr. Walter Fertig, a member of the Moenave Botanical Consulting, collaborated with Dr. Jason Alexander of Utah Valley

University in compiling a species list for Pipe Spring. Dr. Fertig suggests that Pipe Spring focus restoration activities on areas far south of the West Cabin, spring, and sandstone cliffs, as well as along the eastern boundary of the monument, areas that have been compromised by disturbance. According to Dr. Fertig, the area south of the west cabin has experienced significant soil loss (down to the C horizon), but may be brought back to some semblance of a sandy-clay shrub/grass community. Full grassland restoration, however, may be impossible. Along the eastern boundary, soil loss and compaction have degraded the native community. Specifically, he recommends the area north of the monument trail and the visitor center. In this area several desirable species have naturally begun to reestablish, some of which are rare in Arizona (eg. Whipple's Cholla and Mendora Scabra). Extreme care should be taken not to disturb these species. Dr. Fertig strongly cautions against restoration activity in the Hillside Zone, an area that is in fairly good condition (Fertig 2010, pers. comm.).

Locations A and B

VZ Image 11.1: *Location B, west of the visitor center, south of the monument trail*

VZ Image 11. 2: *Location B, west of the visitor center*

Locations A and B are adjacent to the visitor center, providing a chronological interpretive experience as visitors move from the pre-disturbance landscape to the disturbed pioneer period vegetation. The drainage channel crossing provides a point of transition, creating a strong contrast between the two landscapes. This effect would be enhanced by the relocation of the Paiute camp (SGZ 3) to the northwest of the visitor center, east of the flood ditch.

The first location, 6A (VZ Image 11.1), includes the shrub steppe surrounding the revegetation plot established in 2008, south of the monument trail between the monument boundary and the flood drainage channel. This location would support the interpretive sequence and provide a transition from the intensive grassland plot, should the fencing be removed in the future. A direct contrast between the intensive grassland plot and the adjacent shrub steppe, if desired, would however, be lost.

Location 6B (VZ Image 11.2), is directly across the interpretive path from 6A, west of the visitor center. This location would also support the interpretive sequence from a pre-European to pioneer landscape, and provide a context for the Paiute camp, should it be moved northwest of the visitor center.

An alternative to selecting location B or A is to begin reestablishing grass/forb species along the main interpretive trail, moving outward (north and south) into areas A and B. This option would maximize visitor exposure and reduce confusion by providing a consistent treatment along both sides of the path, defining clearly the drainage channel as the point of transition.

Location D

VZ Image 11. 3: *Location D, south of the west cabin*

The final location, 6D, includes the area within and west of the west corral (VZ Image 11.3). This area was selected primarily for its high visibility from the west cabin and its relevance to the audio narration and interpretive signage within the cabin. Visitors in the west cabin listening to narration explaining historic landscape changes would be afforded a bird's-eye view contrasting the grass/forb shrub steppe with the surrounding disturbed landscape. It should be noted, however, that this contrast would be subtle, demonstrating a healthy grass/forb shrub steppe rather than a grass dominated landscape. A stronger and more historically accurate impression would be made by selecting this area as an additional intensive grassland plot under VZ action 6. An approach that is perhaps more respectful of the surrounding natural landscape yet less subtle than the non-intensive approach is to design a plot that is managed, yet less intensively (removing the fencings and avoiding harsh geometric shapes) than the plot west of the visitor center. Such an approach would prevent the plot from appearing more as a research test plot than an interpretive feature. Given the setting of the proposed plot in location 6D, a combined approach could provide a more context-sensitive solution.

Implementation

Sites where the soil has been disturbed by shrub removal should be monitored for invasive species establishment. Any invasive species should be immediately removed or chemically treated. See VZ 6 and appendixes 5-9 for information regarding species selection and restoration techniques.

Visitor Zone

Action 12: Enhance Black Locust planting in picnic area, add drip irrigation and replace bark mulch with crushed local rock mulch.

Treatment Background

Management Overview

Currently the picnic area is defined by a coarsely chopped bark mulch surface, two picnic tables, and a cluster of struggling black locust trees (VZ Image 12.1). Although the locusts offer visitors some light shade and define the picnic area, the trees' poor health detracts from the 1930s oasis quality that justifies their presence within the monument's historic landscape.

VZ Image 12.1: *Picnic area in its present configuration*

The picnic site can be improved through rejuvenating the existing trees, more clearly defining the area, and by altering the surface treatment to one more compatible with the monument's setting.

Recommended Treatment

Locust Rejuvenation

The black locusts within the picnic site appear to be suffering from drought and generally appear unhealthy. Although the locusts could be replaced with another shade tree species, they do offer several benefits. The light and airy form and small leaves of the locusts provide light shade to visitors while minimizing their visual weight and impact on the historic landscape. Additionally, their twisted and rugged branching structure is more compatible with the rustic pioneer aesthetic of the monument than more elegant shade species. Locusts (black and honey) appear to be doing well elsewhere in the monument where drip irrigation is available.

It is recommended that the black locusts be preserved and rejuvenated with one of two forms of supplementary irrigation. One option is to install drip-irrigation, as has been implemented in other areas within the monument. This option, although requiring some planning, labor, and cost during installation, offers a precise water application with minimal effort.

VZ Image 12.2: *Example of a tall Treegator® bag (treegator.com 2008)*

Another less-permanent and more flexible option is to apply tree watering bags during periods of drought. Although manufacturers offer many forms of watering bags, generally they function similarly. Treegator® for example, offers a 20 gallon bag made of polyethylene plastic and nylon that zips around the base the tree (VZ Image 12.2.). The bag is filled through a hose slot and then slowly irrigates the tree through its perforated base. The bags offer the same slow and deep saturation as drip-irrigation but can be moved to any tree on the monument, as needed. Although the bags are more visible than drip-irrigation, they can be applied in the evenings (a recommended irrigation time) and removed during visitor hours. On average, the bags empty in 8 hours and provide enough water for 2-7 days, depending on temperature and soil porosity. Water bags are also limited by tree caliper. A single bag can be applied to a 1”-4” caliper tree and two bags zipped together can be used on trees up to 8” in diameter. Although many manufacturers

produce watering bags, the Treegator® brand is well constructed and has been used successfully at Antietam National Battlefield.
For more information visit http://www.treegator.com/products/original/index.html.

In addition to irrigation, the locust trees will require regular maintenance pruning to remove dead, damaged, and unhealthy limbs. Dead locusts and those in serious decline should be removed and replaced by some of the many young trees growing on the site (VZ Figure 12.1). Black locusts reproduce primarily vegetatively, indicating that most of the desirable healthy trees within the picnic area share a root system with the dead or dying trees (USDA 1990). A cut stump treatment may therefore be difficult, however, without a chemical treatment the shoots produced by the cut trees will require repeated manual removal to control. See VZ 2, "Cut Stump Treatment" and "Other Specifications" for more information on this particular complication.

Creating More Definition

Currently the boundaries of the picnic area are delineated by a mulch surface treatment and by a cluster of locust trees. Although generally the site offers shade, seating, and adequate space, some small adjustments can create a more pleasant experience and more cohesive site.

Reorganization of Space

The size of the picnic area currently meets the needs of the park but does include some excess areas that could be reduced and returned to the native shrub steppe community and exchanged for more appealing areas that could be more functionally incorporated into the picnic area.

The entryway from the main interpretive trail into the picnic area is unnecessarily large, creating an unsightly visual appearance contradictory to the historic setting. The entry is split into two paths by rubber rabbitbrush. It is recommended that the access to the picnic area be limited to one side of the brush and maintained at 5' wide, allowing for ADA access (VZ Figure 12.2 and 12.3). A second reduction could be applied to the southeastern corner of the picnic area, passing between the trashcan and two dead locusts (VZ Figure 12.1, 12.2, and 12.3). As described below, this area lacks morning and afternoon shade, and could be exchanged for the shaded area to the northwest (VZ Figure 12.1, 12.2, and 12.3), if more picnic space is needed.

VZ Figure 12.1: *Reorganization of space in the picnic area. Excess mulch on the left has been revegetated and the picnic area has been extended to the right. A local crushed stone replaces the mulch.*

Supplementary Plantings

Additional plantings around the perimeter of the picnic area can help define the space and create a more favorable microclimate for picnickers. On the eastern and southeastern side of the picnic area the two locusts providing morning and early afternoon shade have perished, leaving the site exposed to full sunlight during the lunch hours. Additional trees are needed to provide shade during these peak hours. The large tree shading the eastern picnic table must also be removed and replaced. The black locusts on the site appear to producing a number of offspring shoots, several of which are still fairly small. These small trees or purchased black locust should be transplanted along the new, reduced southeastern perimeter (VZ figure 12.3).

Plum and/or current bushes could be incorporated into the western perimeter of the picnic area, as an understory winter wind screen. These species would blend in with the adjacent plum and currant thickets to the west, creating visual continuity in an historically acceptable manner.

Additional Seating

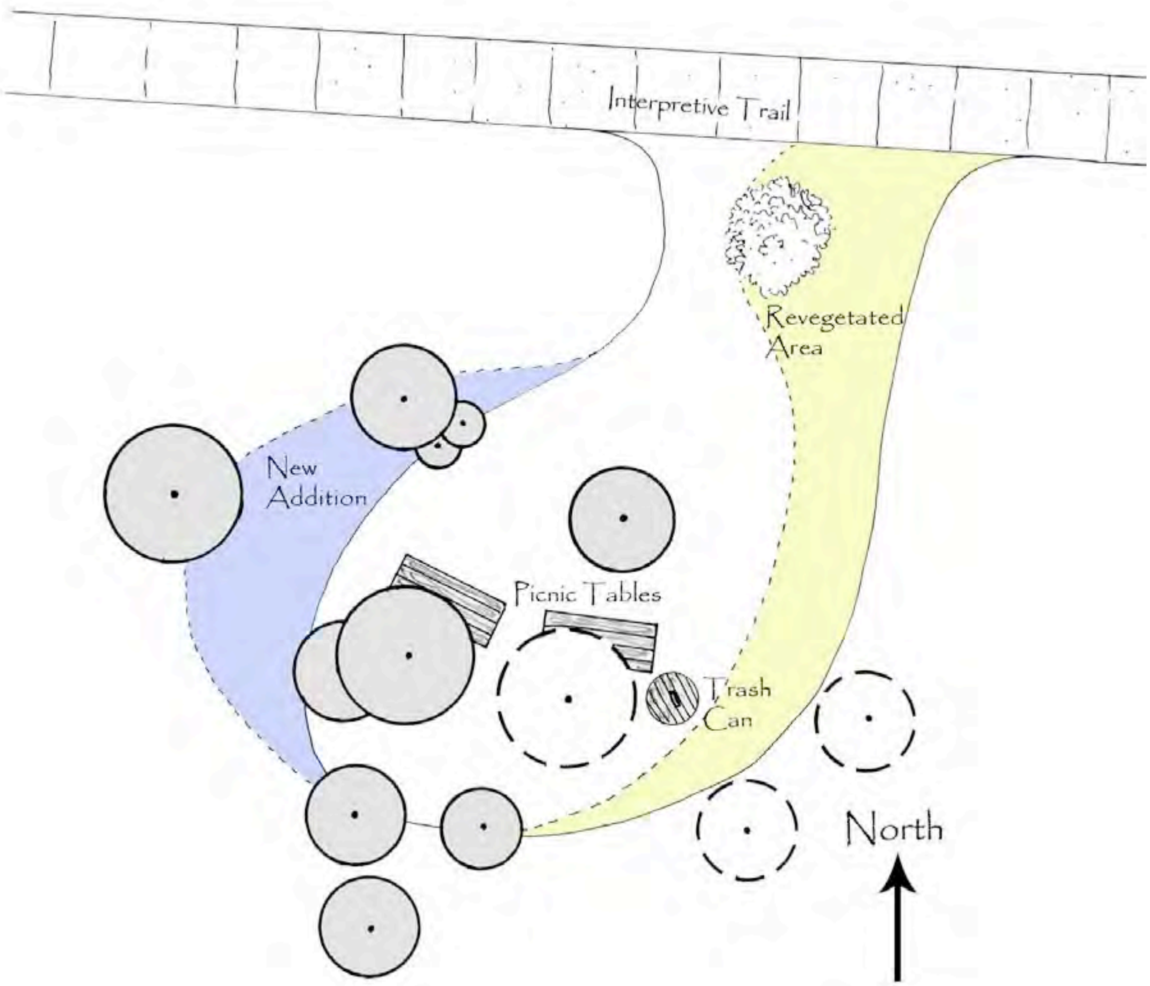
The two picnic tables adequately support the number of visitors using the picnic area but provide only one type of seating. Additional, less formal, small-scale seating could be provided by benches similar to those located in the interpretation area below the ponds (VZ. Image 12.3). Several of these benches, constructed from trees removed within the monument, could be placed along the western boundary of the picnic area, containing the space and creating more seating options for visitors (VZ figure 12.3).

VZ Image 12.3: *Example of additional seating at Pipe Spring*

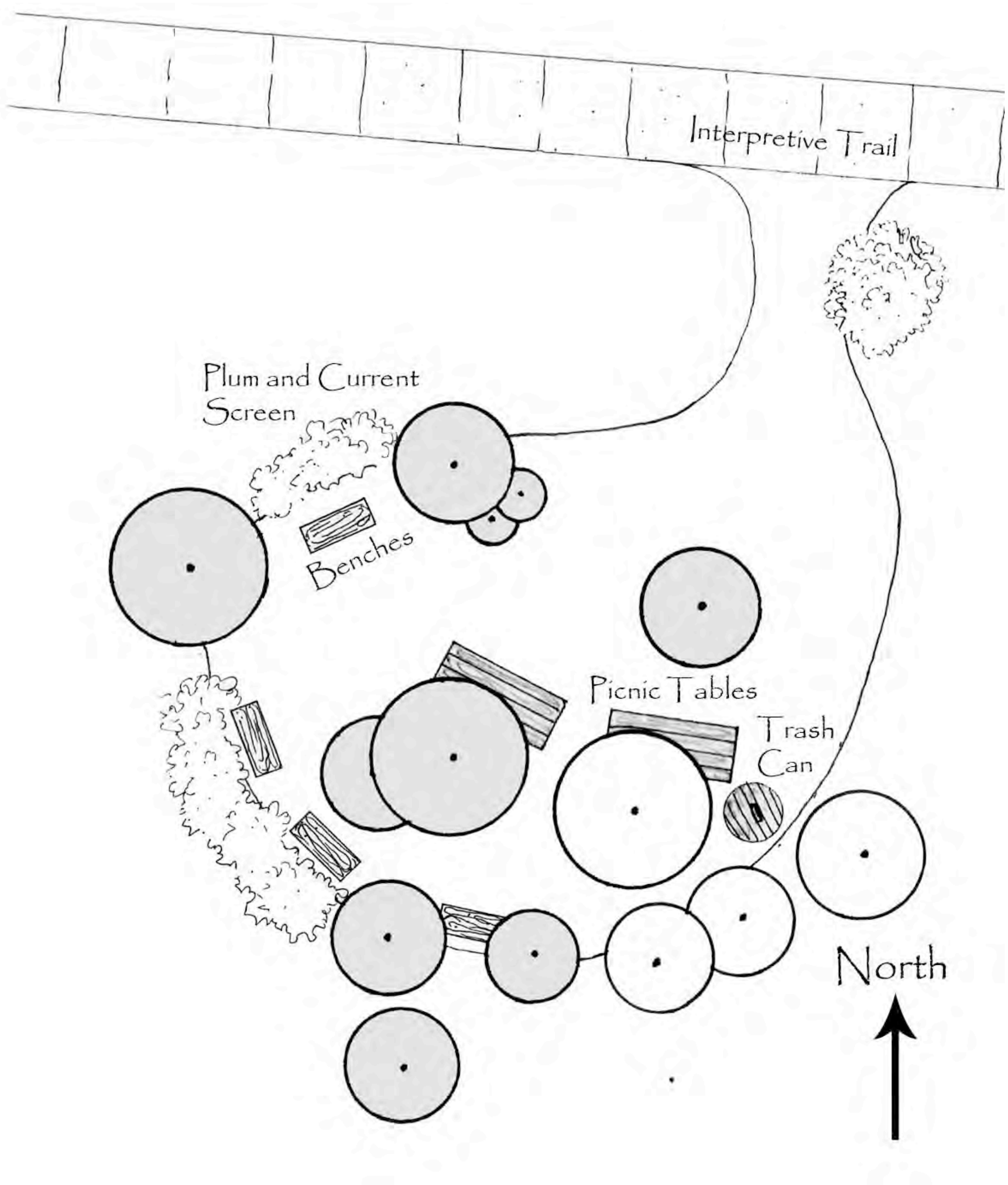
Surface Treatment

The mulch currently used to define the picnic area, although neutral in color, does not support the arid desert context of the site. A more appropriate local option is crushed native stone mulch. Several local retailers, including Connors Landscape and Maintenance (Kanab), and Sunset Rock and Landscape Supply (Hurricane) sell local crushed stone (VZ Image 12.4). An ADA compliant gravel paver system should be installed (see AZ 2 for more details), or, at minimum fine, compacted gravel be used to create a stable surface..

VZ Image 12.4: *Images of crushed stone quarried from the Valentine Quarry in Kingman, AZ, west of Flagstaff.*



VZ figure 12.2: *Existing conditions and proposed site boundaries. The existing boundary, as defined on site by a mulched surface, is shown as a solid line. The proposed boundaries are shown as a dotted line. Yellow indicates existing portion of picnic area to be revegetated; blue indicates area of proposed picnic area expansion. Trees to be retained are shown in gray and removed trees are dashed. Diagram is not to scale and tree locations and sizes have been approximated from GIS points*



VZ figure 12.3: *Proposed site boundaries and alterations. Existing trees are shown in gray and approximate locations for proposed trees are shown in white. Additional bench seating and fruit bush screening are also shown.*

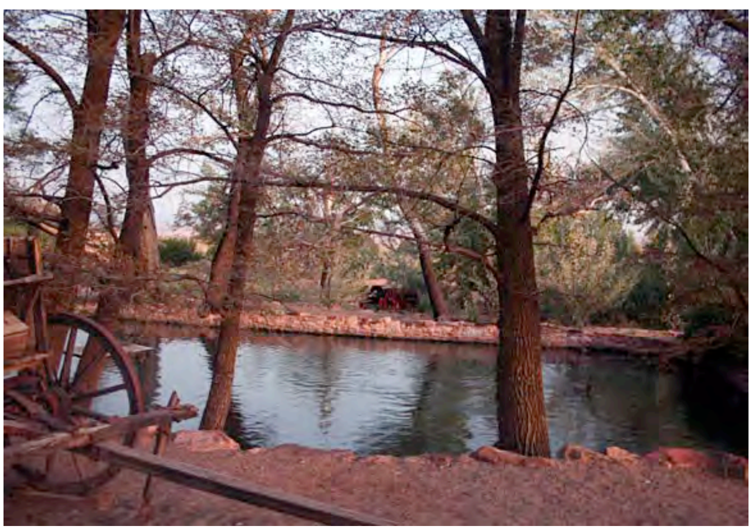
Historic District Zone

Action 1: Removal and replacement of pond trees, following one of two options.
Action 1B: Removal of trees within the east, south and west pond walls at the time of reconstruction/rehabilitation of ponds. Establish new trees within the east, south, and west walls. Selective replacement of existing trees outside of all walls, including north wall. An irrigation system will be necessary.

Treatment Background

Management Overview

Although the exact date is unknown, the two historic ponds at Pipe Spring were established by 1876 just south of the Windsor castle. Built to facilitate crop irrigation, the ponds were likely constructed through a cut and fill method, raising the southern walls from the excavated soil. An earthen dam structure sealed with bentonite is the earliest framework of both ponds, though sandstone walls were later added and modified many times within the monument's management history (USDOI 2007). Early photographs and descriptions document a grove of trees growing along the pond walls. Although the planting of the trees near the earthen structure is nontraditional and destructive to the integrity of the dam, they have been maintained throughout the history of the site and have become a part of the monument's cultural importance as a community "oasis".



HDZ Image 1.1: *Existing condition of the Ponds at Pipe Spring, 2009*

The growth of and demise of trees in the walls surrounding the ponds is one of the monument's greatest management challenges. In 2007 park staff and consultants met and began PMIS project No. 134624 to stabilize the pond walls. During the meeting the team identified the decline of the trees growing around and within the walls as a primary long-term threat to the pond structures and a major cause of the ponds' leakage. The roots of the dying trees decay within the earthen dam, allowing water to flow through the voids left in their place, creating new leaks with every dead tree (USDOI 2007).

Currently monument staff is evaluating the alternative solutions discussed in PMIS No. 134624. This document will provide general information regarding the maintenance of trees along the perimeter of the ponds and potential pond lining options. It is recommended that this section be updated once a stabilization plan has been selected for the pond walls.

Recommended Treatment

Liners

During the 2007 pond stabilization meeting five alternatives were selected for further evaluation, four of which propose the addition of an impervious liner. Although a liner may help with other sources of leakage, the liner must be resistant to tree root penetration in order to prevent long-term leakage through root voids.

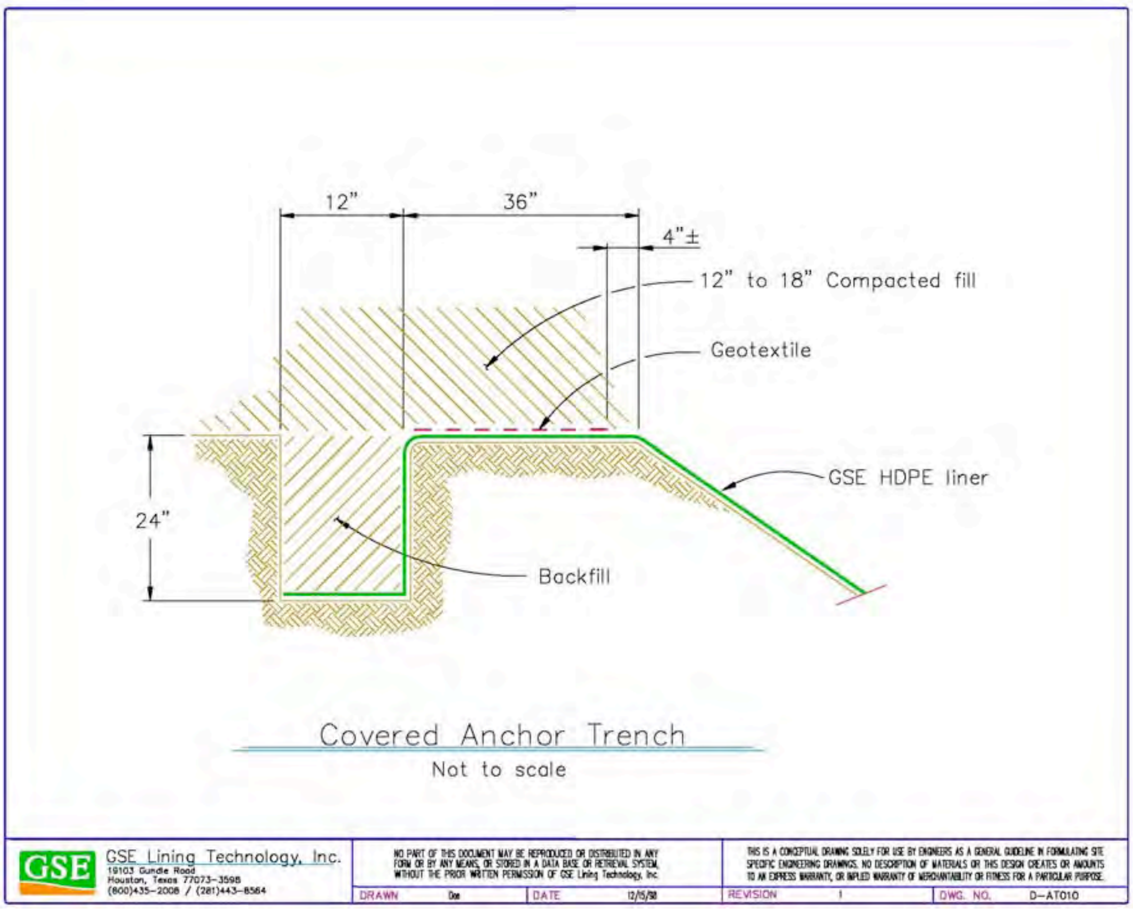
A variety of pond liners are available commercially, some of which are advertised as resistant to plant roots. However, according to several industry experts, all traditional pond liners will eventually fail, especially when confronted by large and aggressive trees such as cottonwoods (California Waterscapes, CTK Quality Pond Products). A representative from CTK Quality Pond Products, LLC suggest 45 mm EPDM (ethylene propylene diene Monome), a geotextile product used for ponds and roofing, as the best option among traditional pond liners, though even this product is likely to fail in the long-term. Geosynthetic clay liners, composed of bentonite sandwiched between geosynthetic fabrics are also used as root barriers, but were cautioned against by one liner manufacturer concerned about the fabric’s long-term resistance against large tree roots. .

Moving beyond the smaller scale pond products, there are widely available alternatives used in larger scale projects such as waste treatment and contaminant containment. Field Lining Systems Inc. in Avondale, AZ installs large lining systems. A representative from their suppler, GSE Lining Technology, suggests that HDPE (high density polyethylene) liners may be the most root-resistant available liner. Although more commonly used for detention ponds and landfills, the company installed an HDPE liner as a root barrier around new homes for a contractor in Texas. The 10 year old liner is still successfully preventing root damage. In several landfill projects the liner has remained intact for over thirty years.

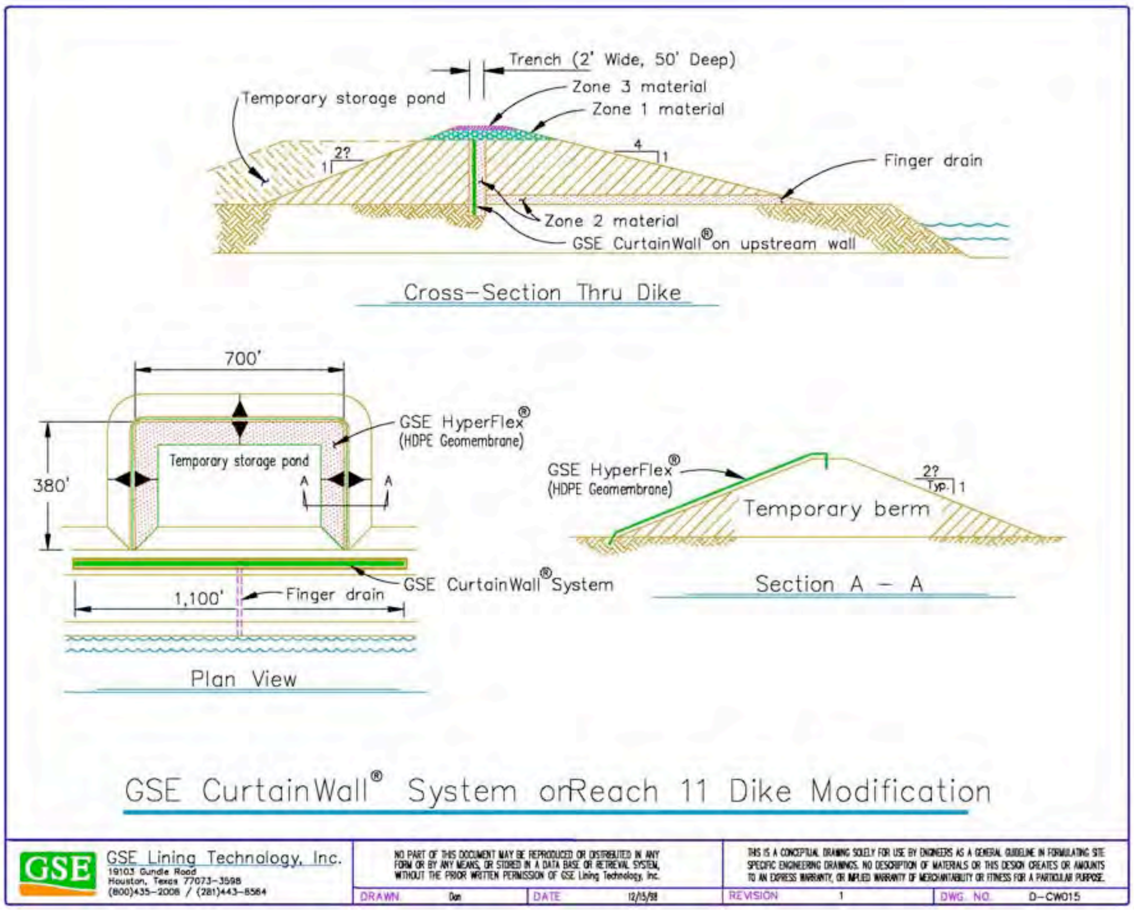
GSE Lining Technology recommends an 80 mm liner for the monument’s ponds. Estimating a combined surface area of 6,000 square feet for both ponds (if they are fully encased), at 47 cents per square foot, the company representative projects a total materials cost of $2,850. GSE Liners, distributed by Field Lining Systems Inc in AZ and

Rainy Day Water Inc in UT, can also be custom built and shipped to the project site (see references for Field Lining Systems Inc. and Rainy Day Water Inc).

Although a standard HDPE lining system would be constructed to enclose the pond on all sides (HDZ Figure 1.1), a vertical liner that is vibrated into place is also available if PISP chooses to line only the sides of the pond (HDZ Figure 1.2). This would significantly reduce the cost of materials and minimize the amount of disturbance to the pond structure during installation. Installing a full liner, however, will prevent any pond leakage beyond what is caused by root voids.



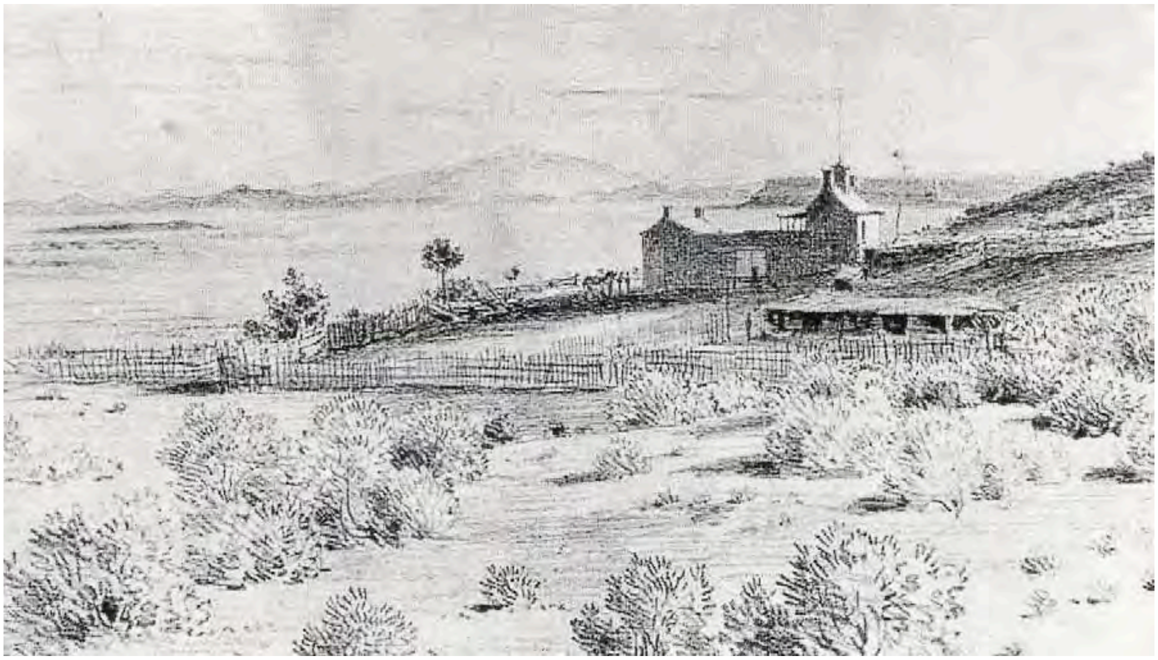
HDZ Figure 1.1: *Example detail of fully enclosed HDPE lining system installation*



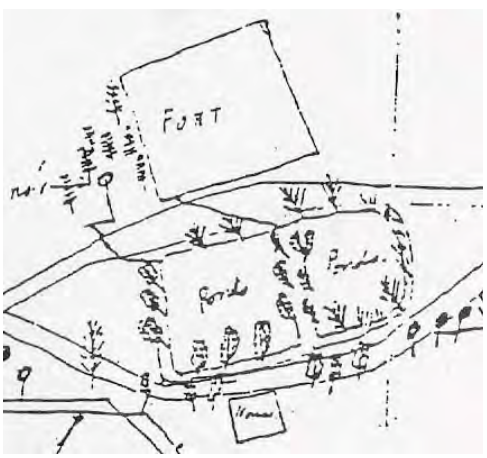
HDZ Figure 1.2: Example detail of a vertical HDPE lining system installation

Replacing the Pond Trees

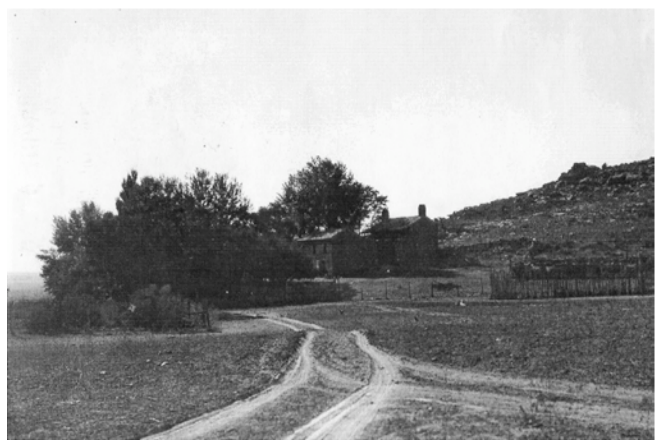
Documentation of the trees growing around the ponds is sparse, but does provide some insights into the variety and density of the trees grown since the ponds' establishment. The earliest image depicting the monument, a sketch by Albert Tissandier from 1885 (HDZ Image 1.2), shows very few, young trees growing in the vicinity of the ponds. The species of tree is not discernable.



HDZ Image 1.2: *Earliest image of the Monument, sketched in 1885 (Tissandier 1885)*



HDZ Image 1.3: *1932 sketch by Leonard Heaton (Heaton 1932, from USDOI 1997)*



HDZ Image 1.4: *1913 photo showing dense vegetation in the vicinity of the ponds (PISP 1924)*

A 1932 plan-view sketch done by Leonard Heaton (HDZ Image 1.3) shows *Ailanthus* growing in the northern and southeastern walls, and silverleaf cottonwoods surrounding the western pond. The plan depicts evenly spaced trees completely surrounding both ponds, though the authenticity of the plan in terms of tree numbers and density is not known. By 1913 the trees around the ponds appear to be very dense, creating heavy shade (HDZ Image 1.4).

Currently a few large shade trees remain in generally poor condition. Over the past 50 years the number of trees has declined due to unidentified health related and/or environmental conditions. The remaining trees are primarily cottonwoods and a few *Ailanthus* trees. The trees are established between the two southern sandstone walls, growing from the sides of the inner stone walls, and surrounding all of the pond walls. (HDZ Figure 1.3). Along the western side of the western pond and eastern side of the east pond are several rose bushes. Although these bushes are not documented historically, they do provide food and habitat for the birds inhabiting and migrating through PISP as a shady microclimate for pond wildlife and microinvertebrates.

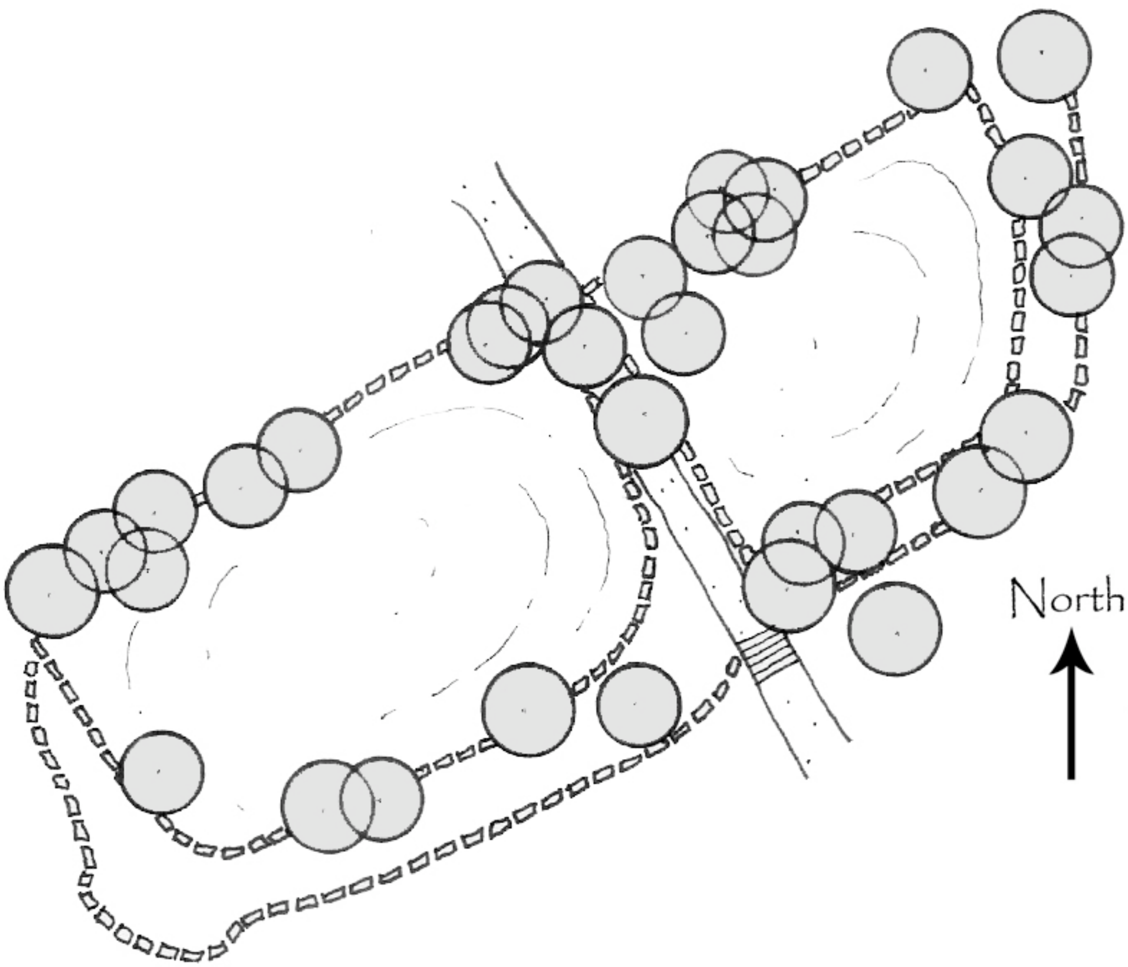
Depending upon the selected stabilization method, there may be an opportunity to augment the trees and shrubs surrounding the ponds without creating any additional disturbance to the pond structures. If the walls of the ponds are reconstructed and/or a liner is installed, declining trees could be removed during the construction. In order to take advantage of this opportunity, only healthy trees should be allowed to remain once the stabilization is complete. Unfortunately, depending upon the method of construction, healthy trees may not be able to be spared and the pond area may not return to its desired appearance until new plantings have matured.

Once the liner is installed, replacement trees can be planted behind the new barrier and provided with drip irrigation (which could be camouflaged by local stone mulch). Though the trees do appear to have some regular spacing in Heaton’s diagram, the sparse historic documentation of the pond trees does not provide much guidance on the density and arrangement in which the new trees should be established in order to maintain an historic aesthetic. During the monument’s period of significance (1863-1895), very few trees were grown around the ponds (HDZ Image 10.2). Although from the NRHP nomination form, “Landscape changes made during the Woolley period (1885-1891) included the planting of cottonwood, elm, willow, and *Ailanthus* trees near the fort and changes to the ponds”. Later in the monument’s history dense pond plantings created the “oasis” feel that is more desirable to the monument’s local visitors and culture.

Given this latitude in the redesign, PISP may consider several planting strategies:

Direct Replacement

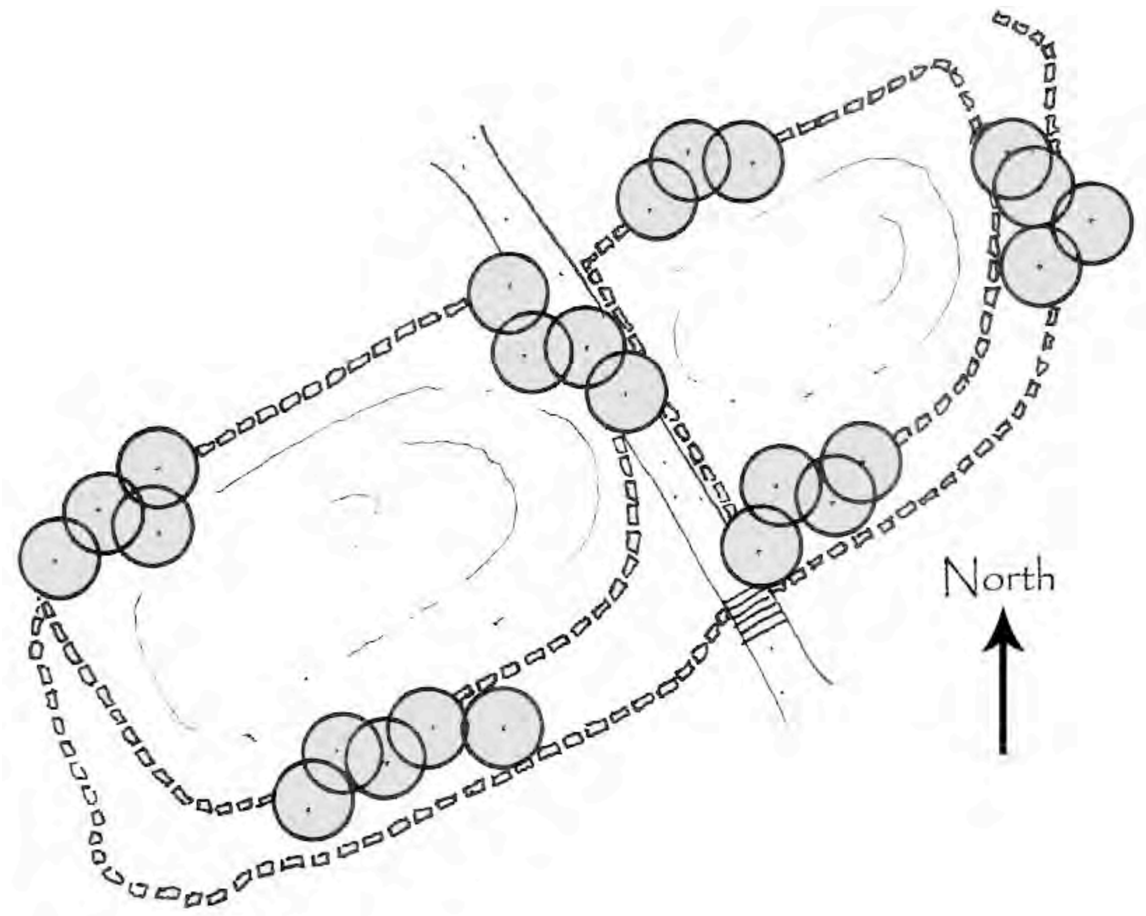
Through direct replacement new trees would be planted where trees were located before their removal during the stabilization activities (HDZ Figure 1.3). This option would reproduce the current pond setting and potentially the historic setting if their arrangement has been preserved from earlier periods. Trees currently growing out from the sides of the ponds walls would be planted behind the new liner.



HDZ Figure 1.3: *Direct replacement (current arrangement)*

Small Clumps

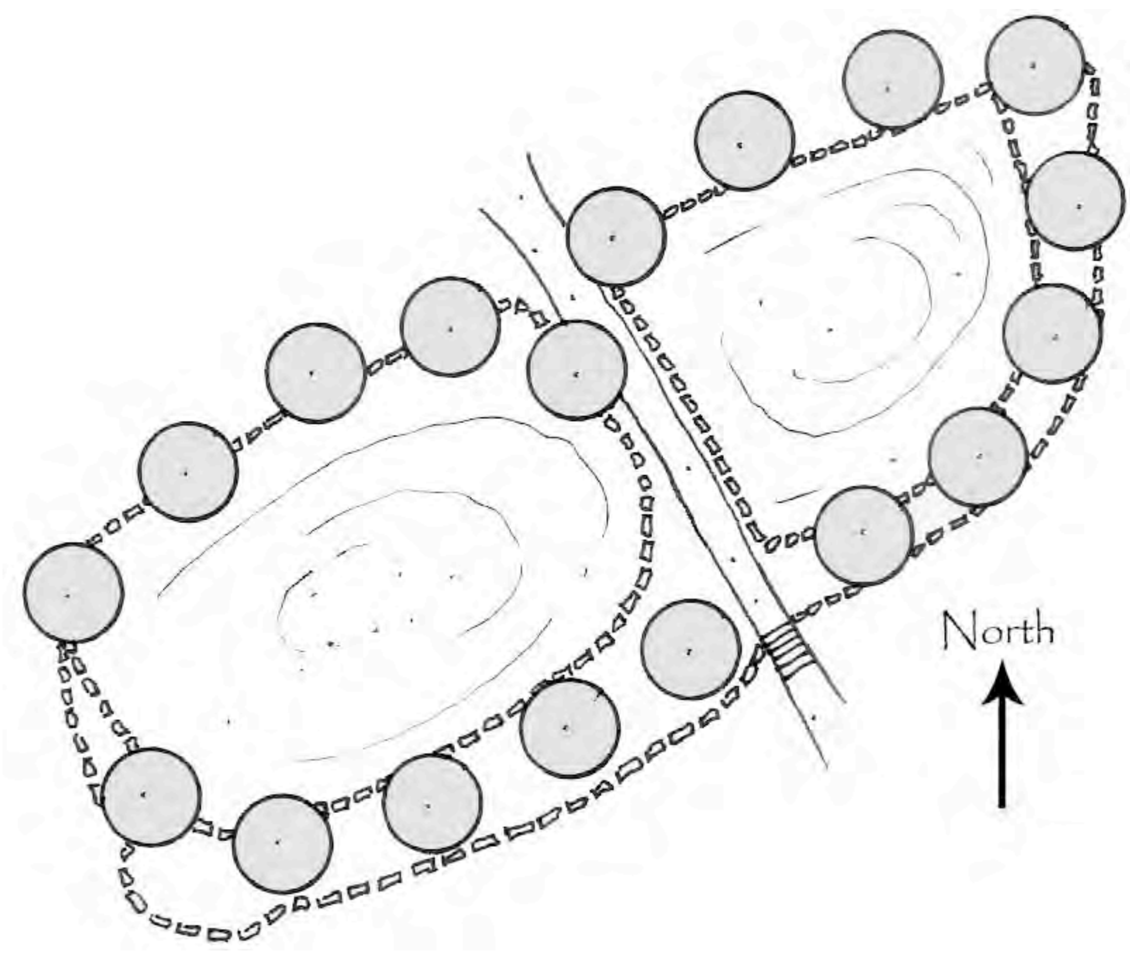
In order to minimize the area that would be impacted by any root penetration and repair activities, the new trees could be planted in smaller clusters around each pond (HDZ figure 1.4). Any liner failure due to roots damage would be easily isolated and locally repaired. This option would still provide the number of trees needed to create an oasis feel but would reduce the surface area shaded by the trees and some sense of pond enclosure.



HDZ Figure 1.4: *Small clumps*

Low Density/Even Spacing

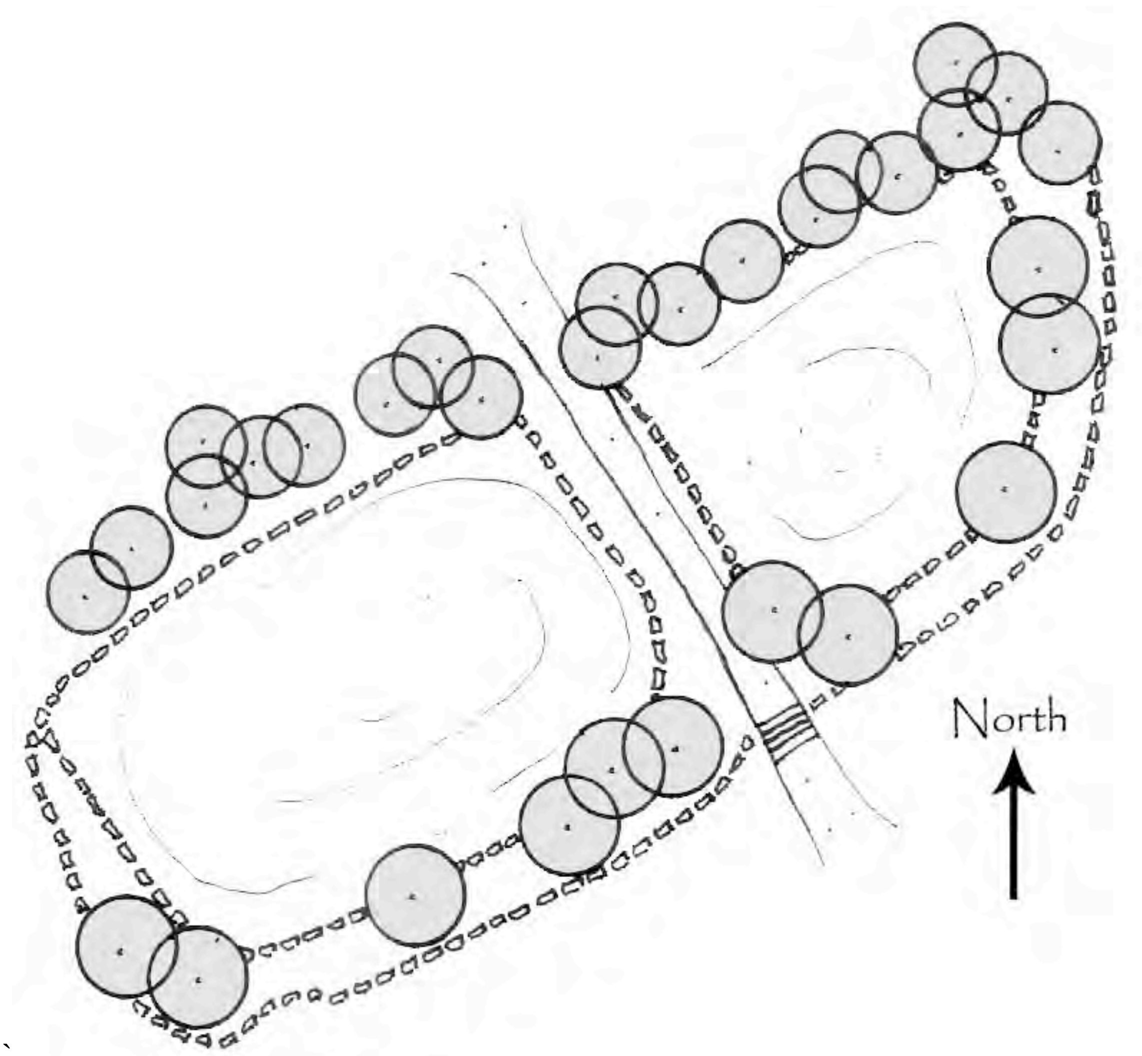
In this option trees are planted evenly around the perimeter of the ponds but at a lower density, reducing the overall number of trees. Reducing the number of trees and creating more space between them may reduce aggressive competitive root growth and therefore reduce liner penetration. The additional space and decreased competition may also produce larger canopies, compensating for some of the loss of density. This arrangement appears similar to Leonard Heaton’s 1932 sketch.



HDZ Figure 1.5: *Low density/even spacing*

Weighted Plantings

Observations discussed during the stabilization meetings indicate that the northern pond walls are currently not leaking and are less predisposed to leakage problems. PIPS could take advantage of this stable area by planting more heavily behind the northern walls. Fewer trees would be replanted behind the southern, eastern, and western walls, providing some sense of enclosure and shade.



HDZ Figure 1.6: *Weighted plantings*

Replacement Species

Very little information on the species of trees planted around the ponds during the monument's period of significance can be discerned from historic documentation (USDOI 1997) (although, again, see reference in NRHP form noted above), however Leonard Heaton's 1932 sketch shows cottonwoods and *Ailanthus* growing along the pond walls.

PISP may chose to replace the trees removed during the stabilization process with the varieties currently present, consistent with Heaton's sketch. However, a potential conflict then emerges between historical fidelity and ecological sensitivity. Replanting *Ailanthus*, a very noxious exotic invasive species, would be ecologically unsound and potentially destructive to surrounding native plant communities. It is therefore recommended that any *Ailanthus* not removed by necessity through construction activities be spared, but that no new *Ailanthus* be encouraged or planted in the pond area. There are several non - invasive trees that may be substituted for *Ailanthus* while still maintaining a similar aesthetic and structure. Species include, fringe tree (*Chionanthus virginicus*), little leaf ash (*Fraxinus greggii*), and Arizona walnut (*Juglans major*).

The large cottonwoods currently established along the ponds could also be replaced with species that are more water-wise and/or smaller (potentially less aggressive roots). Along with the species described in the list above, these include: canyon hackberry (*Celtis reticulate*), common hackberry (*Celtis occidentalis*), European mountain ash (*Sorbus aucuparia*), Siberian elm (*Ulmus pumila*), and Idaho flowering locust (*Robinia x ambigua*).

Rose Bushes

Although the rose bushes growing along the western wall were planted in 2005 and are not historically significant, they do provide wildlife habitat benefits and are unlikely to harm a new pond liner. Those along the eastern wall of the east pond may have been planted during the CCC era, though this is uncertain. The bushes may have to be removed during construction and liner installation, but they may otherwise remain, until they naturally decline, as a fairly unobtrusive element. Their spread to other areas around the pond, however, should be discouraged in order to maintain historical setting of the period of significance.

Historic District Zone

Action 2A: Preservation of elms west of the fort with gradual replacement by undergrowth offspring. In this option the elms will be managed in a state of decay for as long as possible.

Treatment Background

Species Overview

The Siberian elm, *Ulmus pumila,* is a non-native tree that does well in arid environments and is tolerant of a range of soils and growing conditions. Reaching heights of 50'-70', *Ulmus pumila* are fast growing but weak-wooded trees with irregular growth habits. Although Siberian elms can easily establish in a range of environments, they are susceptible to diseases and pests such as the elm leaf beetle, powdery mildew, cankers, aphids, and leaf spot (UConn, USDA 2002, USDA 1994).

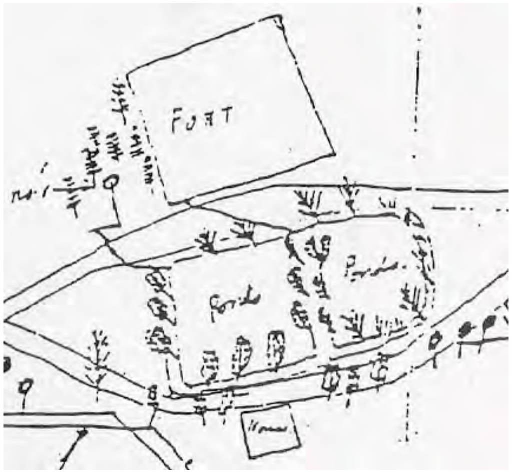
HDZ Image 2.1: *1907 photograph showing the Winsor Castle and several large elms to the west (Shapins Ass. 2006)*

Management Overview

Overview of Historic Significance

The elms growing west of the fort were designated contributing features in the 2006 Historic District CLI (Shapins Ass. 2006). Records from the Woolley family history describe the planting of the elms at the insistence of Florence Wooly, circa 1886, in order to improve the harsh and barren landscape (Shapins Ass. 2006, USDOI 1997). Although the species are indistinct, a 1907 photograph of the fort shows several large trees growing in the present location of the elms (HDZ Image 2.1). In 1924 large trees are still seen adjacent to the fort in a photograph taken from the near the east cabin (HDZ Image 2.2).

HDZ Image 2.2: *1924 photograph showing several large elms west of the fort (Shapins Ass. 2006)*



The most recent record of the elms is from a circa 1926 sketch by custodian Leonard Heaton, who planted 25 additional elms west of the fort on the south side of the road that year (HDZ Image 2.3) (USDOI 1997).

HDZ Image 2.3: *Portion of a sketch by Leonard Heaton, circa 1926, showing seven elms west of the fort (Heaton 1926, from USDOI 1997)*

Present Conditions

The two mature elms west of the fort have produced a large number of offspring representing a range of ages and growth forms (HDZ Image 2.4 and 2.5). Although many of these small trees appear to be stump sprouts, emerging at the base of the tree, there are several clusters of offspring produced either by seed or as root sprouts. At least 20 offspring were identified in the fall of 2009.

HDZ Images 2.4, 2.5: *Image 2.4, left, shows two of the declining mature elms west of the fort. Image 2.5, top, shows abundant young stump and root suckers growing near the base of a mature elm*

Recommended Treatment

There are several available options for producing offspring from the mature elms while preserving the historic genotypes. The simplest method is to nurture vegetatively produced offspring as genetically identical replacements for the parent trees. The mature elms have produced root suckers (growing from the root system) and stump suckers (growing from the trunk), both of which can be grown as replacements.

Although growing stump suckers more faithfully reproduces the spatial distribution of the mature elms, action A requires that the replacement offspring are grown while maintaining the parent tree as long as possible. Growing stump suckers concurrently with the adult trees will inhibit the offspring's growth and produce a crooked form (Nyland 1996). It is therefore recommend that offspring produced by root suckering be selected as replacements for the adult trees.

Replacement shoots should be selected based on form (straightness, irregularities, single-shoot and not V formed), health and vigor (disease and height), spacing (aesthetic, light availability and least competition), and location (approximating the location of the parent trees) (Stroempl 2005). The location of the replacement elms should be as close to the parent tree as possible while still providing enough light and space to sustain healthy growth (elms prefer full sun). Interspecific and intraspecific competition can be reduced by allowing only the best sprouts to continue past the first few years of growth and by clearing any vegetation from around the young trees (Nyland 1996). Mulch may help reduce weed growth and retain water until the trees become firmly established. Although ultimately each mature tree will be replaced by a single offspring, it is wise to nurture several well-spaced replacements through the sapling stage in order to compensate for environmental stochasticity[2]. Once the trees have reached a more stable age, the least promising candidates can be removed, leaving one replacement tree for each mature tree.

Note: In all cases where root or stump shoots are used to preserve the genetic identity of historic trees, the adult tree should be evaluated for root diseases (appendix 3). These diseases can be transferred to vegetative produced offspring, potentially resulting in the death of the offspring and loss of historically significant genotypes. Alternative methods for propagating genetically identical offspring in the case of root disease, or as an additional measure are available (see note below).

For additional propagation options and stump removal techniques, see appendixes 1, 2 and 14.

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[2] Environmental stochasticity refers to random or unpredictable environmental conditions or events that may influence survival or development.

Historic District Zone

Action 3: Preservation of historic wagon road trace, maintaining west cabin spring outflow with selective removal of vegetation from historic road trace.

Action 3A: Clear invasive natural and exotic vegetation from historic road trace.

Recommended Treatment

Vegetation Removal

Currently the historic road trace of the Honeymoon Trail is obscured by native and exotic vegetation. It is recommended that all vegetation be cleared from the road trace in order to maintain a clearly defined dirt roadway visible from the west cabin outlook. The road trace should be carefully monitored for invasive species taking advantage of the site disturbance and freed habitat after removal.

See appendixes 12 and 13 for more information on shrub and grass control and removal

Route Alteration

VZ Image 3.1: *Confluence of historic road trace (top arrow) with west cabin spring outflow (bottom arrow)*

One of the major difficulties of maintaining a distinct road trace is the confluence of the Honeymoon Trail with the west cabin spring outflow (VZ Image 3.1). The west cabin spring outflow meanders, often running along the road trace but also occasionally crossing it. Their confluence encourages vegetation growth on the road trace, giving the spring outflow visual dominance and obscuring their distinction as two separate entities and creating interpretive ambiguity.

It is recommended that the historic road trace be diverted slightly to the south, beyond the reach of the spring's meandering, returning to its original path at the monument's boundary. Although this would create an inaccurate bend in the roadway, the interpretive benefits of creating a distinction between the road trace and outflow outweigh the minor alteration. In order to select an appropriate degree of deviation, a photographic study of the west cabin outflow's path over time may be useful.

Action 3B: Clear exotic vegetation from the west cabin spring outflow.

Recommended Treatment

The west cabin spring outflow is defined by a distinct grass-dominated course through the surrounding shrub steppe. Although this pattern is naturally produced and maintained, regular removal of invasive species will improve the spring's flow and ecological benefits to native species. See appendixes 12 and 13 for more information on exotic species control.

VZ Image 3.2: West cabin spring outflow

Historic District Zone

Action 4: Replacement of trees north of the chicken house

Treatment Background

Existing Conditions

According to the PISP CLI prepared in 2006, the few silver-leaf cottonwoods clustered to the west of the chicken house could be offspring of historic plantings, however as no historical evidence has been located to document their origin, they are noted in the report as being of undetermined significance. These trees visually anchor the chicken house and outhouse, providing a backdrop and adding character to the structures. The location of the trees close to the chicken house creates a strong visual sense of clustering (HDZ Image 4.1, 4.2).

HDZ Images 4.1 and 4.2: *Existing conditions near the chicken house, 2009*

Currently, the three large trees west of the chicken house exhibit extreme dieback and limb death. The large tree west of the outhouse appears to be younger and robust. All of these large trees have produced numerous offspring through root suckering, ranging from 1’-8’ in height. Most of the offspring are located upslope to the northwest of the parent trees (HDZ Figure 4.1).

Recommended Treatment

Under ideal circumstances, four offspring would be selected to replace the large trees as they succumb to age and environment. These replacements would be located in relative proximity to the parent trees, retaining the current clusterings which serve the site well by providing interest around the structures. Unfortunately all of the offspring (as of September 09) appear to be root suckers, eliminating transplantation as an option without labor intensive rooting methods. It is therefore recommended that the healthiest offspring growing in proximity to the parent trees be groomed as replacement trees (HDZ figure 4.1). The trees to the northwest of the chicken house are far upslope from the parent trees, and have not been selected as replacements, as they would dominate the view and detract from the naturalized hillside. They would also not be close enough to the chicken house to contribute to the desired affect.

Selecting offspring near the parent trees, however, does not produce the desired clustering (only three trees are available) and may therefore need to be supplemented by either future offspring, transplants from another location in the monument, alternative propagation methods (appendix 2) or from nursery stock if direct replacements are desired. It should be noted, however, that fewer trees will reduce competition for water and may produce more vigorous replacements. Pipe Spring staff may select from the following treatments, dependant on available resources and future conditions:

Replacement by Future Offspring

Cottonwoods reproduce readily through sprouting and root suckering, especially when in decline or upon death. The site should be monitored for new offspring located near the mature trees over the next few years, or until the condition of the mature trees is such that they must be removed. If the tree fails to produce suitable offspring, a root sprout or sucker can be selected from those that will likely emerge once the adult tree is felled (see VZ 1 for Coppicing discussion). This method does pose certain challenges, however, as the adult tree and undesired suckers cannot be treated with herbicide. Systemic herbicides will harm any plant sharing the root system, requiring the manual removal of new suckers. The shared root system also poses the risk that any diseases, especially root diseases, affecting the parent trees will be inherited by the offspring. Although this option retains the genetic identity of the existing stand, the outcome is unpredictable.

Replacement by Transplant

Silver-leaf cottonwood saplings can be transplanted from other locations within the monument or from alternative propagation sources (appendix 2). Saplings would be selected based on health and size. Although larger trees will more quickly replace the mature trees, they are also more difficult to establish without irrigation. A whip size (0.5”-1” diameter) is recommended if the new trees cannot be irrigated (Nelson 2009). This option allows for a more designed clustering since trees can be placed anywhere on the site near existing trees.

Replacement from Nursery Stock

If all the eligible saplings in the monument prove to be root suckers, it may be necessary to purchase silver-leaf cottonwoods from a local nursery or distributor. As with the transplant option, the new trees can be placed anywhere on the site near existing trees.

Phasing

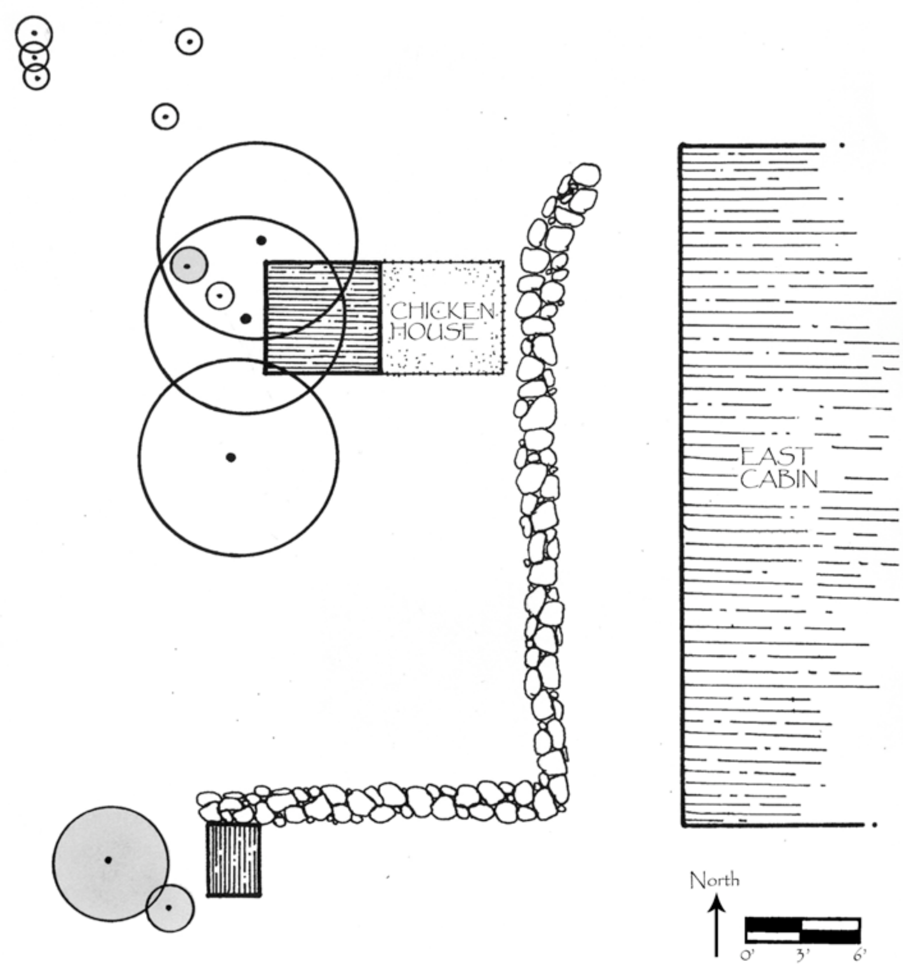
The three mature cottonwood trees west of the chicken house appear to be very weakened and are becoming unsightly. Although they will be replaced by one existing sucker (HDZ figure 4.1), the new tree is still very small and will not have an aesthetic presence at the site for several years. Unless management should decide to proceed immediately to replacement by transplant or nursery stock, it is recommended that the large (triple-trunked) tree to southwest and the northern most tree be removed first, leaving the larger tree between them as a visual presence while suckers establish around the cut trees. The center tree should be removed once it begins to crowd or harm the offspring at its base, or once it has reached a critical state of decline and is hazardous or unsightly. If the adult trees are replaced by transplant or nursery stock, it is recommended that the adult trees be removed first so that the new tree is not harmed during the removal, and so that the new tree can more easily be planted (the shallow roots of the mature tree will make digging more difficult).

The mature tree to the southwest of the outhouse appears to be in good health and does not need to be replaced. The smaller sucker south of this tree can be retained as an additional tree or as a backup, but if it appears to be harming the larger tree, it should be removed.

Removal of Existing Trees

Two removal methods will be required, dependent upon the relationship of the mature tree to its replacement. Any adult trees that share a root system with a desired sucker cannot be treated with herbicide. These trees must be cut in sections in order to prevent damage to the chicken house and to desired offspring. Regrowth and root suckers must be manually removed through pruning or pulling.

If the adult trees are replaced by transplants or nursery stock and no suckers are desired, a cut stump treatment may be used (see VZ 2 for discussion of cut stump treatment).



HDZ Figure 4.1: *Locations of existing cottonwoods and offspring. Suckers to be saved as replacements are shown in gray*

Historic District Zone

Action 5: Selective thinning of shrubs. .

Recommended Treatment

Selecting Shrubs

The primary goal of action 5 is to maintain pathways and spaces used for visitor interpretation. Shrubs should be removed where they interfere with visitor circulation or historic interpretation, including unpaved routes, gathering areas and historic features such as the orchard and vegetable garden.

Shrub Removal

Sites where the soil has been disturbed by shrub removal should be monitored for invasive species establishment. Any invasive species should be immediately removed or chemically treated.

See appendixes 12 and 13 for more information regarding shrub removal and invasive species control.

Hillside Zone

Action 1: Continue current policy of allowing natural processes to operate in the zone. Annual monitoring of vegetation will continue, as will trail maintenance and the removal of invasive exotic vegetation.

Recommended Treatment

See appendixes 12 and 13 for more information regarding invasive species management

Shrubland/Grassland Zone

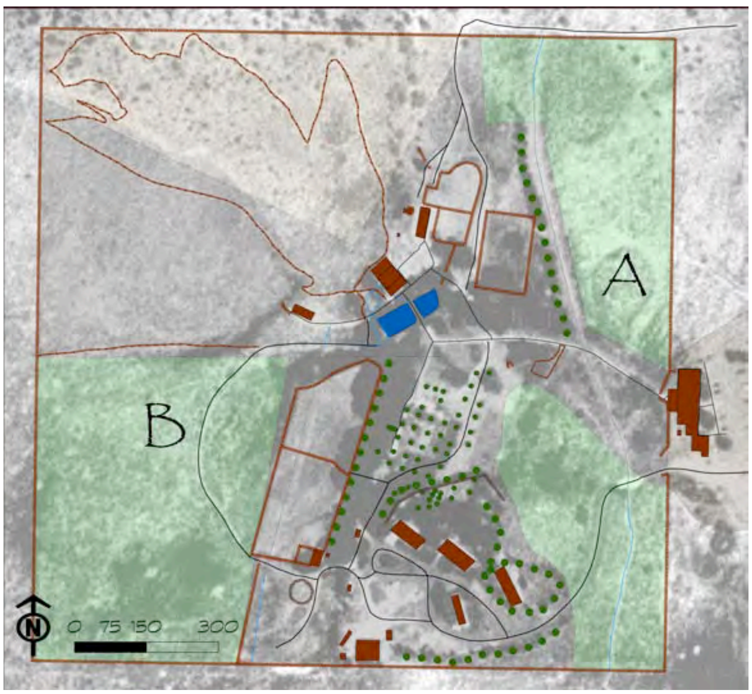
Action 1: Treatment of shrubland zones.

Action 1B: Selective thinning of shrubs and grass/forb reintroduction.

Recommended Treatment

SGZ action 1B may be applied to small areas within the zone. Unlike the intensive grassland restoration plot (VZ 6), the restoration recommended in this action is less formal and management intensive. SGZ action 1B restores a native grass/forb shrub steppe community, thinning existing shrubs but not removing them from the species composition. If the restoration is successful it may be applied to the entire monument.

Location



SGZ Figure 1.1: *Location of recommended restoration sites. Shrubland/Grassland Zone shown in green. Adapted from phase I report, 2009*

Restoration activities should begin in areas with high visitor visibility in order to maximize the interpretive value of the project. Within the shrubland/grassland zone two general locations are appropriate in terms of ecological setting and visitor interpretation. These locations are adjacent to VZ action 11 locations B and D, and should be used as alternatives or extensions to the VZ 11 plots (SGZ Figure 1.1).

In addition to their interpretive value, these sites will not disturb the monument's healthy plant communities. Dr. Walter Fertig, a member of the Moenave Botanical Consulting, collaborated with Dr. Jason Alexander of Utah Valley University in compiling a species list for Pipe Spring. Dr. Fertig suggests that Pipe Spring focus restoration activities on areas far south of the West Cabin, spring outflow, and sandstone cliffs, as well as along the eastern boundary of the monument, areas that have been compromised by disturbance. According to Dr. Fertig, the area south of the west cabin has experienced significant soil loss (down to the C horizon), but may be brought back to some semblance of a sandy-clay shrub/grass community. Full grassland restoration, however, may be impossible. Along the eastern boundary the soil loss and compaction have degraded the native community. Specifically, he recommends the area north of the monument trail and the visitor center. In this area several desirable species have naturally begun to reestablish, some of which are rare in Arizona (eg. Whipple's Cholla and Mendora Scabra). Extreme care should be taken not to disturb these species. Dr. Fertig strongly cautions against restoration activity in the Hillside Zone, an area that is in fairly good condition (Fertig 2010, pers. comm.).

Locations A

SGZ Image 1.1 *Location B, west of the visitor center (beginning north of the tree shown on the left)*

SGZ Image 1.2: *Location B, south of the west cabin*

Location A is northwest of the visitor center, contributing to a chronological interpretive experience as visitors move from the pre-disturbance landscape to the disturbed pioneer period vegetation (SGZ Image 1.1). The drainage channel crossing provides a point of transition, creating a strong contrast between the two landscapes. This effect would be enhanced by the relocation of the Paiute camp (SGZ 3) to the northwest of the visitor center, east of the flood ditch. Care must be taken in this location, however, not to disturb the rare native species that have begun to establish.

This location could also be a later extension of VZ 11, plot A if the alternative is selected in which grass/forb species are reintroduced along the main interpretive trail, moving outward (north and south) into VZ 11, areas A and B. This option would maximize visitor exposure and reduce confusion by providing a consistent treatment along both sides of the path, defining clearly the drainage channel as the point of transition (See VZ 11, *locations* section).

Location B

The alternative to location A includes the area west of the west corral to the monument boundary and adjacent to VZ 11, area D (SGZ Image 1.2). This area was selected primarily for its high visibility from the west cabin and its relevance to the audio narration and interpretive signage within the cabin. Visitors in the west cabin listening to narration explaining historic landscape changes would be afforded a bird's-eye view contrasting the grass/forb shrub steppe with the surrounding disturbed landscape. It should be noted, however, that this contrast would be subtle, demonstrating a healthy grass/forb shrub steppe rather than a grass dominated landscape. A stronger and potentially more accurate impression would be made by selecting this area as an additional intensive grassland plot under SGZ action 1C, below.

Shrub Removal

Sites where the soil has been disturbed by shrub removal should be monitored for invasive species establishment. Any invasive species should be immediately removed or chemically treated (appendix 12 and appendix 13).

See VZ 6 and appendixes 5-9 for information regarding species selection and restoration techniques.

Action 1C: Creation of small plots for intensive grass and forb reintroduction.

Location

The locations described in SGZ action 1B (see above) are also recommended for action 1C (SGZ Figure 1.2). This action includes a more intensive treatment requiring greater labor, materials, and management. An intensive plot in location A would provide a context for the Paiute camp, should it be relocated northwest of the visitor center (SGZ Image 1.1). However the fencing required to maintain the plot would isolate it rather than provide a setting in which the camp would be placed. Additionally, two intensive plots in close proximity (VZ 6) could visually complicate the pre-European landscape and diminish the interpretive value of the area. It is therefore recommended that action 1B be given priority in this location.

The second location, adjacent to the west coral, could support the interpretive theme within the west cabin and along rim trail (SGZ Image 1.2). As in action 1B, visitors in the west cabin listening to narration explaining historic landscape changes would be afforded a bird's-eye view contrasting the grass/forb shrub steppe with the surrounding disturbed landscape. An intensive plot could, however, be difficult to maintain in this remote region of the monument. Providing irrigation and shade would be especially challenging.

Shrubland/Grassland Zone

Action 2: Control of invasive exotics.

Recommended Treatment

See appendixes 12 and 13 for more information regarding invasive species and control methods.

Shrubland/Grassland Zone

Action 3: Alternative location for interpretive Paiute camp with addition of supporting trail.

Treatment Background

Historical Overview of Paiute Lifestyle

Gwen Dorra Homer, the original designer and builder of the Paiute camp at Pipe Spring, provided the following information on the Paiute lifestyle and physical environment (pers. comm. 2010):

Structures

Two types of structures are associated with the Paiutes. The oldest structures, called kahns, provided sheltered sleeping quarters (SGZ Image 3.1). These structures were small, providing only enough space for a single person to lie down and sleep. Homer emphasizes that everyday "living" occurred outdoors and not in these small shelters, a common misconception. The sleeping shelters were constructed of materials found nearby (juniper and brush at Pipe Spring), with the addition of a bark lining during the winter. The Paiute camp at Pipe Spring currently exhibits two of these structures, though Homer suggests that they are larger than they might historically have been.

SGZ Image 3.1: *Example of Paiute kahns* (http://www.texasbeyondhistory.net)

The second structure, a shade house, was not used until the 1920s or 1930s. The shade house at Pipe Spring is constructed of four corner posts and a brush mat roof (SGZ Image 3.2). These structures provide a shaded working space for handwork and other interpretive activities. Homer, who served as an interpretive Ranger at the monument, commented that the shelter provided a great deal of comfort and shade during the summer months and a place to hang her rabbit blankets.

A third semi-structure was also used by the early Paiutes. Brush windbreaks constructed in semicircles provided shelter for the outside living space and a place to gather around a protected campfire.

Spatial Organization

The location of the camp, garden, and storage, as well as the orientation of structures within these areas was determined by the location of key resources, environmental factors, and defensive strategies. The camp was often located near trees, such as juniper, that could offer additional shelter. Gardens were not usually seen near the camp, but were kept distant, adjacent to a spring or stream, in order to prevent their destruction or pillage in the event of an attack. Stored food was also protected and located away from the camp. Improvised storage areas were constructed or found in the landscape, including caves, cliffside nooks, and rock piles.

Within the camp, structures were oriented to maximize sunlight and protection from winds and weather. The entryways of structures were oriented with eastern exposures, as were the semicircular windbreaks.

Recommended Treatment

Relocation

Currently the Paiute camp is located west of the flood ditch and to the north of the monument trail. In this location the camp is placed adjacent to the pioneer vegetable garden and within full view of the structures and activities associated with the pioneer period of the monument.

Relocating the camp east of the flood ditch and north of the visitor center would offer several significant advantages. One of the great challenges in such a small physical area is presenting visitors with both the Paiute and pioneer narratives without creating both spatial and temporal confusion. A solution to this challenge is to create a timeline narrative, beginning with the Paiute museum in the Visitor Center and transitioning to the pioneer era as visitor move towards the fort. In this sequence, the drainage channel could provide both a symbolic and physical transition between the two narratives. In this location the camp could also be viewed from the Visitor Center porch, providing a more distant perspective of the camp in its appropriate ecological context.
Following the timeline, the Paiute camp would be supported by the historic native grassland plot established in 2008 (VZ 6) and by any future revegetation activities. Placing the camp in the context of the historic grassland-shrub steppe would enhance the interpretive value of the revegetation plot(s), creating a stronger transition and impression of the impacts of pioneer settlement on the landscape.

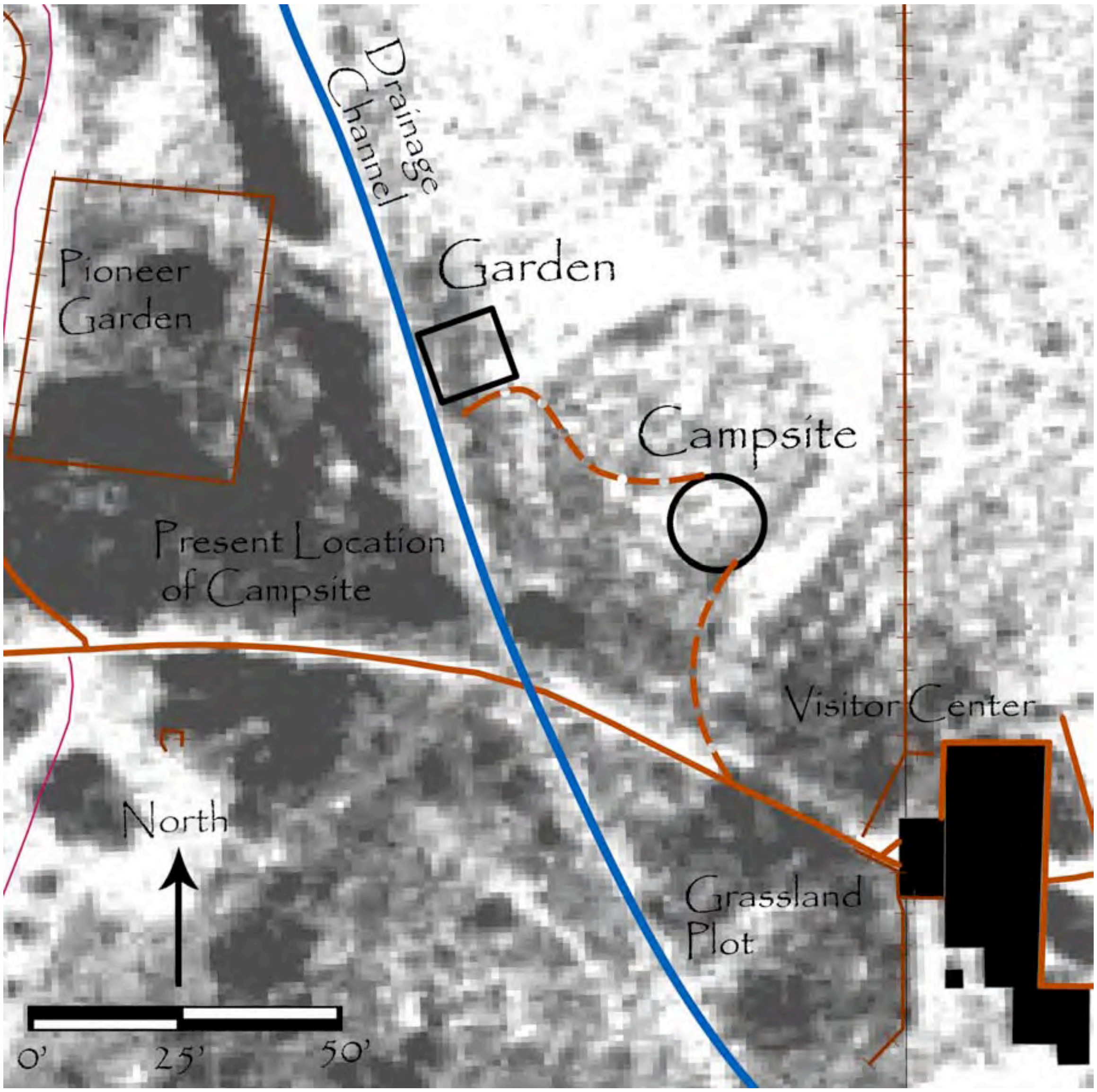
The location also offers a great amount of flexibility in the camp's size and placement. The native plant communities in the area between the Visitor Center and the drainage channel have already been compromised by compaction and disturbance, providing ample space for a larger, more faithful and interactive interpretive area at a minimized ecological cost. The space available in this area also affords a greater sense of isolation and detachment from incompatible pioneer features and a stronger connection with the landscape.

Design

Spatial Arrangement

As argued above, locating the camp in the shrub steppe between the Visitor Center and drainage channel affords great flexibility in expanding the camp and creating multiple interpretive areas.

In the design shown in SGZ Figure 3.1 the camp is placed in a central location, maximizing its isolation from competing features, its context within the shrub steppe, and views from the Visitor Center porch. Although a general location is suggested, the final location of the camp, garden, and trails should be based on the identification and protection of the rare plant species reestablishing north and west of the Visitor Center, ensuring that these plants are not harmed during the construction and use of the new area. (Fertig, pers. comm. 2009). Additional juniper trees may be added to screen views of the pioneer landscape (corral and fort). These plantings should reflect the natural juniper communities and may be combined with VZ9.



SGZ Figure 3.1: *Proposed Paiute campsite and garden relocation with interpretive trails (brown, dashed line)*

GZ Image 3.2: *Existing Paiute camp*

Spaces

The current campsite contains two Kahns, a shade house, and campfire (SGZ Image 3.2). This arrangement, although providing opportunities for ranger-led activities, does not realize the camp's full interpretive potential. The relocated camp could develop visitor understanding of the spatial relationship of camp elements and the strategies behind them. Additionally, the expanded trail system could offer sequential interpretive opportunities relating to the landscape and museum, producing a protracted visitor experience and greater depth of understanding.

The Campsite

The proposed campsite (SGZ Figure 3.2) provides several examples of both summer and winter kahns, resembling a full campsite such as the one shown in SGZ Image 3.1. A semicircular brush structure partially enclosing the campfire is a compatible feature that offers an interactive gathering and seating space for small groups of children during interpretive tours. Both the kahns and the semicircular shelter should face to the east. If the expansion is too large for the monument's resources, it can easily be downsized by reducing the number of Kahn structures.

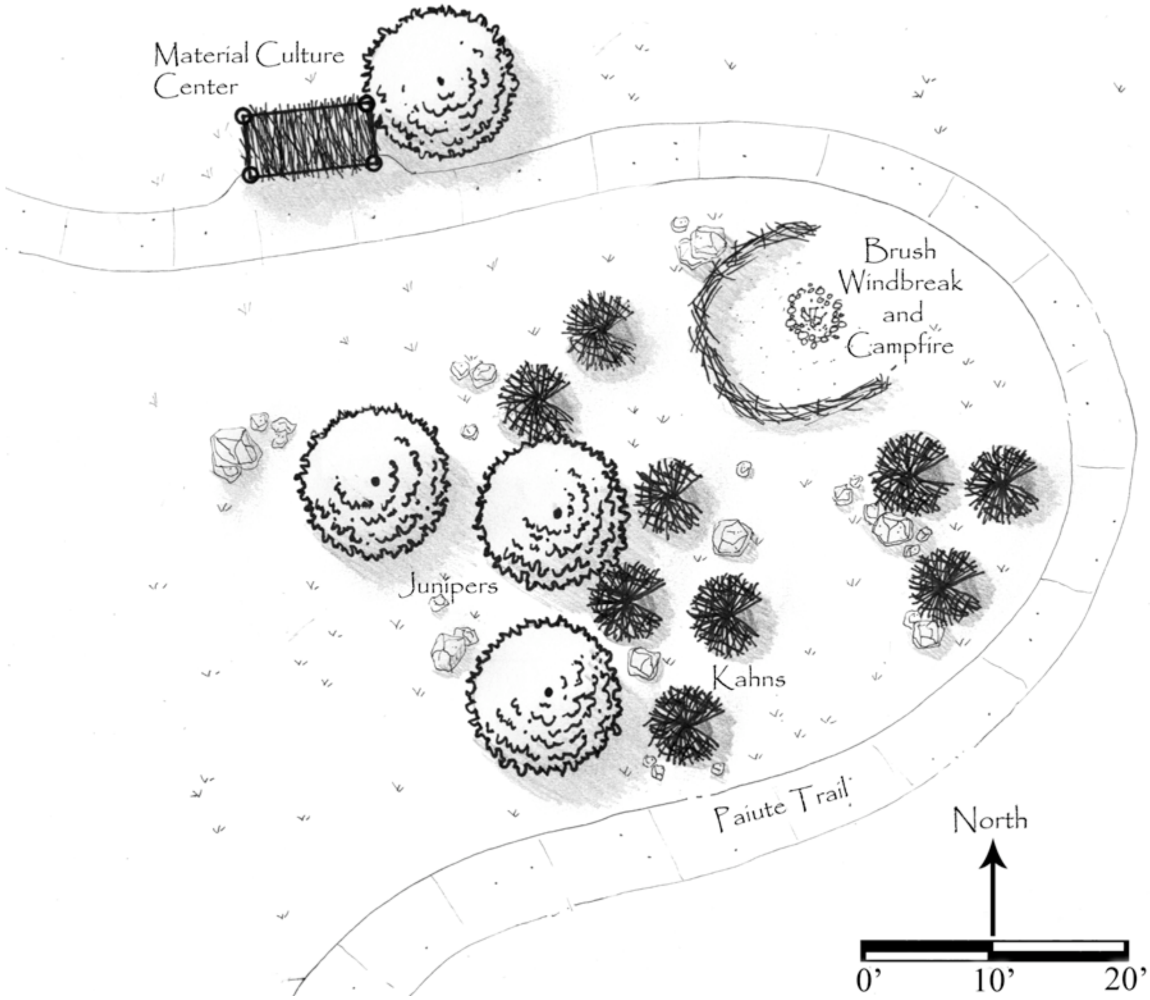
Brush huts are compatible with a much later period in history (the 1920s/30s) but do offer invaluable shade for interpretive rangers as they carryout their daily handcrafts and lectures. It is recommended that a brush hut be located slightly distanced from the central campsite, minimizing its visual impact on the campsite and highlighting it as a distinct interpretive area (SGZ Figure 3.2).

Vegetation should remain within the campsite (in contrast to the bare ground in the existing camp), accurately portraying the transient camps. The addition of junipers or placement of the camp adjacent to established junipers would emphasize the Paiutes' use of the landscape for shelter and safety (SGZ Figure 3.2). A low-intensity (un-fenced) grassland revegetation plot would provide a highly appropriate context for the campsite.

The Garden

The proposed garden is located at a distance from the camp (SGZ Figure 3.1), expressing some of the spatial relationships between campsites and gardens (although it remains fairly close). The garden, which would likely have been located adjacent to one of the monument's springs, is placed adjacent to the drainage channel, representing a source of water without placing the garden within the pioneer landscape. Interpretive signage could clarify the compromises made in regards to the proximity of the garden to the campsite and its location away from the springs.

One potential source of plant materials is "Native Seeds: Southwestern Endangered Aridland Resource Clearinghouse", located at http://www.nativeseeds.org/Home. Native Seeds offers a full catalog of seeds from historic and wild native varieties, specializing in ancient crops used by Native Americans.



SGZ Figure 3.2: *Proposed Paiute camp design. Interpretive trail leading from the main Monument trail passes clusters of kahns (summer style to the west and winter style to the east) situated in the shelter of Junipers and rocks. A Brush windbreak and campfire serve as a small gathering point for ranger-led tours. Disconnected from the main body of the camp is a Shade House providing a sheltered space for material culture education*

Interpretation

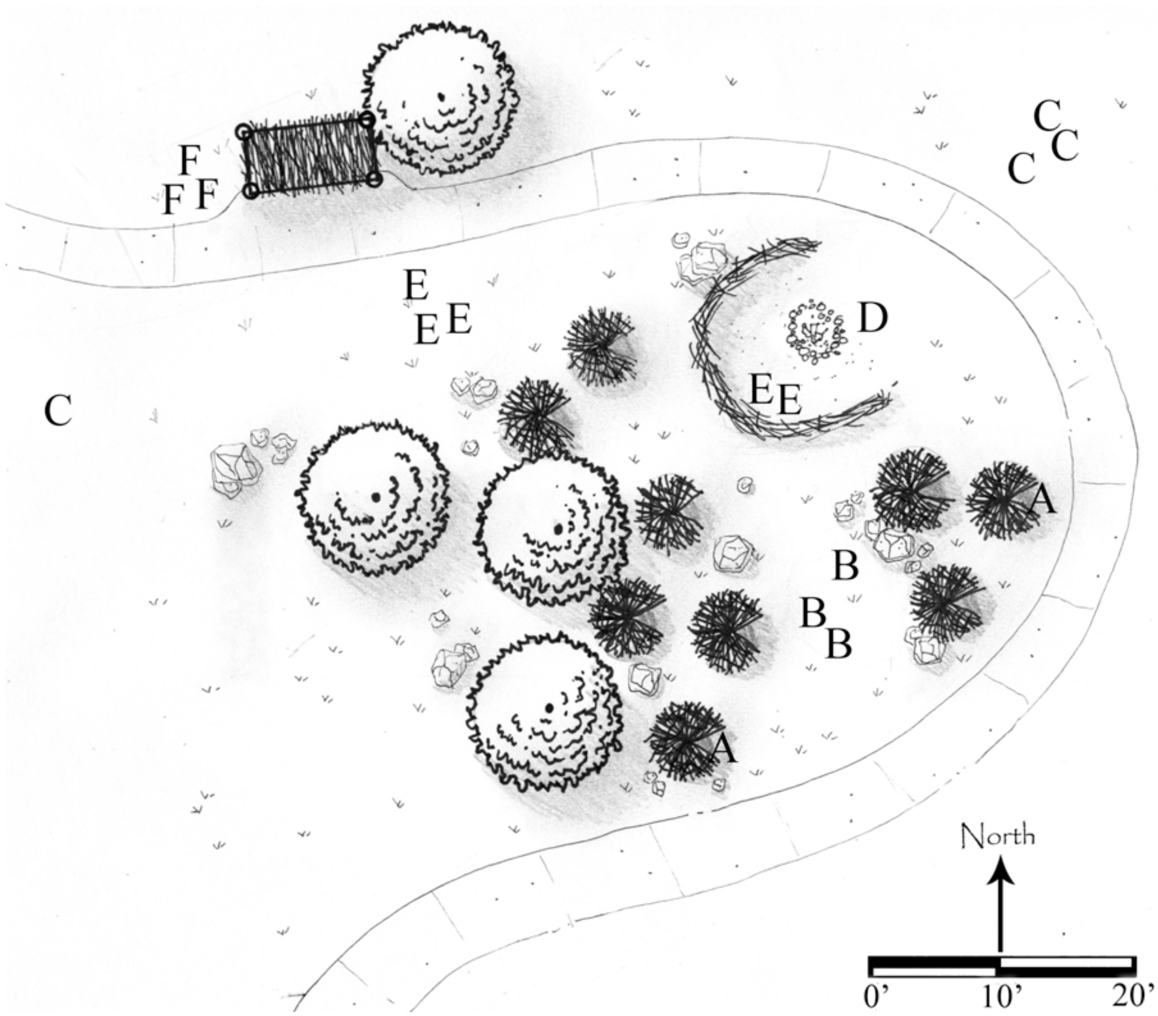
Three forms of interpretation can be offered to visitors exploring the Pauite trail. The first is ranger-led. The trail offers a longer tour with a small space surrounding the shade house for hands-on activities or lectures on the Paiute's material culture.

The second opportunity is visual. In addition to the camp features and environmental context previously discussed, the visual interpretation of the site could be enhanced by stand-in silhouettes. This interpretive devise has been used to great effect by Grand Staircase Escalante Cannonville Visitor Center in a similar Paiute camp setting. (SGZ Image 3.3 and 3.4). The Cannonville silhouettes are made of CORTEN steel. Potential silhouettes designs (or activities) include: gardening, grinding, basketry (or other crafts), sleeping (within the Kahns) and gathering supplies such as juniper branches or game, ceremonial activities, and leisure activities (gathering and talking or playing games) (SGZ Figure 3.4). Interpretive signage could accompany specific activities.

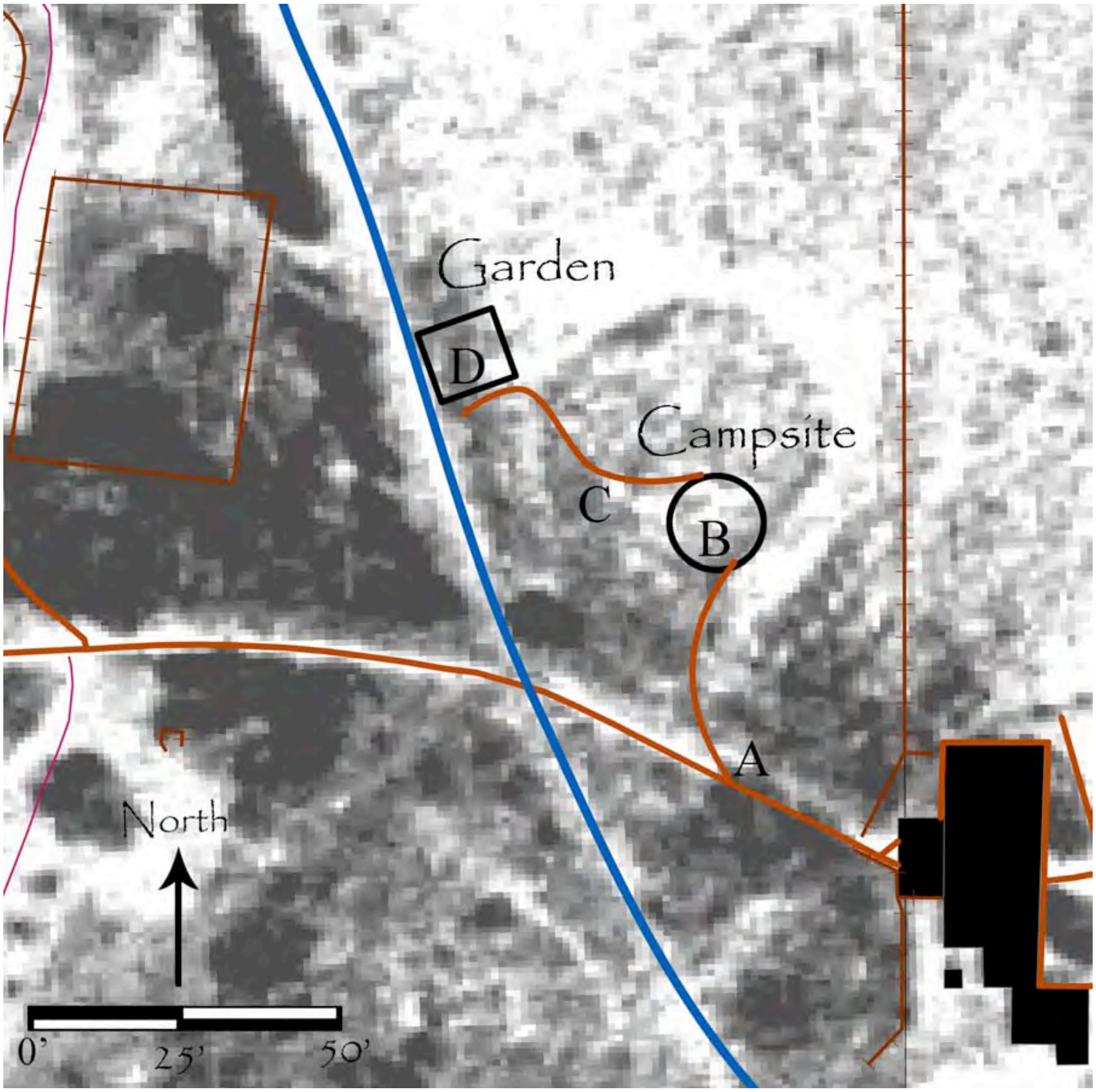

SGZ Images 3.3 and 3.4: *CORTEN steel silhouettes in the Paiute camp at the Cannonville Visitor Center*

The final opportunity is through interpretive signage. Creating a sign style or design unique to the Paiute trail will further distinguish the Paiute narrative from the Pioneer narrative. This could be easily accomplished by adopting a standardized color palette (see SGZ Figure 3.6, 3.7, 3.8, and 3.9). The same design continuity could be applied along the ridge trail where existing signage identifies plants significant to the Paiute culture.

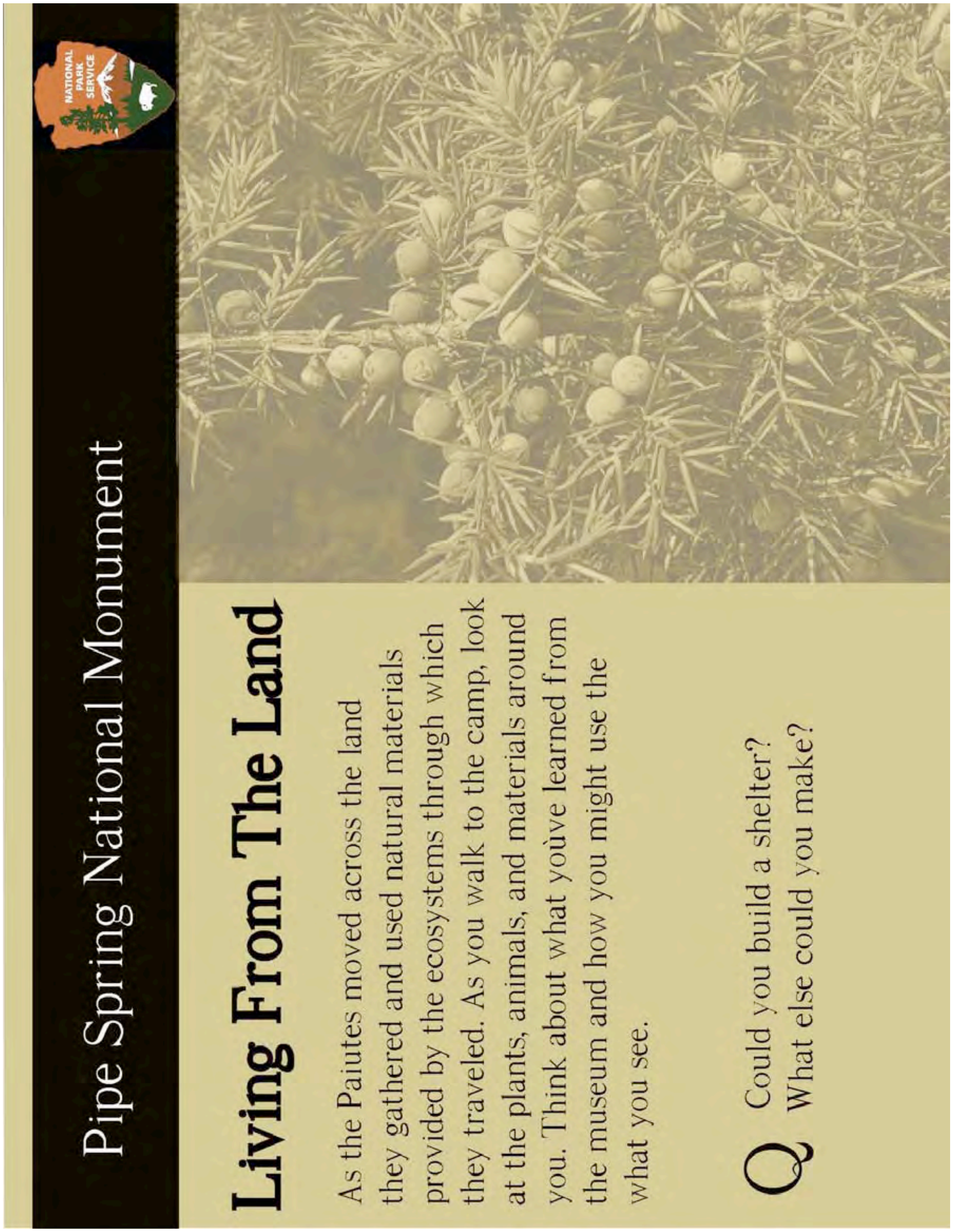
Pipe Spring attracts a large number of local school groups, emphasizing the importance of youth-focused interpretation. Current signage around the monument is high for very young children to see and oriented more towards an adult audience. The Paiute trail could be school group-focused, providing signage for both adult visitors and low signage for a younger audience. Examples of signage for the latter group are provided below (SGZ Figure 3.6, 3.7, 3.8, and 3.9). These signs could guide visitors along the trail sequentially, building upon the experience at each stop (SGZ Figure 3.5).



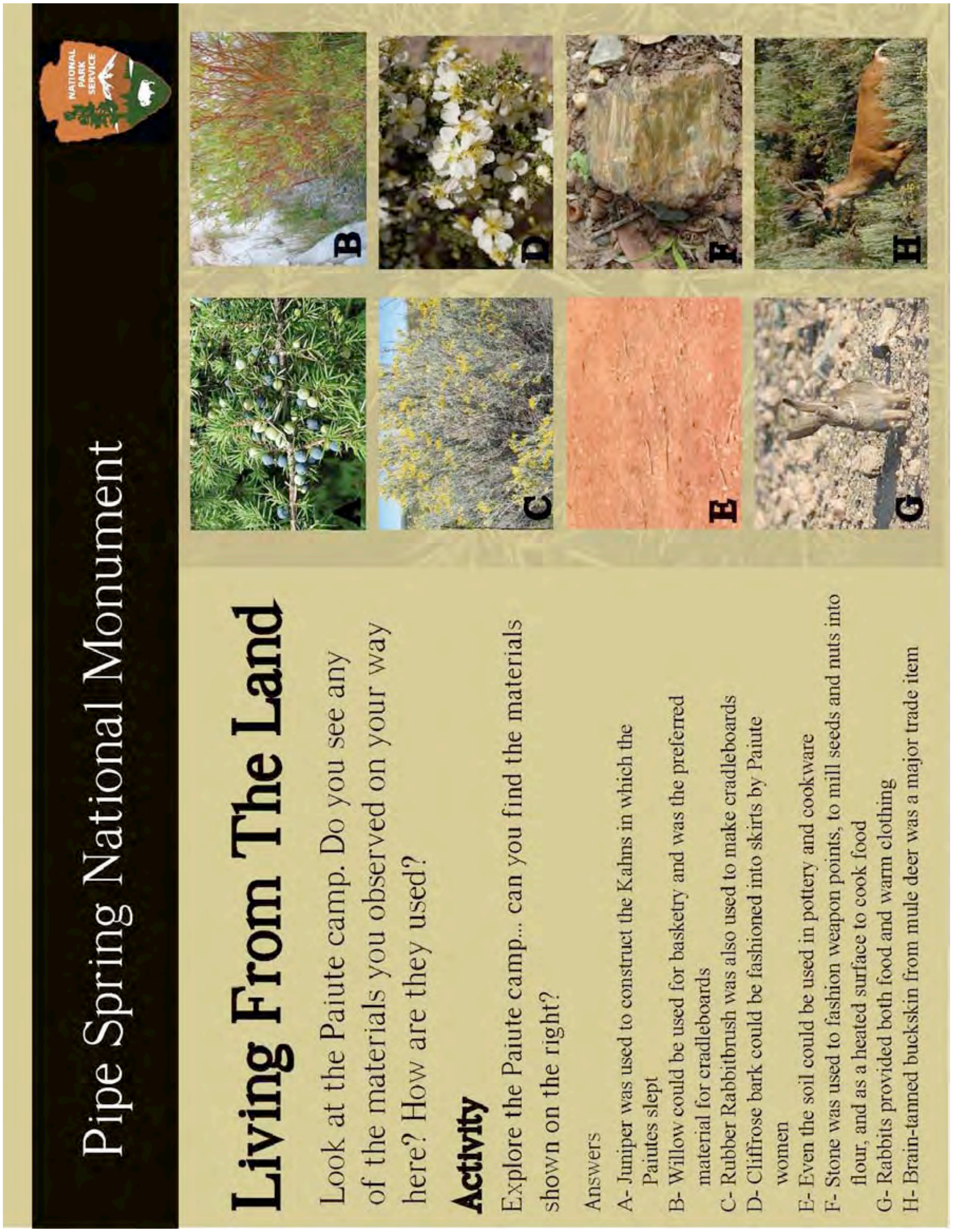
SGZ Figure 3.4: *Placement of interpretive silhouettes. Key: A: Sleeping B: Playing Games C: Gathering and/or carrying materials D: Using the Grinding Stone E: Sitting and talking (around the campfire) and standing and talking. F: Making baskets, cradleboards, rabbit blankets etc.*



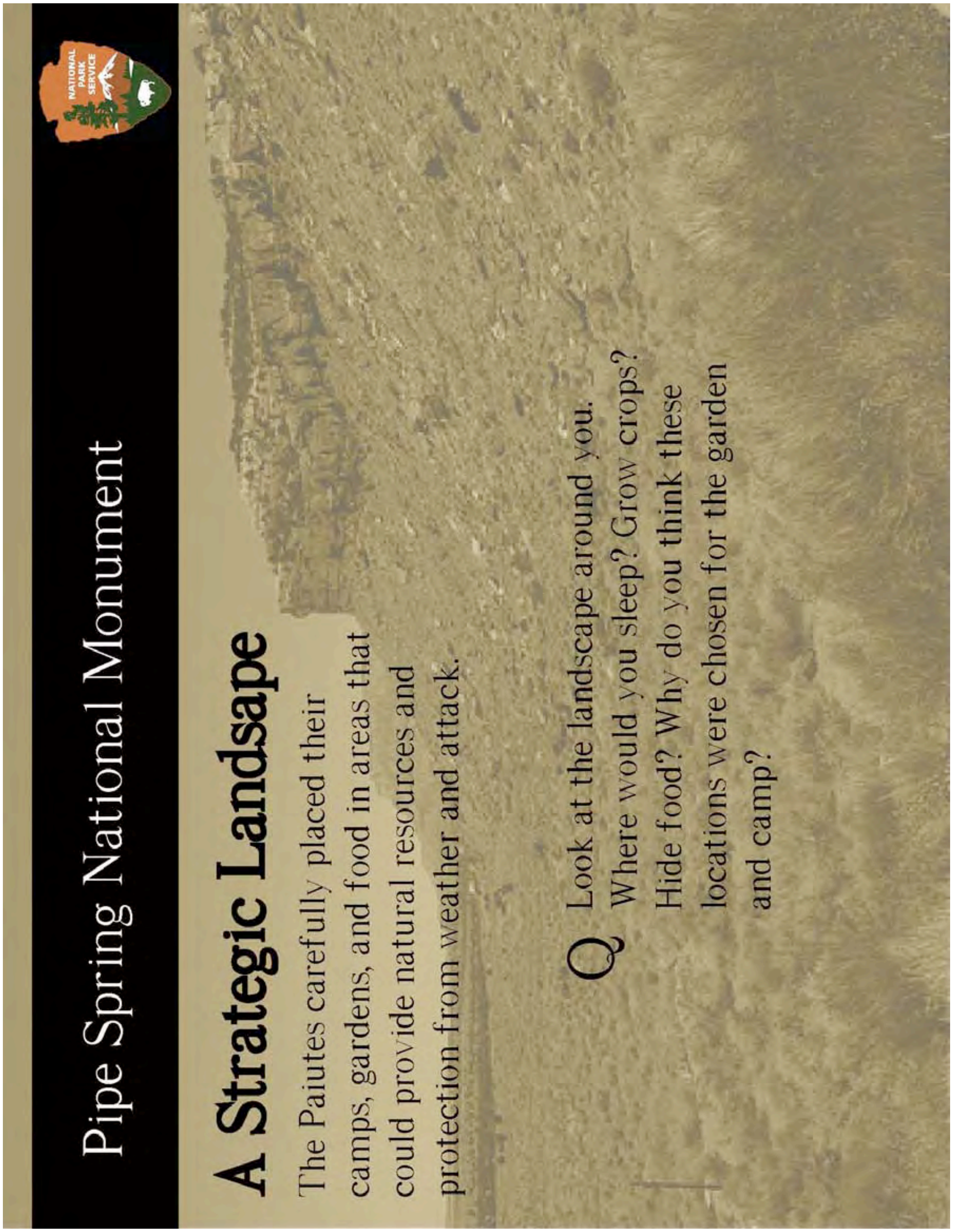
SGZ Figure 3.5: *Proposed location for prototypical sequential interpretive signs*



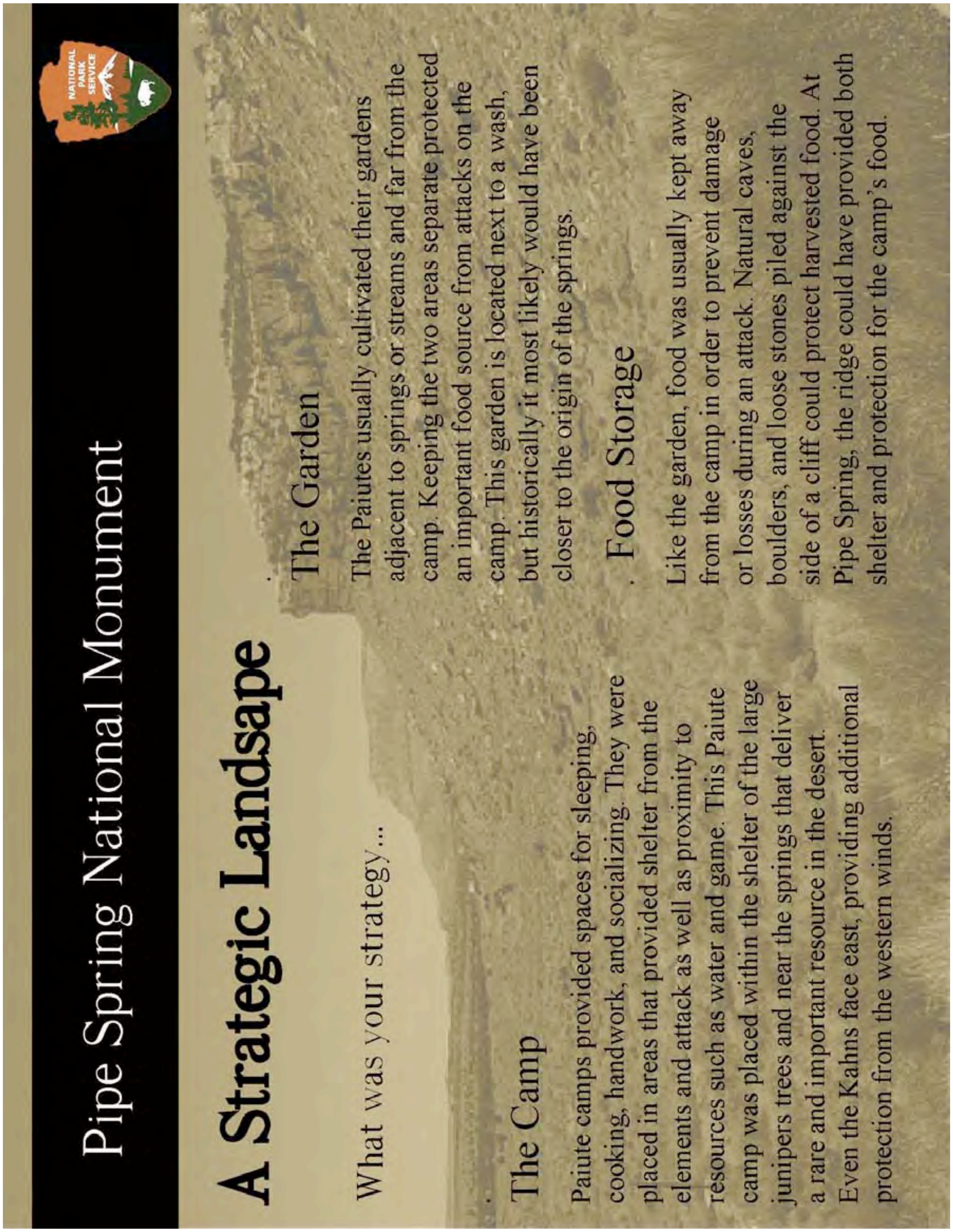
SGZ Figure 3.6: *Sign placed at the beginning of the Paiute Trail*



SGZ Figure 3.7: *Sign placed at the Paiute campsite*



SGZ Figure 3.8: *Sign placed along the trail to the Paiute garden*



SGZ Figure 3.9: *Sign placed at the Paiute garden*

Administrative Zone

Action 1: Phased removal or minimization of the lawn and exotic vegetation with the exception of deciduous shade trees. It would, over time, convert portions of the existing designed landscape to a more water-wise palette of plant materials. Additional shade trees, native or adapted to low water use such as single-leaf ash and netleaf hackberry would be added as needed.

Treatment Background

Species Overview

For more information on native species and water-wise plant selection see appendix 14

Management Overview

Although an irrigation system is in place throughout most of the lawns surrounding the administrative housing, much of the grass has died back in the recent summer droughts. The dieback has created not only barren areas vulnerable to invasive species, but also irregularly shaped lawns that appear unmanaged. The redesign of the lawn areas is focused on reducing the overall amount of lawn, giving shape to the remaining lawn spaces, and establishing a water-wise plant community consistent with the NPS's commitment to sustainable practices.

A central island planting bed (AZ Image 1.1) and the common areas along the perimeter of the housing area are also severely overrun with an eclectic mix of exotic and invasive species. These areas should be cleared and planted with water-wise plants to produce a more unified, attractive and ecologically conscious setting for monument residents.

AZ Image 1.1*: Overgrown ornamental plantings in center island*

Recommended Treatment

Designs for two of the housing units are provided as prototypes for the remaining units (AZ Figures 1.2, 1.3). General recommendations for all units include:

- Reduction and shaping of front and back lawn areas.
- Removal of lawn in exchange for water-wise plants in areas between homes. Crushed local stone paths could be installed to guide circulation around homes (AZ Image 1.2, AZ Figure 1.2).

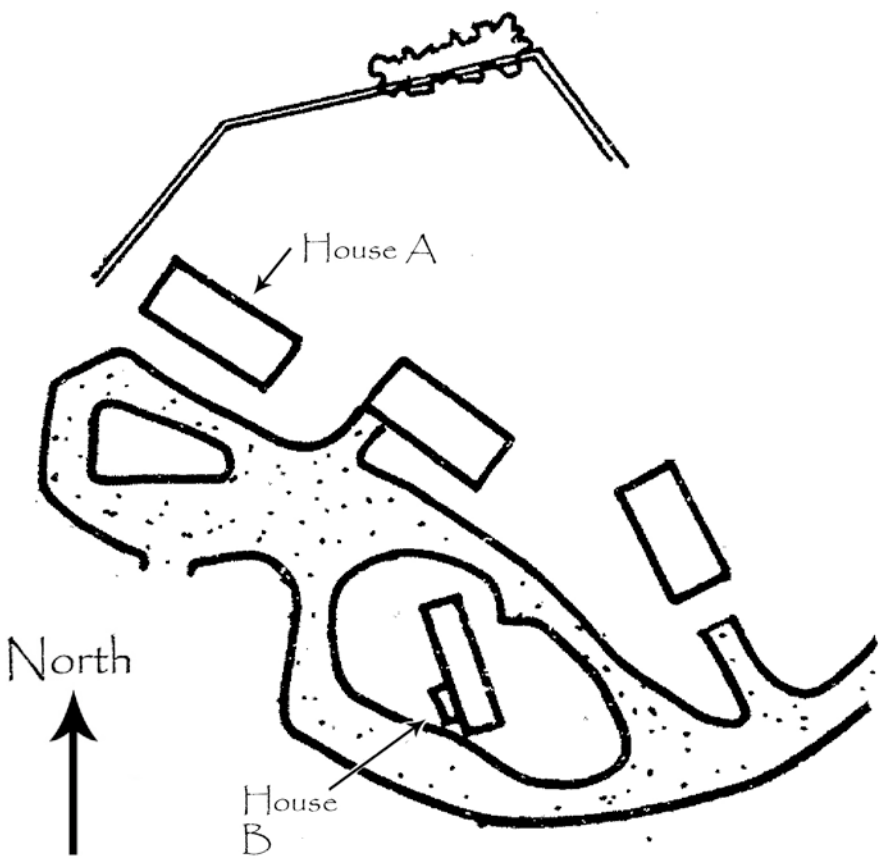
AZ Image 1.2: *Side Lawn*

- Experimental introduction of native blue grama grass in front lawns and, if successful, replacement of existing lawn species (AZ Image 1.3).

AZ Image 1.3: *PISP has begun to experiment with native grasses in residential yards. The native grass (blue-green color, left side of photo) is lush and healthy in comparison to the existing grass species (yellow color, right side)*

- Removal of all exotic and non-water-wise plant materials with the exception of shade trees and fruit bushes near the perimeter of the back yards. Exotic shade trees may be phased out over time and replaced with water-wise species.
- Revegetation of barren areas with water-wise and/or native plants

Prototype Designs

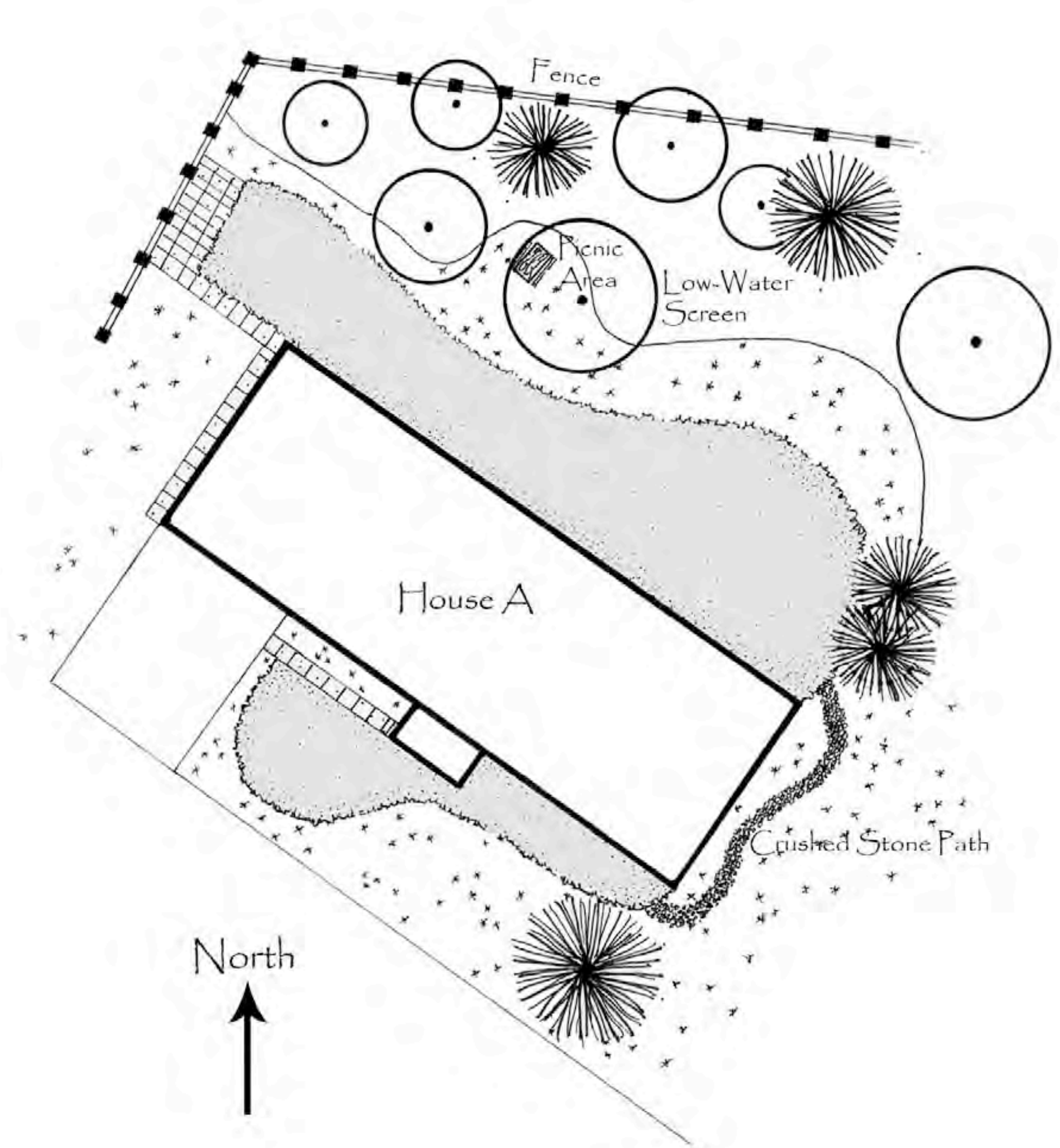


AZ Figure 1.1: *Locations of prototype homes A and B*

House A

House A, located farthest west (AZ Image 1.4), has a fairly healthy but shapeless front and back lawn. The back lawn looses shape and thickness as it transitions into a wild tree and shrub screen in the far end of the yard. This unmanaged area is composed largely of exotic vascular plants, such as vinca, and a mix of exotic trees and orchard species.

The recommended treatment provides a small but useable and shapely lawn. Exotic vascular plants and shrubs should be removed and replaced with water-wise species planted to give definition to the small existing picnic area and to retain a screen between the yard and visitor zone. Fruit trees and hedges may remain as an appropriate screen and transition between the orchard and housing area. The front lawn should be removed, if possible, or at a minimum reduced to small, shapely area highlighting the main entry to the home. The side yard lawn is replaced with water-wise plants and enhanced with a crushed local stone pathway.



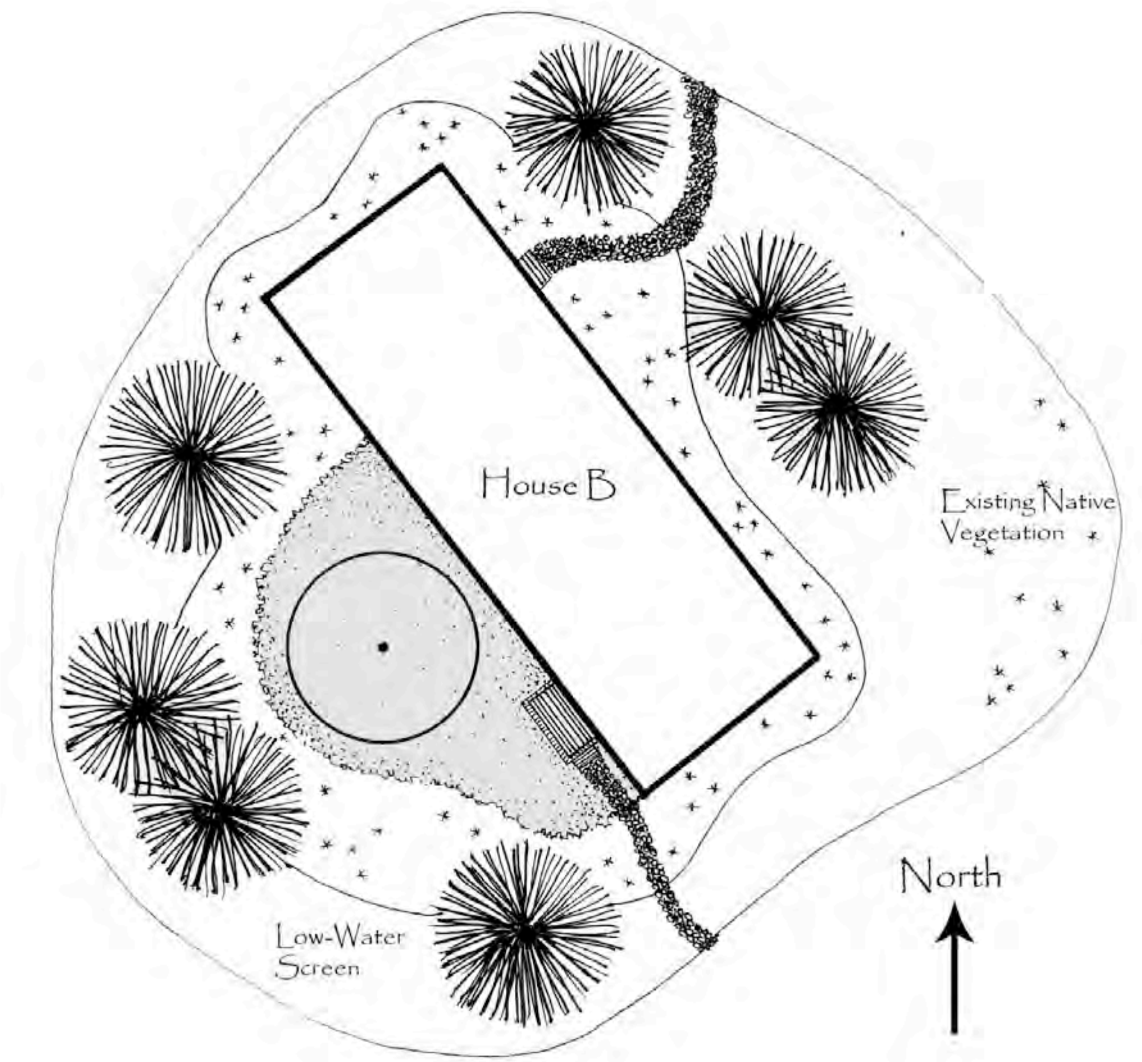
AZ Figure 1.2: *Plan of house A with remaining lawn shown in gray and low-water and/or native beds shown with an asterisk pattern. The remaining area (white) represents a larger and more natural low-water and/or native screen. All trees shown are representative of existing trees, with open circles representing deciduous trees and spiked circles representing conifers*

House B

AZ Image 1.5: *House B*

House B (AZ Image 1.5), located in the center island, has the smallest and most barren yard. The recent drought has killed all of the home's lawn, leaving only a large juniper shrub and several declining poplars.

The recommended treatment for house B is to establish a small lawn in front of the home, and water-wise foundation plantings to cool the site, provide visual interest, and stabilize loose soil. Outside the more formal planting space, the remainder of the site is returned to a native shrub steppe community or a less formal water-wise landscape. The addition of shade trees and pinyon and juniper screens will help provide a more hospitable microclimate and screen some of the disruptive sounds and light from passing traffic.



AZ Figure 1.3: *Plan of house B with proposed lawn shown in gray and low-water and/or native beds shown with an asterisk pattern. The remaining area (white) represents a less formal low-water and/or native screen. All existing trees are removed and replaced with a pinyon and/or juniper screen (spiked circle) and low-water shade tree (circle)*

Administrative Zone

Action 2: Replace asphalt parking with pervious pavement (paving treatments that allow percolation through the surface) that would demonstrate best management practices for storm water management by retaining runoff on site.

Treatment Background

Management Overview

In 2009 the roadways and parking areas at PISP were paved with asphalt as a part of the Federal Highway Administration's Pavement Preservation Program. The following information provides a general overview of pervious paving options that could be applied to future monument projects.

Recommended Treatment

Overview

Pervious pavements have been developed and used since the 1970s and are recently growing in popularity as a Best Management Practice. Pervious pavements are surfaces that allow storm water to percolate into a water-retaining subgrade and then infiltrate into the underlying subsoil. By allowing the water to return to the site's soils rather than directly into storm drains and watersheds, the storm water can reenter a natural filtration system and recharge local groundwater. In addition to its storm water and filtration services, pervious pavements are attractive, durable, and compliant with the Americans with Disabilities Act (Glist 2009)

Paving Options

Unit Pavers

Unit pavers offer the most diversity in form, size, color, and material of all the pervious pavement options currently available (AZ Image 2.1). Unit pavers are placed over a subgrade, usually crushed stone or sand, that is able to accommodate storm water infiltration. The joints between pavers allow storm water to percolate into the subgrade.

AZ Image 2.1: *Example of unit pavers* (http://pdf.archiexpo.com)

Some paver systems are interlocking, leaving voids that are filled with sand or gravel to allow increased absorption.

Depending upon the material of the paver, they can also be the most costly permeable pavement, averaging $5 per square foot in 2006 (Portland 2009). In addition to the cost, unit pavers require annual vacuuming to keep the pores clear and can easily be clogged in areas where windblown sediments are an issue.

Porous Concrete

AZ Image 2.2: *Example of porous concrete* (http://www.perviouspavement.org)

Like traditional concrete, porous concrete is composed of stone aggregates and Portland cement or epoxy binders. Porosity is achieved by excluding the fines from the aggregate component, producing void spaces through which water can percolate. Below the concrete are two subgrade layers, a crushed aggregate filter layer and a 12” minimum coarse aggregate layer that serves as a reservoir from which water can infiltrate the uncompacted subsoil (NRMCA 2010, DCCD 2009).

Porous concrete has 15%-22% pore space in comparison to traditional concrete’s 3%-5%. Porous concrete does, however, have several limitations. Although its life expectancy of at least 20 years is similar to traditional concrete, it does require quarterly vacuuming to clear pore spaces and can become clogged in areas where windblown sediments are problematic. Load limits also apply to porous concrete, though it is acceptable for most residential and low density parking areas (DCCD 2009).

Porous Asphalt

Porous asphalt is similar to porous concrete in terms of longevity and construction technique (AZ Image 2.3). Like porous concrete, porous asphalt is made porous by removing the fines from the asphalt mixture, creating pore spaces through which water can infiltrate a series of layers. The

AZ Image 2.3: *Example of porous asphalt* additional pore space give porous asphalt a slightly coarser appearance than traditional a asphalt. Comparable in life expectancy (20 + years), porous asphalt is more expensive than tradition asphalt and requires regular vacuuming in order to function properly. It does however, resist cracking and potholes, and reduce surface temperatures by allowing air flow through the pore spaces (NAPA 2009, DCCD 2009).

Gravel Pavers

Gravel pavers are an alternative application of more common grass paver systems. The basic structure of gravel pavers is a cell matrix that is filled with fine gravel. The cells stabilize the gravel while providing a supportive surface for vehicular loads. Gravel pavers are long lasting, with life expectancies matching those of concrete and asphalt, and are low maintenance. Unlike concrete, which easily cracks, and asphalt, which must be resurfaced every 8-15 years, gravel pavers are durable and require only yearly touchups to redistribute or add gravel in thin areas. Some studies suggest that grave pavers also have sound reducing qualities (Glist 2006, Invisible Structures Inc. 2001).

AZ Image 2.4: *Example of gravel pavers (Invisible Structures Inc.)*

Generally the most inexpensive and commonly used gravel pavers are made of recycled plastic. These pavers are more flexible than either concrete paver, a good option for irregular surfaces. Gravelpave 2 (Invisible Structures Inc. 2001) is a unique paver designed specifically for gravel (not grass) applications. Created from a durable high density polyethylene plastic, gravelpave2 cells are attached to a filter fabric designed to prevent stone migration and weed growth. Gravelpave 2 and other manufactures offer paving cells in a variety of colors to match local stone treatments (see references for more information).

Gravel pavers have been recently installed in parking lots at the Utah Botanical Center, Kayesville, and at the Grand Staircase Escalante NM Visitor Center in Escalante. Although the GSENM paving does show some signs of use, mostly around bends, the surface is performing well, even during snow removal.

Design

The variety of paver types and designs provides PISP numerous opportunities to incorporate storm water best management practices while maintaining an historic esthetic and accommodating visitor of all abilities. Several of the materials described above could be applied to both the pedestrian and vehicular routes throughout the monument in a number of combinations.

In the monument's administrative areas porous concrete, asphalt and gravel pavers could be used alone or in combination. Gravel pavers may offer PISP the most attractive and low-maintenance option. A local crushed stone (see VZ 12) applied to the residential roadway and parking areas would provide an attractive surface for residents while appearing inconspicuous in the landscape from visitor areas. In comparison to asphalt, stone also increases the surface albedo, reducing ambient heat and providing a cooler microclimate for residents. In high-traffic areas, such as the main roadway through the residential area, porous asphalt or concrete could be substituted for gravel pavers.

Additional Note: A pervious surface could also be applied to the visitor center parking area. As in the residential area, pervious materials could offer a demure and aesthetically pleasing treatment while providing ADA friendly parking, reducing surface heat, and diverting storm water to surrounding planting beds.

Administrative Zone

Action 3: Phased reconfiguration of poplar tree screens around the AZ and the planting of understory pinyon/juniper trees for screening purposes. Additional pinyon/juniper trees, planted in drifts would be added to the AZ, VZ, and SG zones to screen the development from the visitor center and visitor-approach corridor along highway 389.

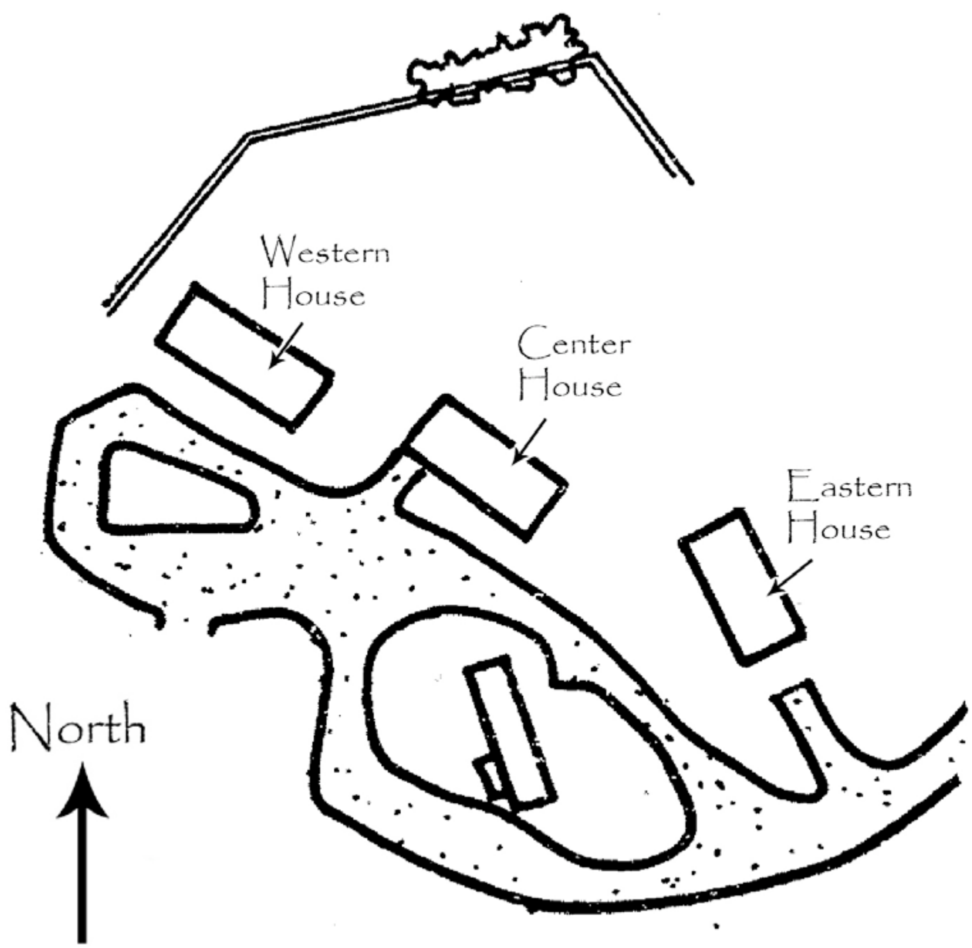
Recommended Treatment

Reconfiguration of Poplar Screen

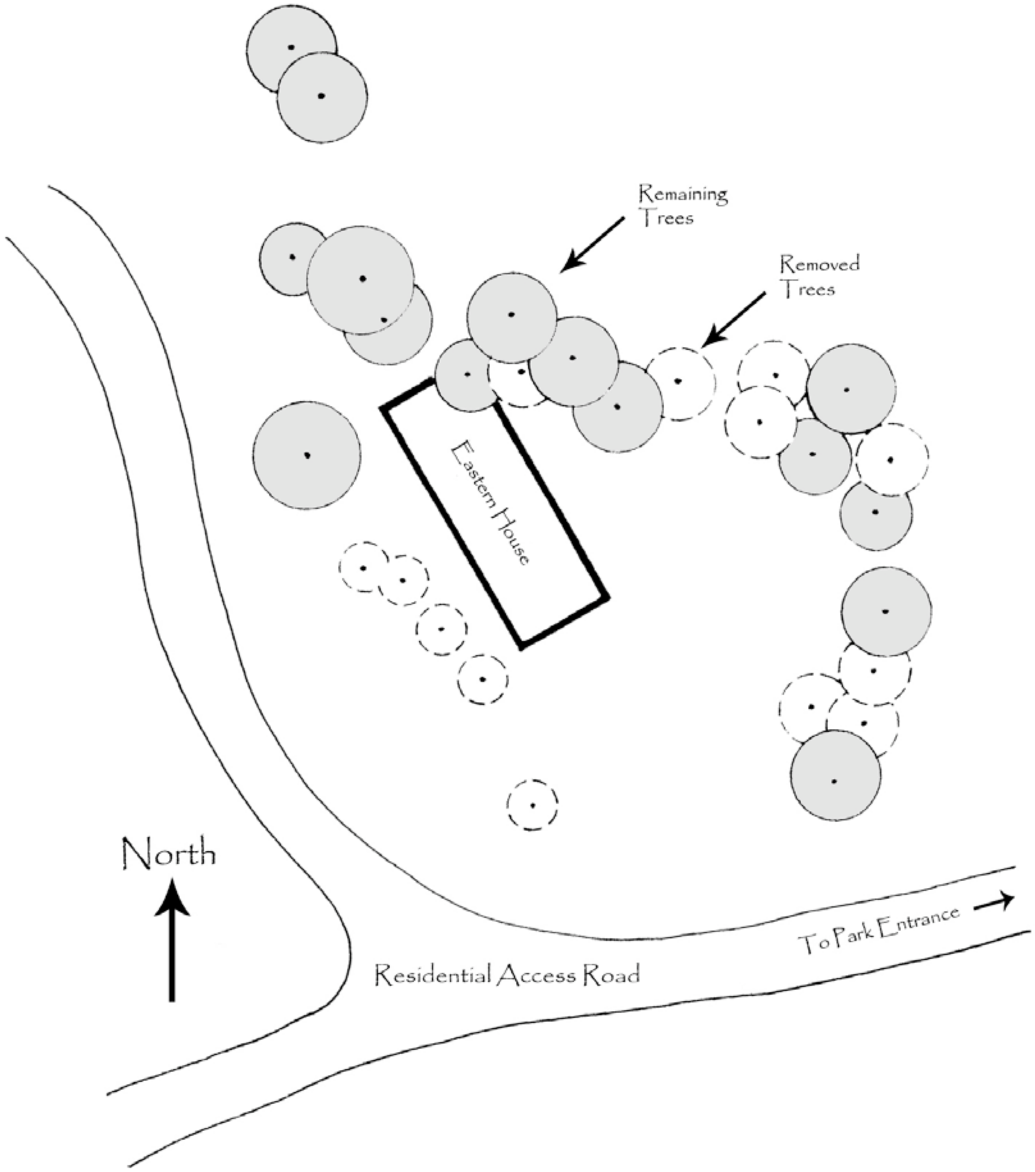
The poplar trees surrounding the administrative housing unit have matured into a tall, linear element within a low natural landscape, drawing attention to the area and suggesting to visitors that it is part of the monument's historic landscape. Although the trees do little to screen the homes, they do provide shade and interest to the residents.

AZ Image 3.1: *View of housing area from west side of visitor center. Note lack of ground level screening.*

It is recommended that the poplar trees be removed in phases and replaced with demure water-wise trees more compatible with the monument setting (see appendix 14 for more information on water-wise plants). During the first phase, several of poplars will be removed in order to break apart the linear form of the screen (AZ figure 3.2). Poplars shown as removed have been chosen based on initial impressions on health and location in reference to forming smaller groupings, but selections may be altered at the discretion of park administrators (see appendix 3). During subsequent years the remaining poplars will be phased out on a tree-to-tree basis as they begin to decline in health. Eventually the entire screen surrounding the residences will be composed of shorter water-wise species and additional understory planting screens as described below. For more detailed information on removing poplars see VZ 2 "Cut Stump Treatment".



AZ Figure 3.1: *Diagram of home configuration and nomenclature*



AZ Figure 3.2: *Schematic plan of phase I of the poplar screen removal. Removed trees, shown with dashed lines, were selected based on health, crowding, size, and desired clumpings. Existing trees to remain shown in gray*

Introduction of New Screening Plants

Although the new shade trees replacing the poplars will provide some screening, additional species will be necessary to provide a lower understory screen and to transition the screen into the surrounding natural and cultural landscapes. These additional screens can be implemented during phase one and in several possible configurations.

To the south of the housing complex and north of the eastern and center homes (AZ Figure 3.1, AZ Images 3.2 and 3.3), naturally spaced pinyon and juniper clusters should be used to provide a screen that will transition into the monument's native plant communities (See VZ figure 9.2 for clumping patterns). The juniper shown in AZ Image 3.2 is approximately 140' from the home and provides excellent screening.

AZ Image 3.2: *View of eastern home from west side of visitor center. Note the effective visual screening provided by junipers in comparison with poplars*

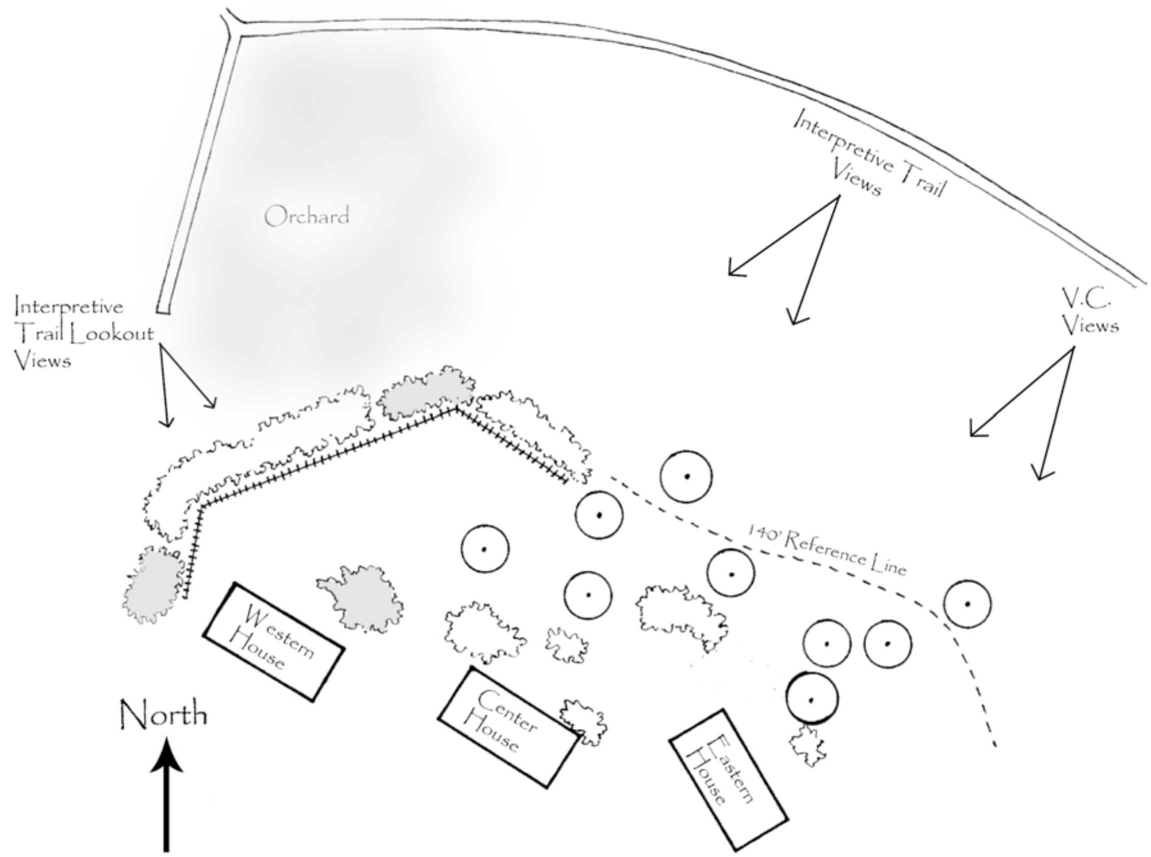
The home farthest west (AZ Image 3.4) is lower in elevation than the other two homes and effectively screened from the main interpretive trail to the north by large plum thickets that have expanded from the adjacent orchard. The plum screens are both effective and complementary to the site's context, easily appearing as part of the orchard from the western end of the interpretive trail.

AZ Image 3.3*: View of center home from main interpretive trail.*

AZ Image 3.4: *View of western home from interpretive trail. Note the screening provided by plums*

The northwestern side of the property, however, is exposed to visitor views from the end of the interpretive orchard trail. Additional plums should be planted as a backdrop to the orchard and to screen the house from the interpretive area. Planting the plums in a roughly linear but unstructured arrangement along the home's yard boundary (defined by the flood fence), will compliment the formal orchard to the north (AZ figure 3.2). The spacing and pattern of the plums should be similar to plum clusters in other parts of the monument, as a whole appearing linear but with random spacing between plants rather than a strict grid.

It is recommended that the plum screen be integrated into the landscape of the center home closer to the home, becoming less contiguous and more subtle into the eastern part of the property as it overlaps with the pinyon/juniper screen (AZ figure 3.3). Other tall, water-wise shrubs could be substituted since the orchard context is no longer prominent. Incorporating a few plums into the western home's perimeter is optional. Unlike the other homes, this property has few understory plants and is highest in elevation, giving it more prominence and less screening in the landscape. Several plums or other larger water-wise understory species are recommended while the pinyon/juniper screen slowly matures.



AZ Figure 3.3: *Schematic plan of residential screening through supplemental plantings. Existing plums are shown in gray, proposed shrubs (plums and other water-wise shrubs) are shown in white clumping, and recommended pinyon/juniper trees are shown as closed white circles .Note the overall linear form of the plum grove but randomized individual plum placement (trunks shown as dots). Shrubs near the center and eastern homes may be plums or any large water-wise shrub. The 140' reference line (see text) is shown to demonstrate the ideal maximum screening distance from the homes*

Tribal Zone

Action 1: Visual screening of Red Hills housing area.

Treatment Background

Management Overview

Currently most of the Red Hills community is visible from the monument's higher elevations, including the Rim Trail and historic district zone. The western-most houses are visible from the monument's lower elevations and visitor center (TZ Image 1.1). Views of the housing from these areas do not support the historic context of the monument and its landscape.

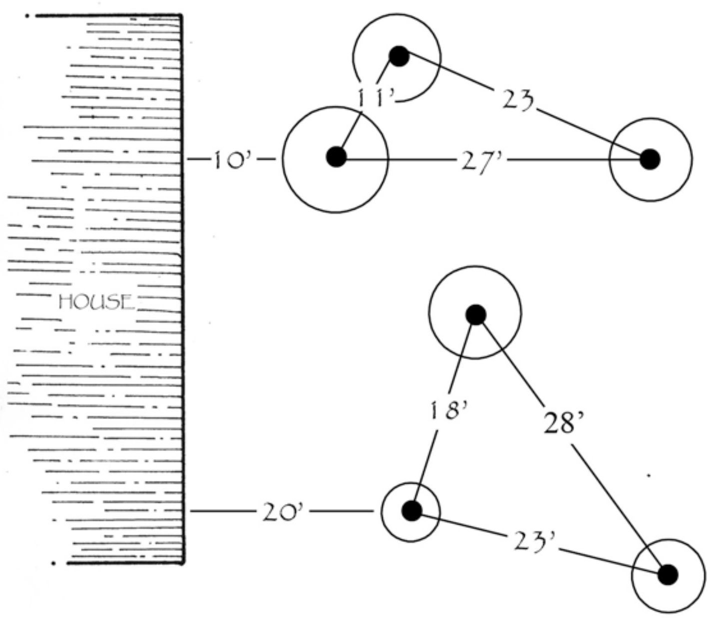
TZ Image 1.1: *View of the Red Hills community from within the Visitor Zone*

The landscape adjacent to the housing is mostly sagebrush scrub with a sparse juniper overstory. Adjacent to the monument and farther to the north and south of the Red Hills community the landscape is much more densely populated by juniper and pinyon pine. These species could be planted adjacent to the housing in drifts reflecting the spacing and patterns exhibited in the denser native stands. The need for screening adjacent to the housing is heightened by the proposed removal of the cottonwood screen along the western drainage (see VZ 9). It is recommended that PISP enter into discussions with the tribe to explore the possibility of plantings on tribal land on the western edge of the Red Hills housing complex.

Recommended Treatment

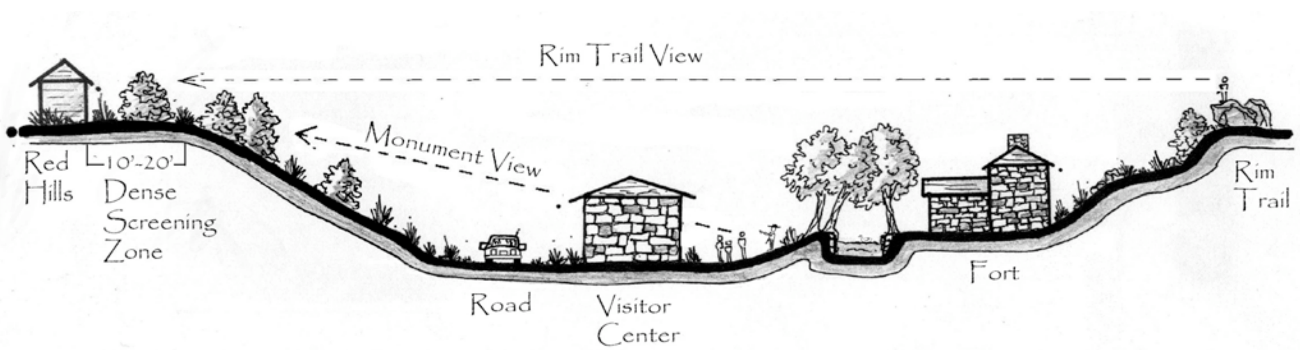
Although the Red Hills development can be screened to a limited extent by plantings within the monument (see VZ 9), true screening can only be achieved by planting directly adjacent to the visible housing on the western edge of the complex. A visual survey of the junipers already established around the community indicates that junipers must be planted within 10-20' of the homes to provide adequate screening from the monument once the trees have matured (TZ Figure 1.3).

Smaller, denser clumps of trees should be planted directly adjacent to the housing in order to provide the most direct screening (TZ Figure 1.1 and 1.2). Larger, more natural densities should be continued at least partially down slope from the homes in order to blend the denser plantings into the natural landscape (VZ Figure 9.2). The clusters represented in TZ Figure 1.1 are based on natural juniper community spacing and can be augmented to space trees as close as 10' apart to accommodate already established trees and to achieve greater screening. Although pinyon pines seem to be found only at the higher elevations, they may be substituted for juniper closer to the homes for added variety and interest.



TZ Figure 1.1: *Small juniper clusters based on natural spacing found in local juniper communities. These two templates can be overlapped as close as 10' to maximize screening. Recommended spacing between clusters and housing shown (10'-20')*

TZ Images 1.2, 1.3, and 1.4: *Images of natural juniper distributions characteristic to the area. TZ Image 1.2 (Top Left): Lower elevation clusters. TZ Image 1.3 (Top Right): Juniper community adjacent to PISP. TZ Image 1.4 (Bottom): Higher elevation clusters*



TZ Figure 1.3: *Cross section (not to scale) of Pipe Spring National Monument from the Red Hills community to the Rim Trail. Cross section depicts dense juniper planting zone within 10'-20' of Red Hills homes, transitioning to lower density hillside plantings*

Tribal Zone

Action2: Remove or reduce lawn panels on east side of visitor center and replace with native species.
Action 2C: Removal of the lawn on east side of visitor center and replace with native species, except for patches left beneath existing shade trees (area that could be used for picnics).

Recommended Treatment

Species

For native species selection information see appendix 14.

Design

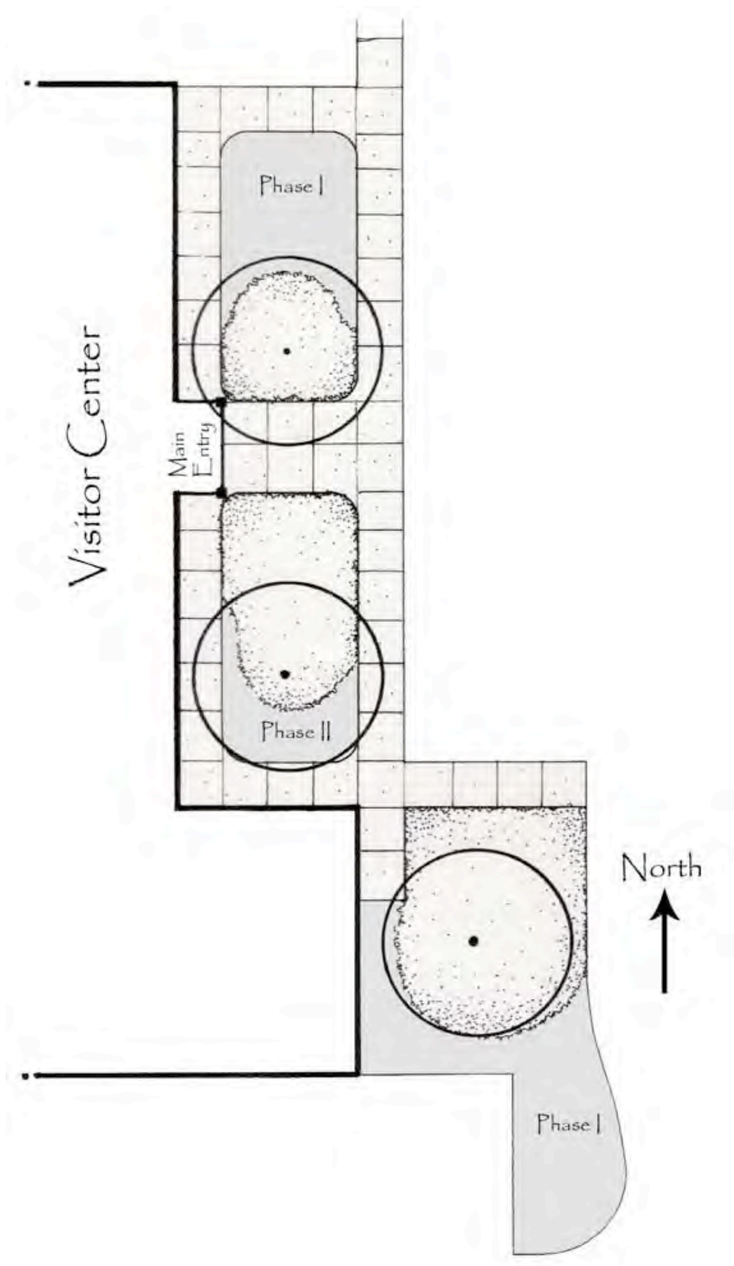
The areas designated for native plantings are based upon shade/sunlight patterns, shade tree irrigation needs, visitor use, and aesthetics (TZ Figure 2.1, TZ Image 2.1, 2.2, 2.3). Plants native to Arizona are largely adapted to full sun conditions and would be more difficult to establish beneath the shade of the three large trees growing on the lawn panels. With the exception of the northern panel, the recommended native beds are established in areas that receive the most sunlight. The northern most panel was excluded from this pattern in order to visually balance the lawn and native vegetation on both sides of the main entry. Placing the native vegetation to the north also allows for a more natural transition into the surrounding shrub steppe.

Lawn is preserved in areas known to be frequently used by visitors and in the shade near the main entry. Visual access to the lawn remains from the main park access road and parking lot, a feature which park staff believes gives the visitor center a more hospitable and eye-catching appearance.

Note: The distant power lines are visible from these lawns (see TZ Image 2.2). Several junipers carefully and naturally placed along the entryway to the employee housing (directly across from the lawn) would provide screening.

Phasing

The phased removal of much of the lawn will give the monument's administrators the flexibility to adjust the amount of lawn necessary for visitor use. Priority for the first removal phase is given to the two panels farthest from the main entryway (TZ Figure 2.1). These panels are the least important from both a function and visual perspective and their removal will maintain a balance around the main entryway. Phase two removes some of the lawn in the southwestern section of the central panel, leaving most of the lawn beneath the tree while connecting visually with the native plants in the southern panel.



TZ Figure 2.1: *Plan of visitor center lawn panels. Proposed area for lawn removal and new native vegetation beds shown in gray. Preserved lawn is shown in stipple pattern.*

During the first phase of removal the northern and southern lawn panels are reduced. Phase two reduces the center lawn panel

TZ Image 2.1, 2.2: *Visual simulation depicting proposed native plant beds for Phase I of the lawn removal. Left: Northern Panel; Bottom: Southern panel*

TZ Image 2.3: *Visual simulation depicting proposed native plant beds for Phase II of the lawn removal. Note the maximization of available sunlight for native plantings and shade for lawn areas.*

Tribal Zone

Action 3: Improve screening of utility installations adjacent to visitor center

Recommended Treatment

Propane Tanks (northwest of the VC and behind the ZNHA shop)

TZ Image 3.1: *Propane tank northwest of the VC*

The two blue propane tanks are currently visible from the visitor's center and patio area (TZ Image 3.1). The tanks should be painted a blue-gray green similar to the color of the rubber rabbitbrush and sage brush in the surrounding landscape. A reddish brown similar to the color of the local soil may also be used, but may not be as affective as a green that blends into the shrubs used for screening. Whichever natural palette is chosen, it is best to use a color one or two shades darker than the natural color being matched (TZ Figure 3.1).

Additional shrub plantings are needed in both locations to screen the tanks from monument visitors. It is suggested that a mix of rubber rabbitbrush, sagebrush, and saltbrush be used to mimic the surrounding natural plant community composition.

Dumpster

TZ Image 3.2: *Dumpster south of the visitor center*

The dumpster south of the visitor center is only minimally visible from the roadway and from within the VZ and HDZ of the monument, but very visible from the parking lot of the visitor center and the lawn areas where visitors picnic. Some screening is currently provided by rubber rabbitbrush and a rustic wooden screen, but the rabbitbrush is not tall enough to conceal much of the wooden screen.

There appears to be space for one juniper on the north side of the dumpster, facing the visitor center and parking lot, but the rabbitbrush and wooden screen will have to suffice for most of the direct screening. Some rabbitbrush should be replaced by four-winged saltbrush and sagebrush to provide a more natural diversity of plants, drawing less attention to the area than a monoculture of rabbitbrush. The conversion of the southern-most lawn panel in front of the visitor center (see TZ action 2) will also provide screening from the picnic are and from much of the parking lot.

The dumpster and any related structures (other than the natural wood screen) should be painted a color that will more appropriately blend into the surrounding landscapes. The recommended color is a blue-gray green similar to the color of the rubber rabbitbrush and sage brush. A reddish brown similar to the color of the local soil is another alternative, but may not be as affective as a green that blends into the shrub screen. Whichever natural palette is chosen, it is best to use a color one or two shades darker than the natural color being matched.

Air Conditioning Units (northwest of the VC)

TZ Image 3.3: *Air conditioning unit northwest of the visitor center*

The air conditioning units northwest of the visitor center are highly visible from the parking lot and main park road (TZ Image 3.3). Currently very little vegetation is growing around these units. Additional plantings of saltbrush, sagebrush, and rabbitbrush should be added around the units in a random and natural pattern similar to the surrounding landscape.

Utility Tanks South of the VC Patio

TZ Image 3.4: *Utility tanks south of the visitor center patio*

Currently two large rectangular tanks are visible adjacent to the visitor center patio and from the grass restoration plot, walkway and picnic area. These tanks could be screened from the patio by a juniper tree placed on the north side of the structures and on from other areas of monument by additional shrub plantings. Sagebrush, rabbitbrush and saltbrush should be used in natural clusters similar to the surrounding landscape.

Sedan Brown Yuma Green

TZ Figure 3.1: *Example of color swatches used by the BLM in Grand Staircase Escalante National Monument, UT. Colors were designed to blend into the monument's landscape, drawing from natural elements and darkened one or two shades.*

Appendix 1

Stump Removal Techniques

In some of the actions discussed in this Vegetation Management Plan, recommendations have been made to completely remove stumps. Whether the reasons are aesthetic, to prevent regrowth, or to reduce visitor hazards, several methods are available to accomplish the task. The following techniques have been excerpted from the publication “Clippings: Replacing Trees in Cultural Landscapes”, published jointly by the Olmsted Center for Landscape Preservation, United States Department of the Interior, and National Association for Olmsted Parks.

REMOVING A TREE STUMP

When replacing a tree in a cultural landscape, it is often important to plant the new tree as close as possible to the location of the original. By doing so, the historic design and landscape character can be effectively perpetuated. Before replanting, the remaining tree stump must first be removed. This procedure can cause significant damage to the site, archeological resources and adjacent features such as historic plants and structures. When determining the best alternative to use, it is important to consider the vulnerability of adjacent resources, site constraints, landscape management goals and the feasibility of implementation.

Considerations:

1. *Site Management*

- Is the stump in a location that could cause a safety hazard? If so, does it need to be removed quickly or would a slower method be acceptable?
- How soon after stump removal does a replacement tree need to be replanted?
- Will the removal and replacement procedures adversely affect or impede other site activities such as visitor access, special events, etc.?

2. *Proximity of Resources*

- Are there archeological resources that need to be studied or documented before disturbing the soil?
- How close are other important resources such as plantings, built landscape features (walls, fences, walkways, sculpture, etc.), structures, roads, etc?
- Can adjacent historic resources be protected during the stump removal process? If damage occurs to adjacent resources can effective repairs be made?

3. *Feasibility of Implementation*

- Is there adequate funding and staffing to accomplish the project?
- Is the needed equipment locally available?
- Is there adequate space available to access the project area and effectively maneuver equipment? How susceptible is the site to equipment damage such as soil compaction or ground disturbance?
- Are there any underground utilities that could be damaged during the process?

PROMOTING A STUMP TO DECAY

Encouraging a stump to decompose is the least invasive method for removal; it is highly localized and causes negligible disturbance to the surrounding area. Because it causes very little ground disturbance, this technique is ideal for removing stumps that are in landscapes with rich archeological resources or other significant features that are susceptible to damage. The process can take 12 to 36 months to be effective, depending on the tree species and local conditions, so, it is best for situations where immediate replanting is not necessary.

Procedures:

- Flush cut the tree trunk as close to the ground as possible and remove bark from the stump.
- Drill a series of holes 3/4 inch to 1 inch in diameter, 6 inches deep and 2 to 3 inches apart into the stump.
- Fill holes with a mixture of 1 part screened compost, 1 part screened topsoil, and 1 part slow release organic high-nitrogen fertilizer such as feather-meal or cottonseed-meal.
- Keep the stump moistened during dry periods and re-fill holes as needed with compost/soil/nitrogen mix.

Promoting decomposition is ideal for removing stumps where site disturbance must be avoided to protect fragile resources.

- Within 12 to 36 months, the stump should be adequately decayed to remove remaining material with hand tools. After removal, backfill the hole with soil that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.

GRINDING A STUMP

A stump grinder can quickly remove an existing stump and cause limited disturbance to adjacent resources. The operator uses the equipment to remove the tree stump and large roots to a desired depth. The machine's range of motion is not precise enough to follow the exact outline of a stump and will result in some adjacent ground disturbance. This can result in damage to archaeological features or roots of nearby plants. Using a stump grinder is best for situations that require immediate replanting and in locations where important resources are not directly adjacent to the worksite.

Using a grinder to remove tree stumps causes minimal site disturbance and allows replanting in the same location.

Procedures:

- Determine if there are any adjacent resources that may be adversely impacted by the use of the equipment.
- Select the smallest equipment possible that will remove the stump to the desired depth. If immediate re-planting is necessary, the depth of the ground stump should be at least six inches more than the height of the replacement plant root ball to allow for adequate backfilling of the planting hole.
- Protect adjacent plants by tying back branches and placing guards, such as plywood sheets, against nearby tree trunks to shield them from possible damage.
- Lay 1 inch plywood sheets or construction matting on the ground where the machine will be operated to minimize soil disturbance and compaction. A double layer of sheeting laid in a criss-cross pattern provides the best protection. In addition, lay planking or matting on the soil along the route the equipment will use to gain access to the work site.
- Grind the stump to a width and depth necessary to plant a replacement. Remove resulting wood chips and debris using hand tools.
- Backfill the hole with soil that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.

EXTRACTING A STUMP WITH A TREE SPADE

A tree spade uses hydraulically driven blades that cut through the ground to form and extract a core of soil, stump and roots. While the mechanical action of a tree spade is highly localized and causes minimal site disturbance, the equipment is usually large and can remove a substantial volume of soil. As a result, soil compaction, damage to nearby plantings and loss of archeological resources can occur. Use this method in areas where there are no significant archeological resources and there is adequate space for the equipment to access and maneuver within the site.

Procedures:

- Determine if there are any adjacent resources that may be adversely impacted by the use of the equipment.
- Select the smallest tree spade that can effectively remove the stump. The lifting capacity of the equipment needs to be adequate to pull the stump from the ground.
- Protect adjacent resources by tying back branches of plants and placing guards, such as 1 inch plywood sheets, against nearby tree trunks and structures to shield them from possible damage.
- Lay 1 inch plywood sheets or construction matting on the ground where the machine will be operated to minimize soil disturbance and compaction. A double layer of sheeting laid in a criss-cross pattern provides the best protection. In addition, lay planking or matting on the soil along the route the equipment will use to gain access to the work site.

A tree spade can be used to remove stumps in locations where the use of larger equipment will not damage resources.

- Adjust blades to be as close to the stump as possible for removal. Localizing the mechanical action close to the stump will result in less damage to the surrounding area.
- Extract the stump and soil core and remove from the site. Backfill the hole with soil that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.

EXCAVATING A STUMP WITH A BACKHOE

Using a backhoe requires substantial digging around and under a stump in order to remove it. This causes significant disturbance to the site and can result in extensive damage to adjacent archeological resources, structures and plants. Only use this method where there is at least fifteen feet clearance from the work site to the nearest resource that could be damaged.

Procedures:

- Determine if there are any adjacent resources that may be adversely impacted by the use of the equipment.
- Select the smallest backhoe that can effectively remove the stump. The equipment must be large enough to dig around and under the stump (a 3 foot diameter stump may extend 4 or 5 feet down into the ground). In addition, the lifting capacity of the equipment needs to be adequate to pull the stump from the ground.
- Protect adjacent resources by tying back branches of plants and placing guards, such as 1 inch plywood sheets, against nearby tree trunks and structures to shield them from possible damage.
- Lay 1 inch plywood sheets or construction matting on the ground where the machine will be operated to minimize soil disturbance and compaction. A double layer of sheeting laid in a criss-cross pattern provides the best protection. In addition, lay planking or matting on the soil along the route the equipment will use to gain access to the work site.
- Use the backhoe to excavate a 2 foot wide trench around the stump. The trench should be deep enough to under cut the stump with the backhoe, typically this will be at least 1.5 times the diameter of the stump. For example a 2 foot diameter stump would typically require at least a 3 foot deep trench to successfully undercut.
- Use a hand or chain saw to cut large roots (2 inches in diameter or larger) as they are exposed by the digging.
- Using chains, slings or other rigging devices, pull the stump from the excavated hole and remove from site. Back fill hole and regrade area with soil that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.

Use of a backhoe to remove a tree stump can cause significant site disturbance and should be used only in locations where adjacent resources can be well protected.

Appendix 2

Alternative Propagation Techniques

Rooting and Growing a Sucker

(From Hill 1985)

Although it is preferable in many situations to replace a decadent tree with a stump or root sprout growing in place, this technique does provide a more flexible alternative. Separating and rooting a sucker affords greater discretion in the placement of the replacement offspring, while still maintaining the historic or local genotype. This technique may also be used to maintain a temporary nursery of offspring as a reserve should the selected offspring fail to survive. This process is best undertaken during the plant's dormant season in the spring or early summer.

Steps:

1. Remove the sucker from the parent tree with a sharp spade, retaining as much soil as possible. Sever the main root connecting the sucker to the parent tree with pruners or a saw.
2. Either pot the sucker or replant it with ample fertile soil, ensuring to keep the roots moist during the transplanting process.
3. Applying a thin layer of mulch may help the new plant establish, warding off weeds and retaining water
4. Water the new plant daily. A liquid fertilizer may also be used, but should be stopped by midsummer to allow the growth to harden.

Layering

(From Hill 1985 and Pogo, pers.comm.)

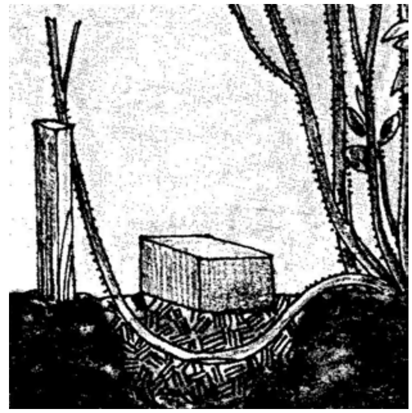
Layering "is a process whereby roots are induced to grow on an outside branch or stem of a plant while it is still attached to the parent" (Hill 1985). This technique produces a transplantable genetic clone of the parent plant with an independent root system, but can in some instances take up to months or years to complete. Elms are amongst the trees that can be propagated using this technique. This process is best undertaken in the spring.

Steps:

This technique is based on bend over a low branch from a young sucker, burring the middle part of the branch 3"-5" deep and encouraging root growth in the buried portion.

1. Select a branch less than a half an inch in diameter.

2. Remove all leaves from the portion of the branch that will be buried.
3. Remove the bark from the underside of the buried portion of the branch. The removed portion should be roughly two times the diameter of the branch.
4. Apply a rooting hormone to the wound
5. Bend the branch over and burry the prepared portion in loose, fertile soil. Secure the branch with a weighted object such as a rock. Ensuring that the tip of the branch is kept vertical will improve the form of the new plant. This can be accomplished by creating a vertical edge on the far side of the hole and staking the tip of the branch (Appendix Figure 2.1).



Appendix Figure 2.1: *Diagram of layering*

6. Occasionally check the progress of root development. Once significance root development is reached, sever the branch from the parent tree. The branch should be cut to a node, removing the dead portion of the branch.

Note: Layering is not appropriate for all species. Additional propagation techniques include grafting, growing from cuttings or culture, and seed germination. Descriptions of these techniques have not been included as they are labor intensive and/or require specialized facilities or skills.

Appendix 3

Tree Health Assessment Guidelines

This document provides general guidelines for assessing tree health based on visual assessments. It is focused primarily on diseases common to fruit trees and poplars. This list is not all inclusive and should be supplemented by professional expertise when necessary.

The material below presents just a few of the diseases and pests common to trees found on the Monument. For more detailed diagnostics please visit the following webpages:

- Arizona Extension, Plant Pathology
  - http://ag.arizona.edu/plp/plpext/
- Utah Extension, Pests
  - http://utahpests.usu.edu/
- Minnesota Extension, Diagnostic Tool

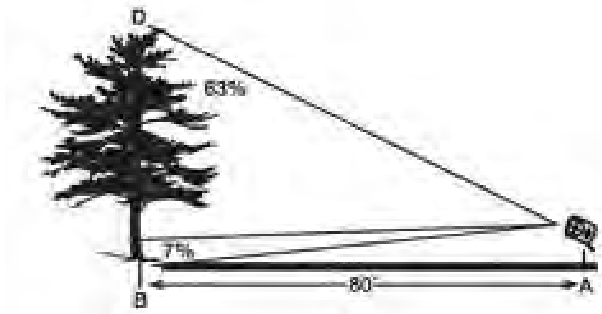
http://74.125.155.132/search?q=cache:Npv4QkqYYHwJ:www.extension.umn.edu/gardeninfo/+minnesota+extension+and+plant+disease+diagnostics&cd=3&hl=en&ct=clnk&gl=us&client=firefox-a

Measuring Height, Spread, and Diameter

The forms located at the end of appendix 3 can be used to record the following information.

- **Measuring Height**
  - A clinometer is the easiest way to measure height. There are many types of clinometers, the two most common of which are the Suunto model and Brunton ClinoMaster. Directions for using these types are provided:
    - Holding the Clinometer
      - Hold it on one hand, keep both eyes open when looking through the lens. Position the site line on the target
    - Reading the Clinometer
      - Look through the lens and make sure the scale is right side up
    - Stand a known horizontal baseline distance away from a tree, making sure you can see both the top and bottom clearly
    - Sight the top of the tree for the top% reading
    - Site the bottom of the tree for the bottom % reading
    - Compute the total % height using the formula:
      - % top - % bottom = total % height
    - compute the tree height using the following mathematical formula:

- total % height x horizontal baseline distance = tree height

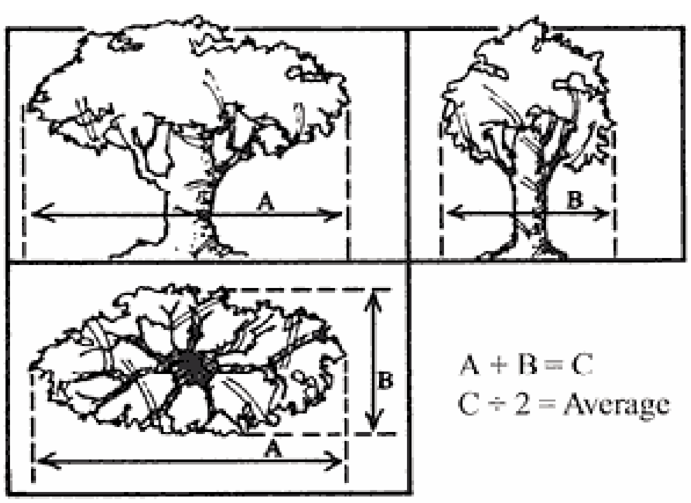


D is the top, B is the bottom, and A-B is the baseline

(Forestry Suppliers, Inc., 2009)

- **Measuring the Crown**
  - The goal of this process is to identify the average width of the top, branching part of the tree.
  - For the crown spread, two sets of measurements are needed to get an average. First, step away from the tree and look at the tree's crown. More than likely the tree is not symmetrical, and it has a narrow and a wide side. Measure from the outermost branch on one side to the outermost branch on the other side of a tree (measurement 1). Complete the same measurement 90 deg from the first measurement (measurement 2).
  - Then average these two measurements:
    (wide spread + narrow spread) / 2 = Average Crown Spread

(Pennsylvania Big Trees 2010)



- **Measuring dbh**
  - Dbh is the diameter of the trunk of the tree measured at breast-height (4.5')

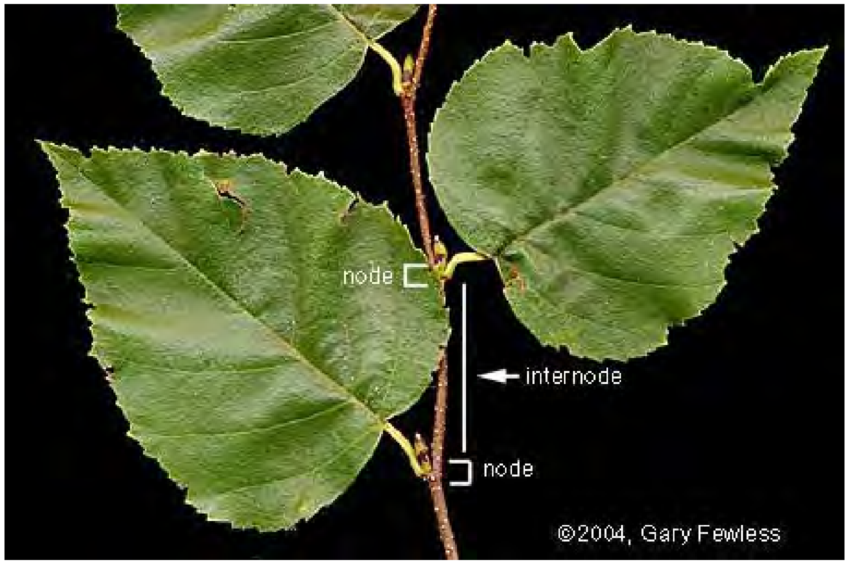
  - A special DBH tape is usually used for this measurement.
    - Wrap the tape around the trunk of the tree at about breast-height and record the measurement. Although the tape appears to be measuring circumference, it is designed to convert the measurement into diameter.

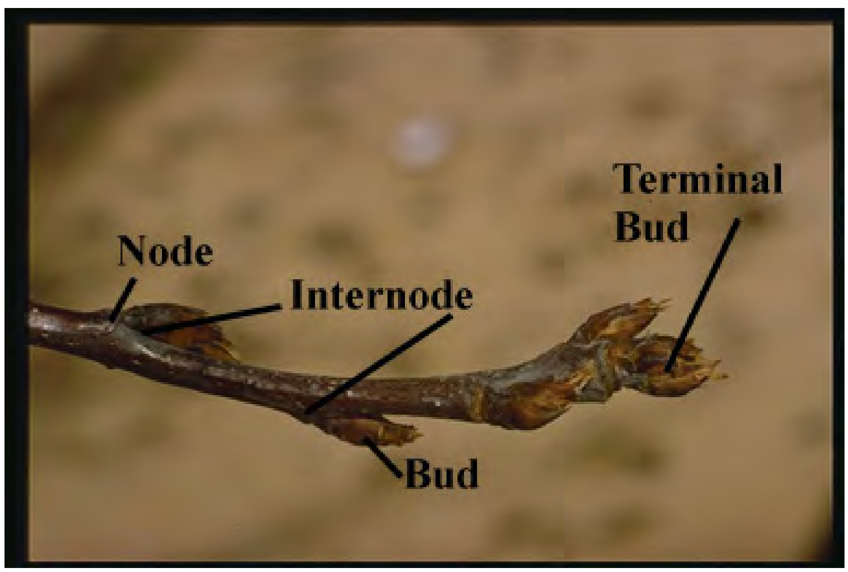
Signs of Illness and Decline

(Arizona Community Tree Council arborist 2009)

- Dieback
  - Dieback is the loss of leaves and healthy tissue at the ends of the tree's branches.
  - Observe:
    - Leaf loss
    - On the ends of low branches, scratch the surface of branch with your fingernail, removing the bark. If the branch is healthy, the bark should be easy to remove and a green or sometimes white or yellowish, moist surface should be visible. Dying branches become hard, dry and brown.

- Growth Rate
  - The growth rate of the tree can be found by comparing the length between internodes of the current year's growth and the last year's growth. This is a more complicated and time consuming assessment that can indicate a tree in decline.
  - A node is the point on the branch where leaves originate or grow. The internode is the distance between the nodes.
  - To find the internode length, measure from the base of the last node (or leaf) on the branch to the base of the second to last node. This goes in the column for 2009 (excel sheet below). To measure for the year 2008, measure from the base of the second to last node to the base of the node below it. Sample two branches per tree.





- **Insects and Signs of Disease**

(These signs are directed towards fruit trees and poplars, the dominant trees in the Monument)

  - Look for general signs of insect activity:
    - Presence of insects
    - Entry/exit holes in the bark of the tree
    - Chewed or shriveled leaves
    - Webs
    - If the tree has lost any bark, look for tunneling patterns or holes in the exposed tree tissue

- Scale: clusters of round growths on the branches
- Borers: On apple trees, look for sap dripping from the trunk and any abnormally sappy, lumpy areas on the trunk
- Conks are a fibrous, sometimes fleshy, wood-rotting fungal growth. Conks look like shelves emerging from the trunk of the tree
- Fire Blight- serious fruit tree disease. Look for rust-colored leaves.
- Look for any other abnormalities (discoloration of leaves, spotty leaves, sap, bark damage, fruit damage etc.)
- Bacterial Wetwood- this disease presents itself as a “slimy flux” or bleeding sap, usually near a wound or joint. It may also emit an unpleasant smell.

Scale

Leaf damage

Apple and leaves with fire blight

Insect tunneling on tree tissue

Signs of the Cystospora Canker, common to Poplars and Apples

Sappy, lumpy evidence of borers

Conks

Bacterial Wetwood

Root Diseases

Root disease, although not as visually striking as other diseases, is of great significance to preservation efforts within the Monument. A primary objective of vegetation management at Pipe Spring is the preservation of historic specimens and their genotypes. Many of the propagation methods recommended in the report are vegetative, duplicating the parent tree from a stump or root sucker. Although these methods do preserve the historic genotype, it also produces an offspring that can inherit the parent tree's root system and diseases. The risk of losing these valuable genotypes can be mitigated by evaluating historically significant parent trees for root disease before beginning vegetative propagation and replacement. Should root disease be found, alternative propagation methods must be used to ensure the successful and long-term preservation of the historic genotype.

Given the devastating consequences of losing an historic resource, it is strongly recommended that the historic trees at Pipe Spring be evaluated by an expert in tree pathology and/or root diseases. Potential resources include:

- Forestry, Fire and State Lands, Utah Department of Natural Resources
    - http://www.ffsl.utah.gov/ffsl.htm
    - This program has been used to assess tree health for an NPS project in Moab, UT. Experts conducted on-site assessments and provided a detailed report of the results (Winkler, 2010).
    - Contact: Bill Zanotti (see references)
- The Northern Arizona University, Cooperative Extension
    - http://cals.arizona.edu/extension/fh/index.html
    - Tom DeGomez, Extension Forest Health Specialist (see references)

Observations
* please note the unit of measurement used

Tree #	Height	Spread			dbh	Dieback	Internode length	
		1	2	Average Spread			2009	2008

Insects and Disease	Other Observations

Appendix 4

Pipe Spring Native Grassland Exhibit Report

The following document was developed by Pipe Spring following the installation of the grassland revegetation plot west of the visitor center in 2008. The report includes a description of the materials, processes, and techniques used to construct the plot.

PISP Native Grass Exhibit Garden Project Write-up

December 2008

Becca Lieberg, Lead Re-veg BioTech

This project was pushed back a year, and will be/has been completed in FY08/09/11

Much of the work was done in FY08, with phase two scheduled for fall of FY09, and follow-up/necessary repairs in fall FY11 Project planning was done by me and Michelle DelaCruz, with collaborative meetings in spring/summer with John Hiscock, Andrea Bornemeier, Terry Strong & crew, Cheryl Decker, and myself. Unless otherwise specified, the work was done by a 7-member UCC crew (supervised by Becca), and assisted by ZION veg & PISP maintenance staffs.

The concept was to create an exhibit garden that would demonstrate to visitors what the Arizona Strip looked like pre-grazing (see attached PMIS project explanation). After several meetings and soil testing across the monument, the area chosen is directly outside the back patio door of the visitor center and extending out towards the closest wash and picnic area, and the maintenance road. Designated area is approximately 100'x 120'x 150', or 0.117 acres. Project steps are described below, followed by a timeline for both finished and upcoming work.

Shrub removal

This was done inside the entire triangular area, as well as a 4-5' swath around the perimeter to allow for fencing and trenching. The shrub removal was done by Eric Lassance and the exotics crew (using primarily chainsaws), with Terry Strong and PISP mtce crew coming in later and grubbing out the stumps with machinery. All shrubs removed are native, but were becoming opportunistic and overgrown, so was decided that all should be removed. A handful of native plants and small shrubs and cacti were left in the interior of the space to be salvaged and planted elsewhere later on. One very large cholla cactus was left inside due to aesthetics and the difficulty of transplanting.

Delineation

Once the three corners were chosen, lines were drawn with flagging and spray-painted on the ground for the trencher. (See attached drawing for general garden shape and measurements.)

Trenching

Trenching was necessary for several reasons. Planning for the project included substantial attempts at keeping the pocket gophers from infiltrating the area, which meant that a two-foot piece of hardware cloth was sunk vertically into the ground. The trench was also necessary for the installation of the juniper fence posts that were sunk two feet into the ground, as well. Trenching was all done by the PISP mtce staff, using the trenching arm of the small backhoe, kept on-site. Trenching took a good part of one day, and the

corners were then dug out by hand by a UCC crew.

Plant Salvage

As mentioned above, a handful of *Gutierrezia sp*. and cactus plants (approx. 12) were salvaged from the interior of the garden space and planted in adjacent areas where machinery/foot traffic had created paths in preparing irrigation lines and the garden areas. These were mulched and hand watered, with additional watering and monitoring taking place on subsequent visits to PISP. The success rate of the transplants was great – as of this writing in Dec 08, more than 90% of the plants survived the move!

Gopher Fencing

Hardware cloth (1/4 in.) was purchased in 2-foot height, and a UCC crew simply attached the 25’ lengths to make 100’ lengths to fit around the entire perimeter. This and the fence posts were put in the ground at the same time, with the gopher fencing going on the inside edge of the trench. This turned out to be slightly difficult, since the deer/rabbit fencing went on the outside edge of the trench and two needed to be connected, but the crew did a great job of making it work! (See more explanation below.)

Fencing and Posts

The fencing was mostly necessary to keep rabbits out, but was also planned for any deer protection that might be necessary, so the height was planned for 4 feet. The juniper posts were sunk into two feet into the ground at 10-foots intervals around the garden,

with some closer together at the corners and where necessary to create a gate and leave an emergency spacing on the SE side of the fencing for any necessary machinery to get in/out. These posts were put on the outside of the gopher fencing and tamped into the ground in several layers as they were buried.

The fencing was also -inch hardware cloth,   and was originally going to be installed on the outside of the posts with fencing staples and the bottom edge of the fencing folded into the topsoil in the ground. After several on-site conversations, it was decided that the gopher and top fencing should meet, which created a couple of difficulties. The posts and gopher fencing had already been buried and tamped, which meant that the top several inches of the gopher fencing had to be redug and exposed so that the two fences could be connected. In addition, the top fencing was put on the outer edge of the trench and the gopher fencing on the inner, which resulted in mis-matched edges and gaps where the two did not completely meet at each of the fence posts. The crew did the best they could in remedying this problem, but the end result is that the top of the

above-ground fencing is now a bit saggy, which may not ever really be remedied.

Fencing was attached to posts with fencing staples, and after the two fencing sections were connected, the trench was refilled and retamped around each fence post.

A 5-ft-wide gate was constructed on the N side of the garden (adjacent to the cement pathway already in place). This was meant to be handicapped-accessible and was set up to swing open inside the garden area. The gate was constructed by two UCC members and will eventually be treated with weatherizing paint to make the gate look old and weathered.

The last step with fencing was to use small wire to try and cinch the tops of the fencing in between posts, with the hopes that it would reduce sagging and produce a more aesthetically-pleasing view.

Irrigation

All plants in the interior of the garden have/will have irrigation lines running to them, with the exception of several yucca plants that don't need that much water. Two main header hoses (2-in) run from the connectors, paralleling the N side of the fence. One hose (Valve 1, on the L side) feeds the four eastern-most lines and the second hose (Valve 2, on the R side) feeds the remaining seven lines, to allow for correct water pressure. All drip lines are set up to run perpendicularly off of the header hose and set up more or less parallel with the east fence line. (See attached scan for general sketch.) These were measured to end approx. 3 feet from the end fence line. Two rows (Rows 5 & 6 from R to L) actually cross the pathway at the northern end and were dug 8 inches into the ground there to prevent breakage. Similarly, Row 8 wrapped around the southern end of the walkway to allow more room for plant placement.

Emitters and spaghetti tubing were placed randomly along each of the drip lines. Total plants to be put in the ground and the total linear length of drip lines actually turned out to be the same number – 486, so in lieu of a fancy scientific approach, we simply decided to put the same number of plants/emitters on each line as the number of plants (i.e. 77 emitters on a line that is 77' long). This was all done randomly, and after the connectors were attached to each line, lengths of spaghetti tubing cut into 1', 3' and 5' lengths were also randomly attached. Emitters were put on the ends of the tubing, and it was then discovered that we could order 1 gal per hour emitters for many of the spaghetti tubes, especially those that were on the eastern side of the garden, since the 2GPH emitters were not dripping, but streaming water! After a LOT of playing around and changing out emitter heads and

connectors, it was also decided to reduce the pressure of the system to 35. We will re-assess irrigation needs in the spring, and again in the fall when the second round of plants is put in.

See attached supply order for irrigation supplies. There are excess supplies on that list, but is all-inclusive and will give a general idea of what was needed.

Interior Walkway

Because this garden is meant to be looked at and used interpretively, it was decided that a walkway would be put in the very center of the garden. This, too, is a triangle, and allows people to walk among the plants that will soon be labeled. We wanted this to be handicapped-accessible, as well, and the minimum diameter of the walkway is four feet, with the corners a bit wider to allow for wheelchair maneuverability. It was lined with juniper posts and cut to fit all corners. Each post was set into the ground by hand, then pegged to the ground with rebar to prevent moving. The path will eventually be covered with wood chips/mulch.

Planting

Just under 500 plants went in for phase one. This included grasses *Sporobolus contractus* (Spike Dropseed), *S. cryptandrus* (Sand Dropseed), *S. airoides* (Alkali Sacaton), *Aristida purpurea* (Purple 3-Awn), Stipa comata (Needle & Thread Grass), Hilaria jamesii (Galletta Grass), *Elymus elymoides* (Squirreltail), and *Yucca utahensis* (Utah yucca). We also planted several *Rhus trilobata* (3-Leaved Sumac) around the perimeter of the garden to help fill in some of the areas we decimated while working on the project. Each plant went into a flagged spot where a piece of spaghetti tubing was already pegged. The tubing was then pointed directly to the plant's roots. Because they were all being irrigated, the plants were not planted with a well and mulch, but rather, planted flush with the ground. Note: the soil on the eastern half of the garden is much more clay than the other half, which meant that digging was extremely hard and also that it may affect the survival rate of the plants. Plans for phase two of planting include planting a small conetainer at each tubing, as well as replacing dead plants and filling in where there is extra water.

Seeding

In addition to planting, seeding was done both on the interior and the perimeter of the garden. Inside, VIPers hand-dibbled *Oryzopsis hymenoides* (Rice Grass) seed that we received from

the increase field at Los Lunas. Additionally, Becca seeded *Stipa comata* (Needle & Thread Grass) and a small amount of *Elymus elymoides* (Squirreltail) on the interior. Outside, a mix was used that was comprised of virtually every grass, forb, and shrub that we collect at PISP NM. This was mostly spread in the areas decimated in installing the garden as a whole. Thirdly, it is planned that we will use over a pound of *Hilaria jamesii* (Galletta Grass) also sent from Los Lunas on the interior of the garden, but we waited on that section of the project until we had mulch delivered to apply over the top. We have very little Galletta grass to use, and want to ensure as much germination as possible.

Mulching
A fine layer of mulch will be applied over the entire garden. This is three-fold. It is mostly meant to reduce the amount of blowing soil when the spring and summer winds pick up, as well as offer a more aesthetically-pleasing view to the visitor. Thirdly, it will help tack down the Galletta grass seed to help with germination. The mulch chosen is primarily Box elder and Cottonwood, chipped to the smallest pieces we can make in Zion.

Finishing Touches
The outside perimeter and adjacent areas were hand-broadcast seeded and raked to help with restoration from overuse while putting the garden in. Irrigation will have to continue to be tweaked as the seasons change and we see how the project evolves. In terms of documentation, this report will be available, as well as some GIS-produced maps in the future. Becca GPS'd all of the perimeters, the walkway, and the irrigation lines to help produce a digital image. Stay tuned.

Interpretation
A wayside exhibit is planned for right next to the gate, along the existing visitor walkway. In addition, small nameplates will be installed inside the garden (details TBD) and interpretive hikes planned through the garden.

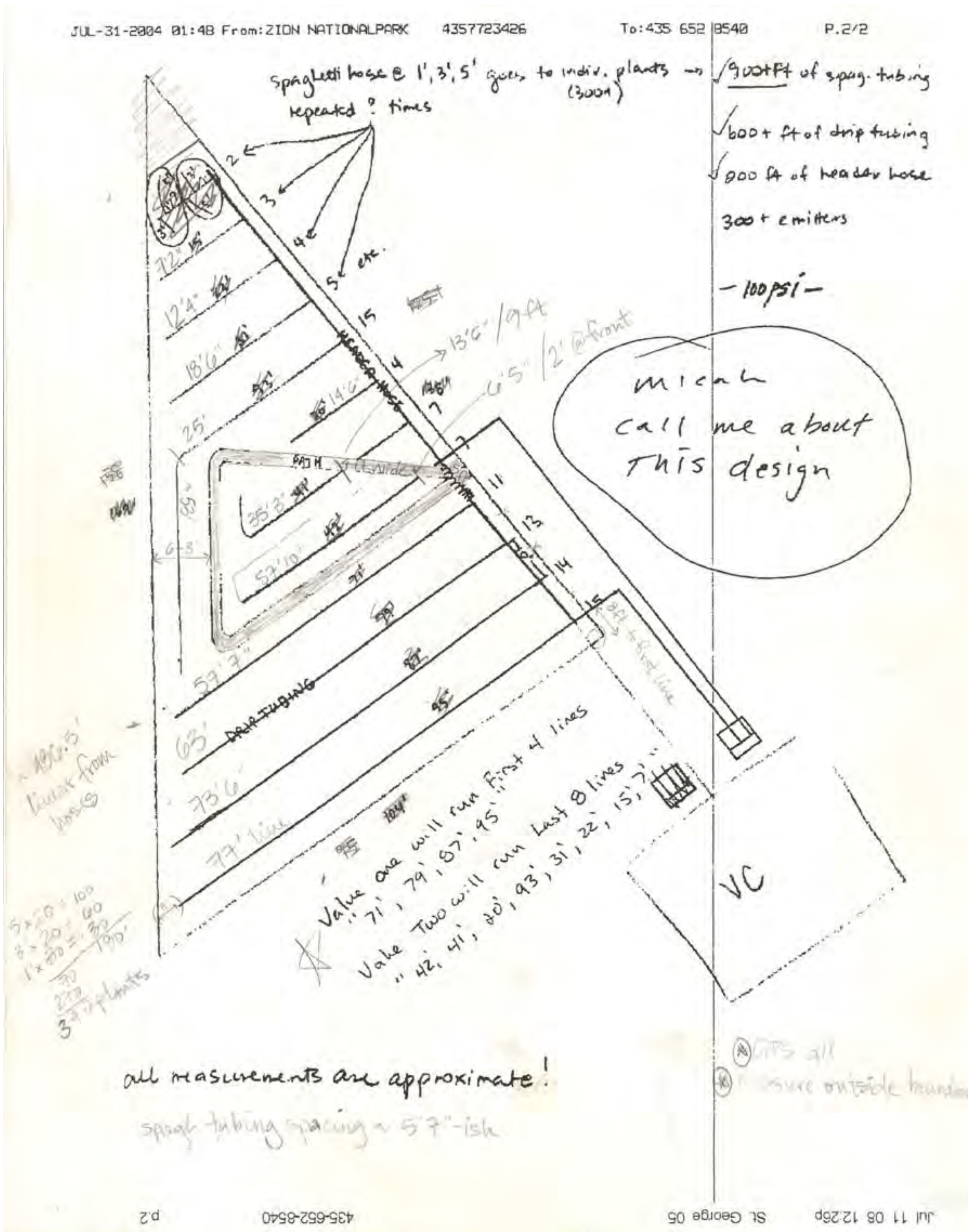
Herbicide Tx's
Eric and the ZION exotics crew will be out to spray the garden area with Plateau in early spring of 2009.

Timeline

Winter 2007:	Plants propagated.
Summer 2007:	Seed collected.
Spring/Summer 2008:	Planning and meetings took place. Supplies discussed & ordered.
Summer 2008:	Seed collected.
September 2008:	Site delineated. Shrubs removed and stumps grubbed out.
October 2008:	Supplies delivered/picked up. All major installation took place: fencing, gopher fencing, post installation, irrigation hook-ups, planting, plant salvage.
November 2008:	Seeding and hand-broadcast seeding done. Finishing touches.

Proposed for upcoming months/years:

January 2009:	*Hilaria* seeding and mulching.
Winter 2009:	Phase two plants propagated. Interpretive signage determined & supplies ordered.
Spring 2009:	Plateau herbicide application.
Summer 2009:	Interpretive signage installed. Seed collected. Necessary maintenance and monitoring to take place.
Fall 2009:	Phase two planting/seeding/irrigation repairs.
Winter 2011:	Propagation of any necessary plants.
Spring 2011:	Phase two Plateau herbicide application.
Summer 2011:	Seed collection. Monitoring and maintenance as needed.



All written measurements were for figuring purposes only and may not reflect actual lengths. This drawing simply gives an idea of the general framework of the project.

Public Land Corps (Core?)

Project Identification - PMIS 122438	
Project Title: PLC:Create A Living Exhibition Of Restored Native Grasslands To Improve Visitor Experience	**Project Total Cost:** $64,835.00
Park/Unit: Pipe Spring National Monument	**Region:** Intermountain
States: AZ	**Congressional District:** AZ02
Old Package Number:	**Reference Number:**
Project Type: Non-facility , Multi-component	**Financial System Package Number:** PISP 122438
Contact Person: Cheryl Decker	**Contact Phone:** 435-772-5662

Project Status - PMIS 122438	
Date Created: 12/15/05	**Review Status:** WASO-Reviewed on 01/31/2007
Date of Last Update: 04/20/07	**Updated By:** John Hiscock

Project Narratives - PMIS 122438

Description

Partner: Utah Conservation Corp (UCC)

Pipe Spring National Monument, located on the arid Arizona Strip, was once covered with "grasses knee-high to a horse." Today, the landscape is dominated by non-native vegetation and opportunistic native brush (saltbush/sagebrush) resulting from over-grazing and drought prior to Monument establishment. With funding from PLC, managers at PISP and ZION will create a living exhibit of the native grasses and forbs that once thrived before the introduction of cattle. The Utah Conservation Corp (UCC) volunteer youth crews will collect seed from the Monument and adjacent areas. Los Lunas Plant Material Center will propagate in bulk, seed that are genetically indigenous to the Arizona strip. Zion Native Plant Nursery will grow grass plugs, and UCC crews will plant the plugs and install drip irrigation for ~~plant establishment~~. Pipe Spring NM staff will provide periodic maintenance of the site. Three acres will be restored to native grassland and 12 cumulative acres of exotic plants will be contained.

Justifications

PROBLEM STATEMENT Pipe Spring National Monument (PISP) is located on the Arizona Strip within an arid saltbush and sagebrush community. Prior to pioneer settlement, the area that is now the Monument was reported to have lush "grasses knee high to a horse."

In the 1860s pioneers brought cattle and sheep to the area; by the 1870s an extensive ranching operation was established. Due to frequent overgrazing and droughts, the native understory vegetation has not regenerated and the Monument?s flora has become less diverse. Recent low rainfall years combined with competition from abundant exotic plants (particularly cheatgrass) as well as large areas of saltbush, require active revegetation to return more sizeable native forbs and grasses to the Monument. Revegetation efforts with grass plugs grown at Zion National Park?s Native Plant Nursery have been successful on a small scale. PISP managers would like the public to experience a living display of the native vegetation that existed prior to the introduction of livestock.

PMC → GALLETTA (2 lbs) ORY-HYM (50 lbs)

PROJECT DESCRIPTION AND TIMELINE Three acres of weed and saltbush-infested area will be treated and managed for exotics each funding year at Pipe Spring by ZION and PISP staff prior to planting. Because the PISP staff is very small, this project will be completed in three manageable increments, rather than all at once.

Each year, Utah Conservation Corp volunteer crews (UCC) will collect seed on the Monument and in adjacent areas (Spring and Fall). UCC and ZION crews will also control exotic plant populations and brush in the spring and fall. Controlling exotic plants, seed collection and planting are all very labor intensive tasks.

The Indian Rice Grass that is collected will be sent to Los Lunas Plant Materials Center (Los Lunas PMC) for bulk production. Plant Materials Centers specialize in growing crops of native species from seed originating from the restoration site in order to maintain genetic integrity. Indian Rice Grass is difficult to propagate and performs best from seeding. A total of 3,750 grass plugs, 1,250 per year, consisting of several species of native grasses will be grown at the ZION Native Plant Nursery.

Each Fall, UCC crews will plant the plugs, install drip irrigation in order to establish the new plantings, and sow the Indian Rice Grass seed and any additional seed that remains after propagation needs are met. Tribal youth from the Kaibab Paiute Reservation (PISP is located within the Kaibab Paiute Reservation) will also participate in planting.

Pre-emergent herbicide will be applied to the project area on a yearly basis by ZION staff. In Spring and Fall, UCC crews will also manually remove invasive plant species. This will reduce competition to both the planted and seeded native vegetation and aid in establishment success. — need to specify species ?

This project will take place in 3 phases in order to minimize annual maintenance costs, allow the increase fields at Los Lunas PMC to produce adequate seed, and to not overtax a small park staff. If funding limitations prevent all phases to be funded, a smaller area may be restored with only partial funding (eg. phase 1 is not dependant on achieving funding for phases 2 or 3). For each funding year, ZION and PISP project contributions will be at least $10,100 equaling $30,300 over 3 years.

COMPLIANCE This proposal is being reviewed by an interdisciplinary team through an environmental screening form. The action will likely fall under the following categorical exclusion: 3.4 E (2) Restoration of non-controversial native species into suitable habitats within their historic range.

Measurable Results

Successful completion of the project will result in the creation of a living display of the native grassland that existed prior to overgrazing. It will restore 3 acres of a native plant community upon which wildlife depends and contain 12 acres (cumulative over 4 years) of exotic plant species. Large supplies of grass seed with genetic integrity indigenous to the area will be made available for this and future restoration projects at PISP.

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UCC participants will benefit by being intimately involved in an important component of a significant and unique restoration project--they will have the opportunity to participate in the design and implementation of plant restoration that would involve a variety of private, tribal, and federal organizations; they will gain experience and insight into management of natural resources within the NPS system; and they will contribute toward restoring a more natural setting for visitors to experience.

This project contributes to Servicewide GPRA Goals: IIIaX park Partnerships, Ia1B Exotic Plants, Ia1A Disturbed Lands

Project Activities, Assets, Emphasis Areas and GPRA Goals - PMIS 122438

Activities	Assets
• Educate • Interpret and Inform • Restoration • Provide Visitor Services/Activities	• Plant Communities (Vascular and Non-Vascular) • Terrestrial Ecosystem • Cultural Landscape • Exhibit - Exterior • Interpretive Program
Emphasis Areas	**GPRA Goals and Percent Values**
• Disturbed Land Restoration • Education • Invasive Exotic Species • Partnerships • Volunteerism • Youth Work Programs	• Invasive plant species control, 25% • Cultural landscapes , 50% • Visitor Understanding , 25%

Project Prioritization Information - PMIS 122438

Unit Priority: 48 IN FY 2007	**Unit Priority Band:** HIGH

Project Assistance Needs - PMIS 122438

Is Assistance Needed: No

Related OFS Funding Requests - PMIS 122438

Request ID: 4487	**Request title:** Improve Resource Management and Preservation
Request ID: 24480	**Request title:** Restore and Maintain Conservation of Cultural and Natural Resources

Project Funding Component - PMIS 122438A

Funding Component Title: Phase 1: FY07	**Funding Component Request Amount:** $19,300.00

does mtce cost change w/ what they've already got?

Funding Component Reference Number (Multi-purpose):	**Funding Component Type:** Non-recurring , Not Deferred
Funding Component Description: Phase 1: Clear targeted Area, Control Weeds, Collect Seed, Increase Seed, Propagate Plants, Plant Plugs and Seed, Install Irrigation.	
Initial Planned FY: 2006	**Requested Funding FY:** 2007
Review Status: WASO-reviewed on 01/31/2007	**Funded Amount:** $19,300.00
Date of Park Submission: 01/17/2006	**Submitted By:** Andrea Bornemeier (1510z)
Upper-level Review Status:	**Fee-demo Submission Number:**
Formulated FY: 2007	**Funded FY:** 2007
Formulated Program: Fee Demo	**Funded PWE Accounts:** 1510-0727-C2S
Formulated Funding Source: Recreational Fee Demonstration, 20%	**Funded Funding Source:** Recreational Fee Demonstration, 20%

Component Cost Estimates

Estimated By: Cheryl Decker **Date of Estimate:** 12/15/2005

Estimate in 2006 dollars **Class of Estimate:** B

Item	Description	Qty	Unit	Unit Cost	Item Cost
Labor	8-person UCC volunteer crew for 5 weeks. 2 wks in spring & 3 weeks in fall @ $2,800/week. Cost covers UCC administration, round-trip transportation from ~~Flagstaff, AZ~~ Logan, UT insurance, food, housing, training and some equipment.	5	Each	$2,800.00	$14,000.00
Seed Propagation	Field Maintenance Costs for Los Lunas Plant Material Center for Indian Rice Grass @ $3,500/year	1	Lump	$3,500.00	$3,500.00
Supplies and Equipment Costs	Seed Collection Bags, Hand Tools, Safety Gear, Nursery Supplies (potting soil, containers, fertilizer)	1	Lump	$1,000.00	$1,000.00
Supplies and Equipment Costs	Drip Irrigation Supplies	1	Lump	$800.00	$800.00
			Component Funding Request		$19,300.00

shift UCC $ to NRCS for this year?

Eligible Funding Sources and Funding Priorities

ViPex sessions

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Project Funding Component - PMIS 122438B

Funding Component Title: Phase 2: FY08	**Funding Component Request Amount:** $18,575.00
Funding Component Reference Number (Multi-purpose):	**Funding Component Type:** Non-recurring , Not Deferred
Funding Component Description: Phase 2: Clear targeted Area, Control Weeds, Collect Seed, Increase Seed, Propagate Plants, Plant Plugs and Seed, Move Irrigation.	
Initial Planned FY: 2006	**Requested Funding FY:** 2008
Review Status: Region-reviewed on 03/15/2006	**Funded Amount:**
Date of Park Submission: 01/17/2006	**Submitted By:** Andrea Bornemeier (1510z)
Upper-level Review Status:	**Fee-demo Submission Number:**
Formulated FY: 2008	**Funded FY:**
Formulated Program: Fee Demo	**Funded PWE Accounts:**
Formulated Funding Source: Recreational Fee Demonstration, 20%	**Funded Funding Source:**

Component Cost Estimates

Estimated By: Cheryl Decker — **Date of Estimate:** 12/15/2005

Estimate in 2006 dollars — **Class of Estimate:** B

Item	Description	Qty	Unit	Unit Cost	Item Cost
Labor	8-Person UCC volunteer crew for 5 weeks. (2 wks in Spring, 3 wks in Fall) at $2,900/week. Cost covers UCC administration, round-trip transportation from Logan, UT ~~Flagstaff, AZ~~ insurance, food, housing, training and some equipment.	5	Each	$2,900.00	$14,500.00
Native Seed Propagation	Field Maintenance Costs for Los Lunas Plant Material Center for Indian Rice Grass @ $3,675/year	1	Lump	$3,675.00	$3,675.00
Supplies	Drip irrigation parts, nursery supplies, safety gear.	1	Lump	$400.00	$400.00
				Component Funding Request	**$18,575.00**

Eligible Funding Sources and Funding Priorities

Funding Source	Unit Priority at Formulation	Regional Priority	National Priority	Year Unit-Prioritized
Recreational Fee Demonstration, 20%	52	116		2006

Component Status Report

Last Reported Status Date: 04/20/2007	**Last Reported Completion Status:** Planning/Design Underway
Last Reported Planned Completion Date: 09/30/2008	**Reason for change/delay from schedule:** Work Proceeding as Planned

Explanation for the change/delay from project schedule:

Comments:

- Planning meeting w/ project specialists to be held late spring, 2007.

Last Reported Account Status as of 04/20/2007:

Account	Amount Obligated	Revised Estimate
1510-0727-C2S	$0.00	$0.00

Component Completion Report

Component Account Costs By Budget Object Class (based on AFS3):

Account	Personal Service	Travel	Contract	Supply	Equipment	Other	Total By Account
1510-0727-C2S	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
			Total Component Account Cost				**$0.00**

Component Start Date: 06/01/2007	**Component Completion Date:**
Completion Report Date:	**Created By:**
Change in Condition:	**Report Last Updated By:**
As Built Drawing or Report Number:	**As Built Drawing or Report Title:**
Location of Original As Built Drawing or Report:	**As Built Drawing or Report Author:**
Superintendent Approval Date:	**Superintendent Certification:**

Brief Quantified Description of Final Product/Outcome:

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Funding Source	Unit Priority at Formulation	Regional Priority	National Priority	Year Unit-Prioritized
Recreational Fee Demonstration, 20%	52	133		2006

Component Completion Report

Component Start Date:	**Component Completion Date:**
Completion Report Date:	**Created By:**
Change in Condition:	**Report Last Updated By:**
As Built Drawing or Report Number:	**As Built Drawing or Report Title:**
Location of Original As Built Drawing or Report:	**As Built Drawing or Report Author:**
Superintendent Approval Date:	**Superintendent Certification:**

Brief Quantified Description of Final Product/Outcome:

Project Funding Component - PMIS 122438C

Funding Component Title: Phase 3: FY09	**Funding Component Request Amount:** $19,860.00
Funding Component Reference Number (Multi-purpose):	**Funding Component Type:** Non-recurring , Not Deferred
Funding Component Description: Phase 3: Clear targeted Area, Control Weeds, Collect Seed, Increase Seed, Propagate Plants, Plant Plugs and Seed, Move Irrigation.	
Initial Planned FY: 2006	**Requested Funding FY:** 2009
Review Status: Region-reviewed on 03/15/2006	**Funded Amount:**
Date of Park Submission: 01/17/2006	**Submitted By:** Andrea Bornemeier (1510z)
Upper-level Review Status:	**Fee-demo Submission Number:**
Formulated FY: 2009	**Funded FY:**
Formulated Program: Fee Demo	**Funded PWE Accounts:**
Formulated Funding Source: Recreational Fee Demonstration, 20%	**Funded Funding Source:**

Component Cost Estimates

Estimated By: Cheryl Decker | **Date of Estimate:** 12/15/2005

Estimate in 2006 dollars | **Class of Estimate:** B

Item	Description	Qty	Unit	Unit Cost	Item Cost
Labor	8-person UCC volunteer crew for 5 weeks, 2 wks in spring & 3 wks in fall @ $3,100/week. Cost covers UCC administration, round-trip transportation from Flagstaff, AZ, insurance, food, housing, training and some equipment.	5	Each	$3,100.00	$15,500.00
Native Seed Propagation	Field Maintenance Costs for Los Lunas Plant Material Center for Indian Rice Grass @ $3,860/year	1	Lump	$3,860.00	$3,860.00
Supplies	Nursery supplies, drip irrigation parts, safety gear.	1	Lump	$500.00	$500.00
				Component Funding Request	$19,860.00

Eligible Funding Sources and Funding Priorities

Funding Source	Unit Priority at Formulation	Regional Priority	National Priority	Year Unit-Prioritized
Recreational Fee Demonstration, 20%	52	126		2006

Component Completion Report

Component Start Date:	**Component Completion Date:**
Completion Report Date:	**Created By:**
Change in Condition:	**Report Last Updated By:**
As Built Drawing or Report Number:	**As Built Drawing or Report Title:**
Location of Original As Built Drawing or Report:	**As Built Drawing or Report Author:**
Superintendent Approval Date:	**Superintendent Certification:**

Brief Quantified Description of Final Product/Outcome:

Project Funding Component - PMIS 122438D

Funding Component Title: PROJECT SUPPORT	**Funding Component Request Amount:** $0.00
Funding Component Reference	**Funding Component Type:** Recurring ,

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Number (Multi-purpose):	Not Deferred
Funding Component Description: Describes project support for each funded year.	
Initial Planned FY: 2007	**Requested Funding FY:** 2007
Review Status: Park-submitted	**Funded Amount:**
Date of Park Submission: 01/17/2006	**Submitted By:** Andrea Bornemeier (1510z)
Upper-level Review Status:	**Fee-demo Submission Number:**
Formulated FY:	**Funded FY:**
Formulated Program:	**Funded PWE Accounts:**
Formulated Funding Source:	**Funded Funding Source:**

Component Cost Estimates

Estimated By: Cheryl Decker — **Date of Estimate:** 12/15/2005

Estimate in 2006 dollars — **Class of Estimate:** B

Item	Description	Qty	Unit	Unit Cost	Item Cost
Project Support	ZION Native Plant Nursery Facilities and Equipment: $2,000/year ZION Horticulturist project direction: $4,200/year ZION weed control activities: $1,500/year Transportation Costs from ZION: $400/year PISP periodic maintenance: $2,000/year **Total Project Support: $10,100 per year or $30,300**	1	Lump	$0.00	$0.00
				Component Funding Request	**$0.00**

Eligible Funding Sources and Funding Priorities

Funding Source	Unit Priority at Formulation	Regional Priority	National Priority	Year Unit-Prioritized
Recreational Fee Demonstration, 20%	62			2006

Component Completion Report

Component Start Date: — **Component Completion Date:**

Completion Report Date: — **Created By:**

jump from
FY09 - FY11
- can change to
FY10 if nec.

Change in Condition:	**Report Last Updated By:**
As Built Drawing or Report Number:	**As Built Drawing or Report Title:**
Location of Original As Built Drawing or Report:	**As Built Drawing or Report Author:**
Superintendent Approval Date:	**Superintendent Certification:**
Brief Quantified Description of Final Product/Outcome:	

Project Funding Component - PMIS 122438E

Funding Component Title: PLC: Improve Visitor Experience by Creating a Living Exhibit of Restored Native Grasslands	**Funding Component Request Amount:** $7,100.00
Funding Component Reference Number (Multi-purpose):	**Funding Component Type:** Non-recurring , Not Deferred
Funding Component Description: Follow up maintenance to 3 phase project.	
Initial Planned FY: 2007	**Requested Funding FY:** 2011
Review Status: Region-reviewed on 03/16/2006	**Funded Amount:**
Date of Park Submission: 01/17/2006	**Submitted By:** Andrea Bornemeier (1510z)
Upper-level Review Status:	**Fee-demo Submission Number:**
Formulated FY: 2011	**Funded FY:**
Formulated Program: Fee Demo	**Funded PWE Accounts:**
Formulated Funding Source: Recreational Fee Demonstration, 20%	**Funded Funding Source:**

Component Cost Estimates

Estimated By: Cheryl Decker — **Date of Estimate:** 12/15/2005

Estimate in 2006 dollars — **Class of Estimate:** B

Item	Description	Qty	Unit	Unit Cost	Item Cost
UCC CREW	2 weeks for follow up maintenance to 3 phase project. $3,300 per week for 6 person crew per week.	2	Each	$3,300.00	$6,600.00
Supplies	Hand tools, safety gear,	1	Lump	$500.00	$500.00

Original PMIS agreement pp. 9-10

	Component Funding Request	$7,100.00

Eligible Funding Sources and Funding Priorities

Funding Source	Unit Priority at Formulation	Regional Priority	National Priority	Year Unit-Prioritized
Recreational Fee Demonstration, 20%	52	120		2006

Component Completion Report

Component Start Date:	Component Completion Date:
Completion Report Date:	Created By:
Change in Condition:	Report Last Updated By:
As Built Drawing or Report Number:	As Built Drawing or Report Title:
Location of Original As Built Drawing or Report:	As Built Drawing or Report Author:
Superintendent Approval Date:	Superintendent Certification:
Brief Quantified Description of Final Product/Outcome:	

Cultural Landscape Assessment

basically what's around the structures
Veg mgmt plan will determine what plants
we should target now

Q's

- 5 weeks UCC?
- "Success" of project defined as what?
- what are our respons. for the 4 seasons?

PISP
irrigation
rodent control
regular mgmt/mtce

ZION
initial work
seeding
planting

· fencing on bottom & sides

- heavy equip
- moving & relocating topsoil
- exotics ↑ ?
- perm. irrigation (from top - OK?)

- Veg Mgmt
- PLC - this yr "this proposal"
- NRCS
- Seed Coll

2 sep. projects
- PLC - CEBR/PISP Ed & Interp on Native Veg/Grasses
- PLC - CEBR/PISP " (Educational Program for schools?)
- Ethno botanical apprenticeship - coop. agreement w/ NAU (fund w/ PLC & CESU & stretch the duties)

SCA?
UCC? - have a mtg @ diff pts to help student

183

Original PMIS agreement p.11

Michelle sent 7/11

Exhibit Garden Supply Co

Product	Units	Unit Cost	Est. Cost
Hardware cloth			
gopher barrier (underground), 2' x 25' (1/4" mesh)	18	38.990	701.82
rabbit barrier (aboveground fence), 4' x 25' (1/4" mesh)	18	54.990	989.82
			0.00
Fencing			0.00
7' juniper posts	50	5.000	250.00
fence staples, 1 lb. box	5	2.290	11.45
large anchor pins, 8"x2"x8", 1000/box	1	149.990	149.99
large anchor pins shipping	1	9.990	49.95
Irrigation			
controller and wire			
4 station outdoor controller, internal transformer	1	63.864	63.86
6" pigtail w/right angle plug	1	5.425	5.43
5 conductor 18 ga. 250' roll	1	71.000	71.00
valves	1	5.951	5.95
1" socket utility ball valve	1	2.311	2.31
1" spig x 3/4" slip adapter	1	4.211	4.21
double manifold	2	2.464	4.93
male adapter	2	1.179	2.36
transition nipple	1	2.405	2.41
1" cap	2	32.657	65.31
1" control zone w/prf filter	2	1.244	2.49
1" FIPT x buttress nipple	2	2.541	5.08
1" x 3/4" MIPT x insert male adapter sent 3/4" x 3/4"	2	1.315	2.63
Jumbo valve box 12"	1	31.987	31.99
Black & White king connector	3	0.437	1.31
tubing			
1" header hose, poly tubing, 500' roll	1	58.500	58.50

Original supply order, p. 1

1/2" drip tubing, 250' roll	1	14.300	14.30
1/2" drip tubing, 500' roll	1	23.430	23.43
1/4" distribution tube (spaghetti tubing), 1000' roll	1	39.000	39.00
emitters			
2.9 gph xeri-bug emitter – sent 2.0 gph	325	0.294	95.55
self piercing barb	325	0.308	100.10
6" plastic stake – sent 300, not 325	325	0.127	41.28
misc fittings			
3/4" x 3/4" x 1/2" insert tee – same as insert ? OK	15	1.315	19.73
techline male adapter 1/2"	15	0.269	4.04
1/2" figure eight line end	15	0.086	1.29
punching hole tool	5	6.000	30.00
techline 1/2" couplers	10	0.200	2.00
techline 1/2" insert elbow	5	0.250	1.25
flush cap	1	1.020	1.02
6" X 1" Saddle	1	33.500	33.50
1" Brass Valves (2)	2	10.000	20.00
Watts Pressure Reducer	1	220.000	220.00
1" Water Meter	1	125.000	125.00
1" Backflow Preventer	1	250.000	250.00
1" PVC Pipe 100 ft	100	0.370	37.00
Assorted Fittings	1	50.000	50.00
Valve Boxes	3	45.000	135.00
TOTAL			3726.27

all missing??

Original supply order, p.2

sts

Source	Contact info
Ace hardware	635-4449 (Hurricane)
Ace hardware	635-4449 (Hurricane)
Johnson Enterprises Stock bldg. supply	(Fredonia) 635-9755 (Hurricane)
http://www.catalogclearance.com/products/anchoringpins_ nonwovenlandscapefabric.html	1-866-727-6658
Sprinkler supply	652-8351 (St. George)

→ pig-sized hogring clamp $3.99/box 100/box + pliers

(928) 643. 7105

Need

- 5 elbows for drip tubing
- 10 elbows for header
- 6 couplers for header
- emitters ✓
- spagh tubing x _ ft ✓
- connector ✓

- 1 gph emitters ✓
- spagh tubing stakes ✓

Original supply order, p. 3

Irrigation Supplies for PISP Grass Exhibit Garden –
Secondary Order

Item	**Qty**	**Item #**	
6" plastic stake	200	AG-S6	
1.0 gph Xeri-Bug emitter	200	?	
2.0 gph Xeri-Bug emitter	200	XE-XB20	
Self Piercing Barb	200	XE-SPB025	
.16" Poly Micro Tubing 1000'	1	TL-EDTUBE10	double-check that this is the spagh. tubing!
Techline insert elbow	10	TL-ELL	

10 elbow inserts for header hose (header hose is "5 conductor 18 ga. roll" - not sure on size???)
6 couplers for header hose ("   ")

Sprinkler supply - St George
435.652.8351

Appendix 5

Grassland Revegetation Techniques

Species Selection

The steps below describe the basic process of selecting appropriate plant species and community composition (Dr. Mark E. Miller 2009, pers. comm.). See appendices 6 ,7, and 8 for a soil map of Pipe Springs, NRCS Ecological Site Descriptions, rangeland productivity and USDA VegSpec reports described in the process below.

Overview

1. Determine the soil type
2. Determine the type of 'ecological site' that is associated with the particular soil
3. Examine the appropriate ecological site description and rangeland productivity to determine the appropriate vegetation.
4. Use population data to determine relative seed requirements for each species

Application Example: Prototype Revegetation Plot

In this example, a hypothetical plot west of the visitor center and east of the flood ditch has been selected for a grassland revegetation project. The ecological site description has been selected as the primary reference.

Step 1: The soil type for this location has been determined as Mido Fine Sand by referencing the soils map in appendix 6.
Step 2: According to the list provided in appendix 6, this soil type correlates to Ecological Site Description RO35XC315AZ , Sandy Upland 10-14” p.z.
Step 3: The following information is provided by the Ecological Site Description:

Historic Climax Plant Community
This site has a plant community made up primarily of mid and short grasses with a relatively small percentage of forbs and shrubs. The dominant aspect is desert grassland with scattered shrubs. In the original plant community there is a mix of cool season and warm season grasses with shrubs and half shrubs. Plant species most likely to invade or increase on this site when it deteriorates are broom snakeweed and annuals.

Historic Climax Plant Community Plant Species Composition:

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
	0			5	14
		Forb, perennial		5	14
		Milk vetch	*Astragalus*	0	5
		Mariposa lily	*Calochortus*	0	5
		Lark spur	*Delphinium*	0	5
		Pepper weed	*Lepidium*	0	5
		Phlox	*Phlox*	0	5
		Ragwort	*Senecio*	0	5
		Globe mallow	*Sphaeralcea*	0	5
		Vetch	*Vicia*	0	5

Grass/Grasslike

Annual Production in Pounds Per Acre

Group	Group Name	Common Name	Scientific Name	Low	High
0				270	383
		Grass, annual		23	45
		Indian rice grass	*Achnatherum hymenoides*	23	48
		Three awn	*Aristida*	5	23
		blue grama	*Bouteloua gracilis*	14	23
		Squirrel tail	*Elymus elymoides ssp. elymoides*	0	5
		needle and thread	*Hesperostipa comata ssp. comata*	23	45
		James' galleta	*Pleuraphis jamesii*	90	135
		sand dropseed	*Sporobolus cryptandrus*	23	68
		Six weeks fescue	*Vulpia octoflora*	0	23

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				65	150
		fourwing saltbush	*Atriplex canescens*	23	45
		Greene's rabbitbrush	*Chrysothamnus greenei*	5	9
		yellow rabbitbrush	*Chrysothamnus viscidiflorus*	4	8
		Joint fir	*Ephedra*	0	9
		rubber rabbitbrush	*Ericameria nauseosa ssp. nauseosa var. glabrata*	5	9
		broom snakeweed	*Gutierrezia sarothrae*	23	45
		winterfat	*Krascheninnikovia lanata*	14	23

*Note: The above information has been reduced for this example

Structure and Cover:
Ground Cover (%)
    Vegetative Cover
        Grass/Grasslike : 1-5%
        Forb: 0-1
        Shrub/Vines: 10-20%
        Trees: 0

Step 4:

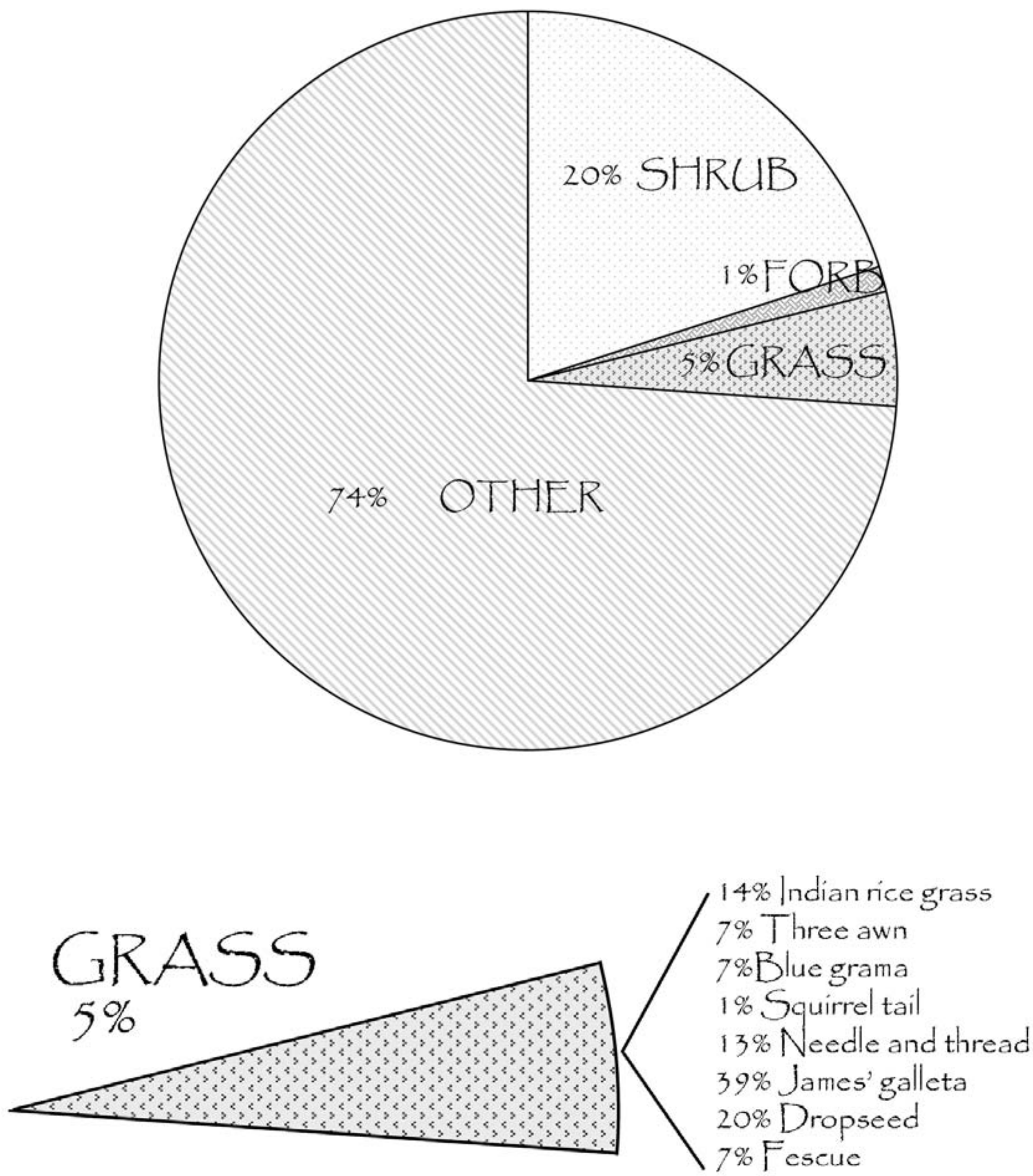
In this example, in a given plot size, 10-20% of the ground cover would be composed on grasses and 0-1% composed of forbs, and 1-5% composed of shrubs or vines (Appendix Figure 5.1). In order to determine the percentage of each species within category, the annual production (pounds/acre) must be used as a relative proportion.

Therefore, in the "Grass" ground cover category, the annual production of each species would be divided by the total annual production of all grass species (selecting either highs, lows, or averages). In this example:

Total High Values = 48 + 23 + 23 + 5 + 45 + 13 + 5 + 68 + 23 = 370

Indian rice grass	48/370	= 13%
Three awn	23/370	= 6%
Blue gramma	23/370	= 6%
Squirrel tail	5/370	= 1%
Needle and Thread	45/370	= 12%
James' galleta	135/370	= 36%
Dropseed	68/370	= 18%
Fescue	23/270	= 6%
Six weeks fescue	23/270	= 6%

These figures represent the percent composition of each grass species composing the 10-20 percent total grass coverage within the plot (Appendix Figure 5.1). This calculation would be continued for each species within each category. Programs such as VegSpec (appendix 6) provide organizational tools for calculating and purchasing the correct quantity of seed for each species.



Appendix Figure 5.1: *The pie graph shows the percent ground cover by each plant category (above) and an extracted portion (below) showing calculated species composition within one category. "Other" refers to non-plant material such as soil and rock*

Seeding

Overview of Seed Dormancy and Germination
(Leffler 2008, lecture)

Although often demure in form, a seed's life cycle can be a complex web of chance and strategy, the outcome of which can be germination, death, or an ecological purgatory. Managers of restoration projects must be aware of this cycle and how to intercede in order to produce the desired restoration results.

Once a seed is dispersed from the parent, it may follow one of two courses. The fortunate seed will find a "safe-site", a location that provides protection and the necessary resources to establish. Alternatively, the seed can undergo transport, settling in either a safe-site or a non-safe site where it will fall victim to predation.

Upon reaching a safe-site, the seed will either germinate, producing a seedling, or enter a state of dormancy maintained by the presence of inhibitors (such as seed coats and chemical inhibitors) or by a lack of conditions conducive to germination. Through this strategy of dormancy a seed may be able to remain in a suspended state, forgoing successive germination periods, until the acceptable conditions present themselves.

Dormancy may be released by a number of physical, chemical, and other environmental mechanisms, depending upon the germination strategy of the seed species. There are six general mechanisms:

- Physical Degredation
    - These include abrasion, removal, and damage to the seed coat (scarification).
    - This mechanism operates by allow water to reach the heart of the seed, inducing germination.
    - Processes that result in physical damage include predation, which degrades the seed coat during digestion. This is a common strategy of animal-dispersed seeds.
- Water Solubility
    - Water soluble chemical inhibitors coating the seed are washed away upon contact with water (rain, flooding etc.)
- Nitrate Saturation
    - Although nitrates are not necessary for germination, a high concentration can act as an indicator of the competitive environment.
    - If nitrate is readily available, it is likely that there is a lower density of vegetation present (less is used) and a less competitive environment.
    - Early successional species (many annuals and grasses) often establish in nitrate rich conditions, whereas late successional species establish in low nitrate, high competition environments.

- Presence of Smoke
    - Fire-adapted species often require a fire of a certain magnitude to break dormancy
    - Dormancy can be broken by either the heat of the flame itself, or the chemical compounds found in smoke.
- Absolute Light Requirements
    - A twofold strategy, the seed will break dormancy within a light window. In the correct balance, there is enough light to signal that the seed is not buried too deep and low enough light to prevent seeds from germinating on the surface.
    - There are also spectral requirements, which indicate whether the seed is in the shade of a canopy.
- Absolute Temperature Requirements
    - Seeds will germinate once a specific temperature is reached.
    - Diurnal temperature changes indicate seed burial and max/min daily temperatures over time indicate the correct season for germination.
    - Some seeds require a period of cold stratification, passing through a winter season before germination

Application

It is important to be aware of the seed lifecycle and dormancy mechanisms in order understand where in the cycle intervention can be beneficial to the restoration process. Specifically, knowing the strategies employed by the species selected for a restoration project can allow restorationists to facilitate germination.

Important implementation steps that follow these considerations may include selecting seeds whose need will be met by the site, artificially inducing germination (i.e. scarification, smoke or light treatments), broadcasting during appropriate seasons or conditions, and supplementing the site to produce safe-sites and conditions conducive to survival and germination. Pipe Spring should evaluate the selected species and intervene as necessary to encourage germination.

Providing Safe Sites and Access to Resources

There are several low cost and labor steps that may be taken to decrease the mortality of seeds broadcasted throughout the monument and in intensive plots.

Herbicide Applications

In areas where seed establishment could be impeded by competition from aggressive plant species, a proactive non-selective, post-emergent herbicide (kills most plants, after germination) treatment may be used reduce competition during germination and establishment. The timing of the application should be determined by the germination period of the restoration species. For example, if fall germinating species are used, the herbicide should be applied late in the season. After germination, selective broadleaf herbicides may be used to target undesirable broadleaf plants without injuring the desired grass species. Herbicide applications should be used with discretion, as they may harm established desired plants. The site should be surveyed for desirable plants and areas where rare native plants are established (north of the visitor Center) should be avoided The site should be regularly monitored for invasive species, using manual removal or herbicide applications when necessary (Sheley 1999).

Providing Safe Sites

Microtopography

Small adjustments to the restoration site can easily provide safe sites for germinating seeds and emerging seedlings, lowering predation risks and encouraging establishment. A recommended treatment is to prepare the soil bed by creating a rough microtopography. Racking the application site will loosen the soil, providing a deeper soil surface for seed penetration, water absorption, and protection from sunlight and predation. Dr. Fertig of Moenave Botanical Consulting recommends this treatment for areas where the soil has been compacted, but cautions that raking should remain light in order to prevent the encouragement of advantageous weeds (Fertig 2010, pers. comm., Call 2009, pers.comm).

Shelter

In addition to raking, safe sites can be provided by placing shelter elements throughout the site. These can be temporary features that will provide shade and protection from predation and wind. Rocks, sticks, existing shrubs and other natural features can easily be collected and used as shelters without detracting from the natural appearance of the site. Plant debris/litter or a light application of mulch can also provide protection but should not prevent rainfall or sunlight from reaching the seeds.

Water

Water is one of the most difficult provisions for a non-intensive (non-irrigated) restoration site. The site can, however, be subtly amended to manipulate and maximize the benefits of natural rainfall. Carefully placing linear elements, such as branches, along the boundaries of the site and within it can help direct and contain water. The branches should be situated to funnel water from upslope towards the plot and to prevent rainfall from continuing past the plot. The placement of these elements should appear as random and natural as possible in order to limit their visible impact.

Symbiotic Relationships

Heteromyid Rodents share a symbiotic relationship with native arid grassland and shrub steppe communities, and are one of the most important ecological ingredients in many systems. This group of rodents cache seeds as a form of food storage, which in turn, provides safe sites where many of those seeds are able to establish and grow. (Dr.Chris Call, per. Comm.; Longland 2001; Longland 2009).

Pipe Spring may want to consider a small mammal survey in order to understand the rodent population in the monument and gauge their potential in grass revegetation within the intensive plot (if the fencing is removed) and in other sites throughout the monument. Rodents can easily be studied using small live-traps baited with peanut butter and placed in various habitat types throughout the monument. Recording the presence or absence of rodent species may indicate whether there is a healthy population that could assist in revegetation and could possibly recommend certain sites within the monument for additional revegetation projects.

Knowledge of any additional interactions and relationships between the selected revegetation species and local plants or animals may offer further insights into processes affecting the restoration.

Seed Selection and Application

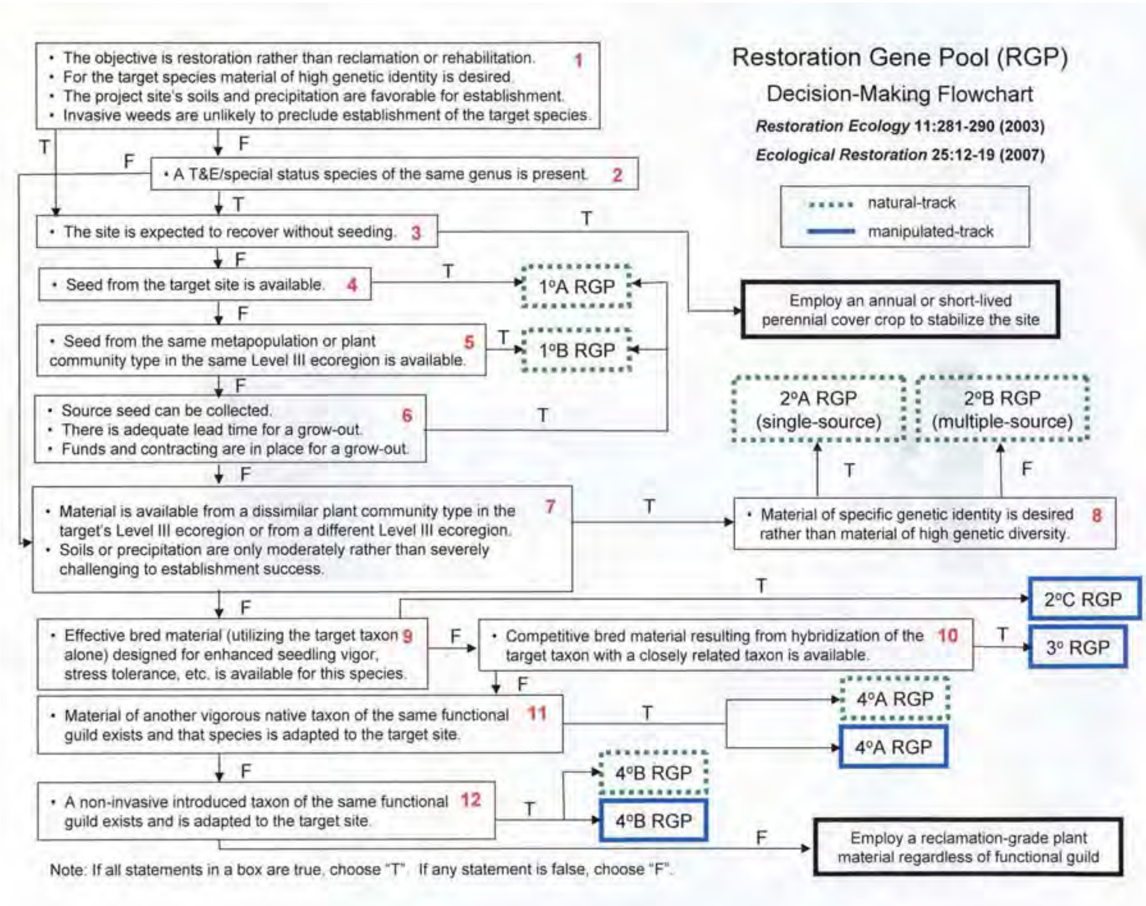
Seed Selection

Seed selection for a restoration site plays a critical role in the outcome of the project and involves careful and often complex decision making. There are numerous strategies involving hedging bets between local genetic species, non-local adapted species, and variations between the two. One concept that has helped organize the decisions made by restoration ecologists is the "Restoration Gene Pool Concept" (RGP Concept) put forth by T.A. Jones (2003) and expanded in Jones 2007. This concept provides a gradient of solutions from local materials to non-local adapted materials:

- Primary Material
    - Material that is genetically adapted to the site (material from a local population)
- Secondary Material
    - Material from the same taxon as local species but from a different population (mixed genotypes)
- Tertiary
    - Material of a related taxa specifically adapted to the post-disturbance site conditions (eg. Replacing a local grass with another, better adapted grass that is a hybrid of desired local traits and related taxa). These materials can be difficult to find if the species is not commonly used in restoration projects.
- Quaternary
    - Material with low genetic relatedness to local materials but highly adapted to post-disturbance site conditions. These species replace the function guilds of local species but not their genotypes. Many restoration ecologist

will not use quaternary sources, although they may often serve as a temporary phase until local species can proliferate

The first choice for any restoration is the use of primary material, moving down the list as site conditions become more altered and challenging or as urgency increases. As a result, in the worst case scenario (Quaternary) ecosystem function are restored although species composition is not local and may be a cultivar or non-native (and non-invasive) species. There may be long-term consequences for introducing non-local or non-native materials, however, the RGP concept proposes that immediate recovery of function may provide the best alternative in severely disturbed sites (Jones 2003, 2007). See Appendix Figure 5.2 for a flow chart illustrating the decision making process.



Appendix Figure 5.2: *Decision making flow chart from Jones 2003, 2007.* 1^0 *corresponds to Primary Material,* 2^0 *corresponds to Secondary Material etc. A and B subheading refer to the source of the material (see Jones 2003, 2007 for more information)*

Local, Adapted Species

Local species provide genotypes that have evolved in response to local site conditions and disturbance regimes. These species may be best adapted establish and survive in a local restoration. “Local” in this instance, refers to species within the same geographic, physical and biological context as the site. It may include seed collected on site or on sites where gene-flow occurs (preferred) and seed from sites not connected by gene-flow but under the same environmental influence (ecoregions). Acquiring seed from the site may be challenging. Dr. Fertig suggests collecting seeds from the healthy plant communities within the Hillside Zone of the monument. Other local seed sources may be available from nearby public lands and/or agencies (Leffler 2008, Lecture, Jones 2007).

Other Sources

Broadly adapted species (species for which local conditions are less relevant and are widely used) that are prolific seed producers are often available for purchase through collection programs. Other species must be cultivated or genetically manipulated and harvested from plants in fields or nurseries. The Association of Official Seed Certifying Agencies (AOSCA), provides inspection and labeling programs that ensure the selection of site-appropriate species for restoration projects utilizing purchased seed sources. The AOSCA requires that information including source, genetic identity, and genetic purity be available to the consumer. It is recommended that Pipe Spring use AOSCA certified seeds for non-local seeds in order to assure seed quality and suitability.

Species Assemblage

The concept of an ecological niche is critical to selecting a species assemblage that will limit competition between restoration species and undesirable species. Niches include all of the abiotic and biotic requirements of a particular species. A community of species that maximize the use of niches in a particular location will also maximize resource efficiency and prevent the introduction of additional species. Niches can be filled by combinations of species whose resource use varies both temporally and spatially. A plant community, for example, might be composed of plants with shallow roots, deep roots and intermediate roots. Although they may be extracting the same resources, their activity is spatially distributed. In the same community two species may both require he same nutrient in order to germinate. If one species germinates in the spring and the other in the fall, then they are using the same resource but their use is temporally separated. If a community fills the spectrum of available niches, few resources will remain for new species and the community as a whole may be more resilient through long-term environmental changes and events.

The concept of the niche can be applied to restoration projects by selecting a species assemblage that varies in both spatial and temporal resource use. This includes features such as root form, nutrient requirements, germination season, reproductive strategy, photosynthetic pathways and growth rate. A closely related concept, the function guild concept, groups species by their niches or function within an ecosystem. Many restoration ecologists argue that it is the presence of functional guilds, rather than individual species, that promote a stable and resilient community. The RGP concept utilizes this framework.

Seeding

Once the correct species have been selected and the site has been prepared for germination, seed distribution may proceed. Although there are numerous mechanical methods available for sowing seeds, both the scale and sensitivity of the site and the availability of resources and labor recommend broadcast seeding for non-intensive plots and hand dibbling for intensive plots as the most appropriate seeding methods for projects around the monument. Several additional considerations should be taking into account during seeding:

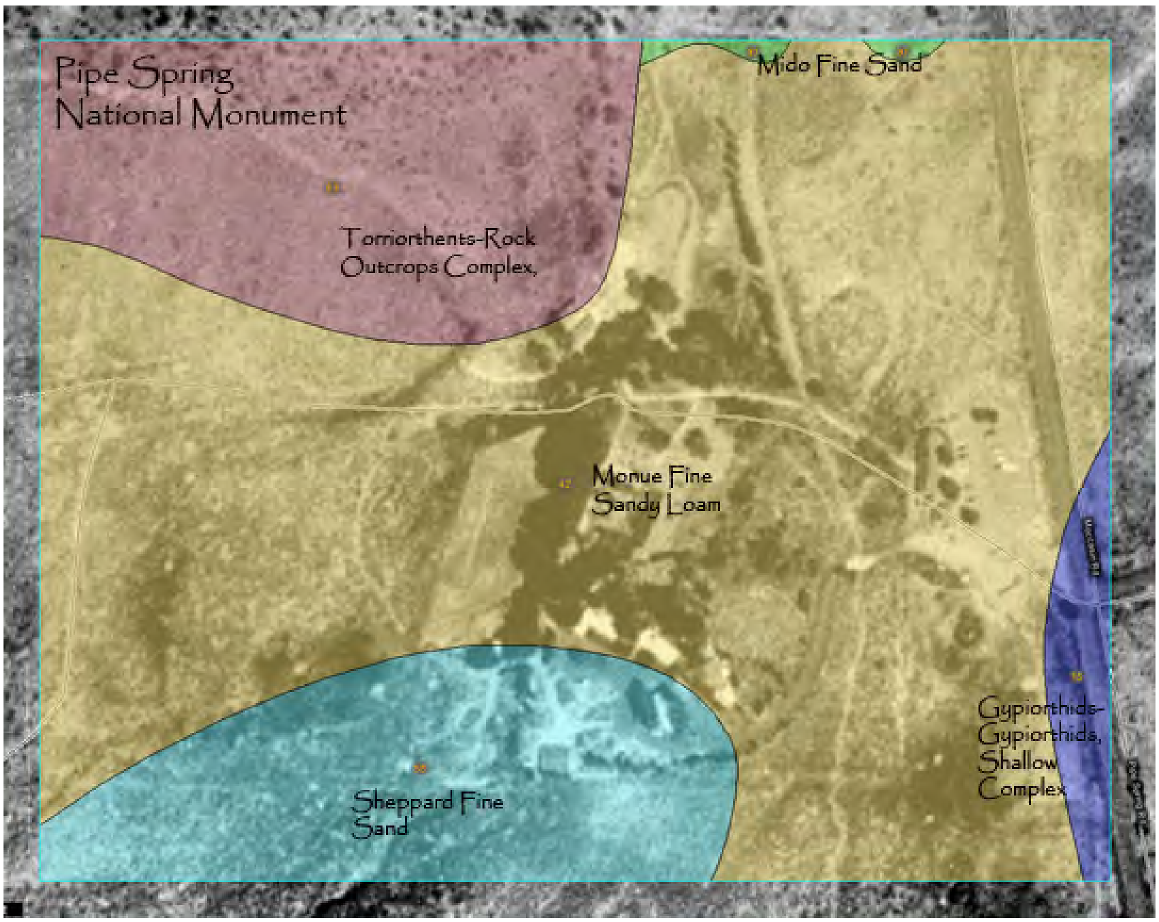
- The appropriate planting depth varies by species, usually in response to seed size
    - Sheley 1999 recommends depths of ” for sm all seeds and ” for large seeds.
    - Dr. Call provides two examples of the disparity in ideal seedling depths. He suggests that the large seeds of Indian rice grass be planted at a depth of 1” or deeper, whereas the tiny seeds of the dropseed be distributed very near the surface (2009, pers. comm.).
    - Each species should be researched for ideal seeding depths when using the hand dibbling method.
- Seed establishment is a function of the availability of safe sites and the availability of seeds (Sheley 1999).
    - If safe-site preparation is not possible or desired (due to time or labor) the germination and establishment rate can be maintained by increasing the volume of seed applied to the site. Overseeding minimally managed plots can overcome mortality due to unsafe sites and may be a viable option for non intensive plot treatments.

Note: The information presented in this appendix should be used as a general reference and introduction to the concepts of restoration and revegetation. Supplementary and periodic expert consultations are encouraged throughout the course of the revegetation process, ensuring that management plans respond to current site conditions and progress.

Appendix 6

Soil Types and NRCS Ecological Site Descriptions

Map of PISP Predominant Soils Types



Appendix figure6.1: *Map adapted from NRCS Soils Maps showing soil classifications for Pipe Spring National Monument. Note: Soil unit boundaries are generally accurate at the original mapping scale (shown above), becoming less accurate at finer scales.*

The soil types for the Monument have been located using NRCS Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. The soils map based on this data is congruent with the map used in the Pipe Spring Vegetation Classification and Mapping Project Report (USDOI 2008).

Ecological Site Descriptions

An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time throughout the soil development process; a characteristic hydrology, particularly infiltration and runoff that has developed over time; and a characteristic plant community (kind and amount of vegetation). The hydrology of the site is influenced by development of the soil and plant community. The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production. Descriptions of ecological sites are provided in the Field Office Technical Guide, which is available in local offices of the Natural Resources Conservation Service (NRCS).

Note: The full report is provided for each Ecological Site, however the “Plant Communities” and “Historic Climax Plant Community” sections that are most relevant to this management plan. These reports may be accessed by visiting:. http://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD Site descriptions are found by searching for the “RO…” numbers provided below and located under MLRA 035X on the website.

The following pages contain reports for the ecological sites listed below:

1. Ecological Site: Sandy Loam Upland 7-11” p.z. Calcarious, RO35XD413AZ
2. Ecological Site: Torriorthents-Rock Outcrops Complex: Sedimentary Cliff 10-14” p.z. RO35XC302AZ
3. Ecological Site: Mido Fine Sand: Sandy Upland 10-14” p.z. RO35XC315AZ
4. Ecological Site: Monue Fine Sandy Loam: Sandy Loam Upland 7-11” p.z. Calcarious RO35XD413AZ
5. Ecological Site: Gypsiorthids-Gypiorthids: Shallow Complex p.z. Calcarious RO35XD405AZ

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

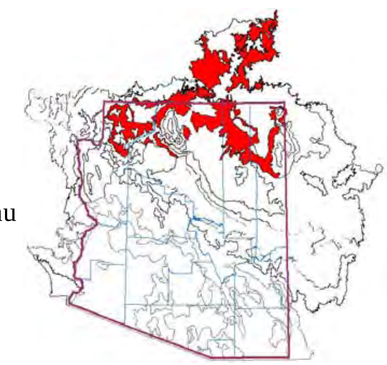
ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Sandy Upland 10-14" p.z.

Site ID: R035XC315AZ

Major Land Resource Area: 035 - Colorado Plateau



Physiographic Features

This ecological site is found on nearly level to gently rolling partially stabilized or stabilized dunes on fan terraces and stream terraces. The soil associated with the site is deep to very deep to any plant root restricting layer. The surface texture of the soil is generally fine sand or loamy sand. Subsurface horizons are generally fine sand or loamy sand. The slope of the site is generally 1 to 10 percent, but may be as high as 15 percent.

Land Form: (1) Terrace
(2) Stream terrace
(3) Dune

	Minimum	Maximum
Elevation (feet):	4800	5800
Slope (percent):	1	10
Water Table Depth (inches):		
Flooding:		
Frequency:	None	None
Duration:	None	None
Ponding:		
Depth (inches):		

Frequency:	None	None
Duration:	None	None
Runoff Class:	Very low	Very low
Aspect:	No Influence on this site	

Climatic Features

Winter summer moisture ratios range from 70:30 to 60:40. Late spring is usually the driest period, and early fall moisture can be sporadic. Summer rains fall from June through September; moisture originates in the Gulf of Mexico and creates convective, usually brief, intense thunderstorms. Cool season moisture from October through May tends to be frontal; it originates in the Pacific and the Gulf of California and falls in widespread storms with longer duration and lower intensity. Precipitation generally comes as snow from December through February. Accumulations above 12 inches are not common but can occur. Snow usually lasts for 3-4 days, but can persist much longer. Summer daytime temperatures are commonly 95 - 100 F and on occasion exceed 105 F. Winter air temperatures can regularly go below 10 F and have been recorded below - 20 F.

	Minimum	Maximum
Frost-free period (days):	137	168
Freeze-free period (days):	164	193
Mean annual precipitation (inches):	10.0	14.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.68	0.69	0.84	0.66	0.47	0.32	1.21	1.6	1.06	1.02	0.8	0.0
Precip. Max.	1.44	1.62	1.58	0.97	0.63	0.41	1.38	1.66	1.27	1.16	1.2	0.98
Temp. Min.	14.5	19.1	23.9	29.7	37.7	45.9	54.6	53.6	45.9	34.8	23.3	15.6
Temp. Max.	47.7	52.3	58.6	66.4	76.8	87.4	92.7	90.2	82.7	71.7	57.6	48.8

Climate Stations: (1) 21920, Colorado City, AZ. Period of record 1963 - 2005
(2) 23303, Ganado, AZ. Period of record 1948 - 2005

Influencing Water Features

Wetland Description:	System	Subsystem	Class

Representative Soil Features

The soil associated with this ecological site is deep to very deep to any plant root restricting layer. The surface texture of the soil is generally fine sand or loamy sand. Subsurface horizons are generally fine sand or loamy sand. The soil ranges from nuetral to moderately alkaline (pH 6.6 to 8.4). The permeability is rapid to very rapid and the soil profile can absorb all the moisture the climate can supply. The available water capacity is low. Wind erosion is a severe problem if the vegetative cover is lost.

Typical taxonomic units include ; Fort Defiance Area, Parts of Apache and Navajo Counties, Arizona, and McKinley and San Juan Counties, New Mexico "SSA715" MU's 68 & 81 Pinavetes family.

Predominant Parent Materials:
Kind: Eolian sands
Origin: Sandstone

Surface Texture: (1) Fine sand
(2) Loamy sand

Subsurface Texture Group: Sandy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):	0	2
Surface Fragments > 3" (% Cover):	0	0
Subsurface Fragments <=3" (% Volume):	0	1
Subsurface Fragments > 3" (% Volume):	0	0

Drainage Class: Excessively drained To Excessively drained
Permeability Class: Rapid To Very rapid

	Minimum	Maximum
Depth (inches):	60	
Electrical Conductivity (mmhos/cm):	0	2
Sodium Absorption Ratio:	0	0
Calcium Carbonate Equivalent (percent):	0	0
Soil Reaction (1:1 Water):	6.6	8.4
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	1.92	3.66

Plant Communities

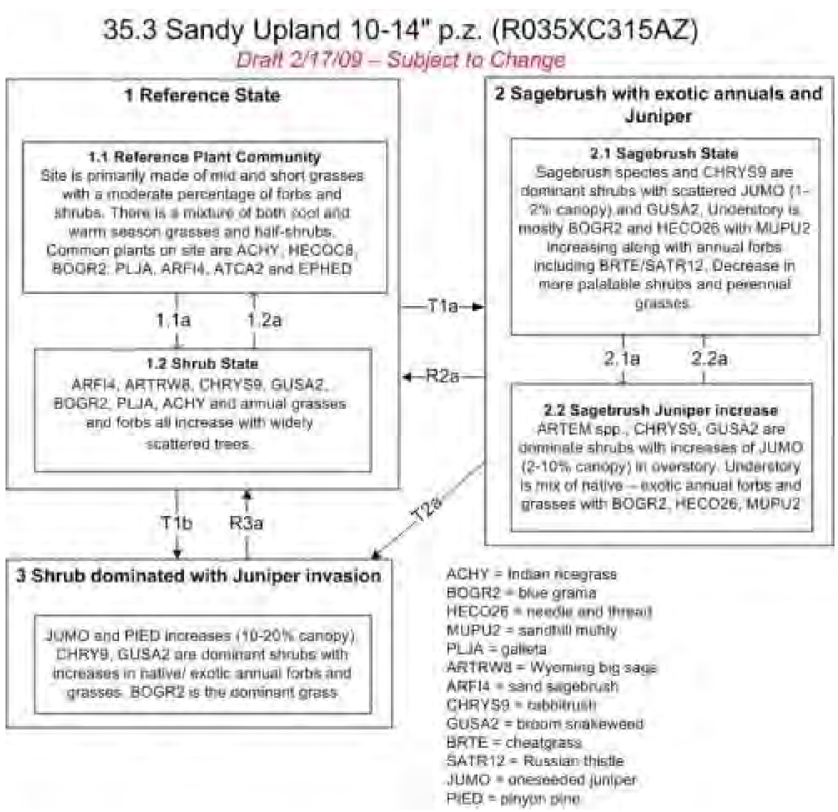
Ecological Dynamics of the Site

The plant communities found on an ecological site are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites. Other plant communities described here represent plant communities that are known to occur when the site is disturbed by factors such as grazing, fire, or drought.

Production data provided in this site description is standardized to air-dry weight at the end of the summer growing season. The plant communities described in this site description are based on near normal rainfall years.

NRCS uses a Similarity Index to compare existing plant communities to the plant communities described here. Similarity Index is determined by comparing the production and composition of a plant community to the production and composition of a plant community described in this site description. To determine Similarity Index, compare the production (air-dry weight) of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total normal year production shown in the plant community description. If rainfall has been significantly above or below normal, use the total production shown for above or below normal years. If field data is not collected at the end of the summer growing season, then the field data must be corrected to the end of the year production before comparing it to the site description. The growth curve can be used as a guide for estimating production at the end of the summer growing season.

T1a = Extreme herbivory, Summer Drought,
R2a = Prescribed grazing, brush management/ Herbicide treatment
R3a = Prescribed grazing, brush management/ Herbicide treatment
T1b = Extreme herbivory, fire exclusion
T2a = Lack of fire, summer drought, heavy grazing



Reference state

1.1 Reference Plant community

Site is primarily made of mid and short grasses with a moderate percentage of forbs and shrubs. There is a mixture of both cool and warm season grasses and half-shrubs. Common plants on site are ACHY, HECOC8, BOGR2, PLJA, ARFI2, ATCA2 and EPHED. There are widely scattered Juniper <1% in cover.

1.2 increased shrubs

Shrubs; ARFI4, ARTRW8, CHRYS9, and GUSA2, increase. Perennial grasses and forbs all increase with widely scattered juniper trees (no invasion). BOGR2 is the dominant grass.

1.1 a Continuous heavy grazing, summer drought
1.2 b Rest, managed grazing, prescribed grazing, and adequate summer moisture

Plant species most likely to invade or increase on this site when it deteriorates are sand sagebrush, rabbitbrush, annuals, sandhill muhly, wooly groundsel, and snakeweed.

Reference state Plant Species Composition:

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				65	162
		 needle and thread	*Hesperostipa comata ssp. comata*	65	162
2				130	228
		 Indian ricegrass	*Achnatherum hymenoides*	130	228
3				32	65
		 squirreltail	*Elymus elymoides ssp. elymoides*	32	65
4				32	98
		 black grama	*Bouteloua eriopoda*	32	98

5				32	98
		 blue grama	*Bouteloua gracilis*	32	98
6				0	0
		 James' galleta	*Pleuraphis jamesii*	32	98
7				32	130
		 spike dropseed	*Sporobolus contractus*	0	130
		 sand dropseed	*Sporobolus cryptandrus*	0	130
		 mesa dropseed	*Sporobolus flexuosus*	0	130
8				0	65
		 sandhill muhly	*Muhlenbergia pungens*	0	65
9				6	32
		 threeawn	*Aristida*	6	32
10				0	32
		 Grass, perennial		0	32
11				0	0
		 Grass, annual		32	65

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
12				32	65
		 Forb, annual		0	65
		 Forb, perennial		0	65
		 globemallow	*Sphaeralcea*	0	65
		 Rocky Mountain zinnia	*Zinnia grandiflora*	0	65

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
13				0	0
		 sand sagebrush	*Artemisia filifolia*	32	230
14				0	0
		 Wyoming big sagebrush	*Artemisia tridentata ssp. wyomingensis*	0	98
15				32	65
		 fourwing saltbush	*Atriplex canescens*	32	65
16				0	32
		 winterfat	*Krascheninnikovia lanata*	0	32
17				65	130
		 jointfir	*Ephedra*	65	130
18				13	65

		 rabbitbrush	*Chrysothamnus*	0	65
		 broom snakeweed	*Gutierrezia sarothrae*	0	65
19				0	32
		 pricklypear	*Opuntia*	0	32
		 yucca	*Yucca*	0	32

Tree

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
20				0	65
		 juniper	*Juniperus*	0	65
		 twoneedle pinyon	*Pinus edulis*	0	65

Annual Production by Plant Type:

Plant Type	Annual Production (lbs/AC) Low	Representative Value	High
Forb	32		65
Grass/Grasslike	390		488
Shrub/Vine	162		260
Tree	0		65
Total:	584	0	878

Plant Growth Curve:
Growth Curve Number: AZ3501
Growth Curve Name: 35.3 10-14" p.z. needle and thread
Growth Curve Description: Growth starts in spring and extends into summer, plants may be green in the fall.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	10	20	30	10	5	5	10	10	0	0

Plant Growth Curve:
Growth Curve Number: AZ3505
Growth Curve Name: 35.3 10-14" p.z. Indian ricegrass
Growth Curve Description: Growth begins in spring, with semi-dormancy occurring during July through August. Plants will green up again in the fall.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	10	20	25	20	5	5	10	5	0	0

Plant Growth Curve:
Growth Curve Number: AZ3531
Growth Curve Name: 35.3 10-14" p.z. all sites
Growth Curve Description: Growth begins in the spring and continues through the summer.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	3	17	18	10	19	20	10	1	1	0

Sagebrush with exotic annuals and Juniper

2.1 Sagebrush scattered Juniper
Sagebrush species and CHRYS9 are dominant shrubs with scattered JUMO (1-2% canopy) and GUSA2; Understory is mostly BOGR2 and HECO26 with MUPU2 increasing along with annual forbs including BRTE/SATR12. Decrease in more palatable shrubs and perennial grasses.

2.2 Sagebrush Juniper increase
ARTEM spp., CHRYS9, GUSA2 are the dominant shrubs with increases of JUMO (2-10% canopy) in overstory. Understory is mix of native – exotic annual forbs and grasses with BOGR2, HECO26, MUPU2

2.1 a Continuous heavy grazing, summer drought
2.2 b Fire, Rest, managed grazing, prescribed grazing, and adequate summer moisture

Shrub dominated with Juniper invasion

JUMO and PIED increases (10-20% canopy), CHRY9, GUSA2 are dominant shrubs with increases in native/ exotic annual forbs and grasses. BOGR2 is the dominant grass.

Ecological Site Interpretations

Animal Community:
This site is suitable for grazing throughout most of the year with shrubs providing forage during the period when snow covers palatable grasses. When the ground cover is removed, this site is highly subject to wind erosion. However, the site responds quickly to proper management.

The habitat diversity of this shrub-grassland is restricted due to the lack of a tree overstory and permanent waters. Some animals may tend to avoid the site when the plant cover is sparse because of the poor traction properties of dry sand. This may give predators a slight advantage. Deer, rabbits, and buteos (hawks) typify the fauna on the site. Maintaining the site in good or excellent conditions provides the greatest habitat diversity for wildlife.

Plant Preference by Animal Kind:

Hydrology Functions:

Recreational Uses:
This site may occur near the base of sandstone cliffs as rolling hills or fans or on undulating plateaus with sandstone parent material.
The winters are cold and summers are warm. Late spring, summer and fall are the most pleasant seasons for recreation activities.
Activities may include hunting, cross-country riding, photography, and wildlife observation.

Wood Products:

Other Products:

Other Information:

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative

Similar Sites:

Site Name	Site ID	Site Narrative

State Correlation:
This site has been correlated with the following states:
AZ

Inventory Data References:

Type Locality:

State:	AZ
County:	Mohave
Township:	42N
Range:	6W
Section:	31
General Legal Description:	Colorado City United Effort farm field number one. (conservation plan map)
Universal Transverse Mercator (UTM) system:	

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
Steve Barker	6/7/2002	Steve Cassady	12/5/2006

Reference Sheet

Author(s)/participant(s): Steve Cassady, Kyle Spencer, Tobiah Salvail

Contact for lead author: Steve Cassady

Date: 5/30/2008 **MLRA:** 035X **Ecological Site:** Sandy Upland 10-14" p.z. R035XC315AZ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

1. **Number and extent of rills:** None

2. **Presence of water flow patterns:** None

3. **Number and height of erosional pedestals or terracettes:** No pedestalling, but turf building of to i nch occurs on blue grama. Some mounding, 1 to 2 inches, on long-lived shrubs.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground is < or = 40 percent.

5. **Number of gullies and erosion associated with gullies:** None

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** No appreciable movement of litter.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** A thin crust or "cap" will develop on the soil surface providing some protection against erosion. This crust is easily broken.

9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** The surface of soils associated with this site are single grained; loose. Color is reddish yellow (7.5YR 6/6) dry, yellowish red (7.5YR 4/6) moist.

10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Randomly scattered plants consisting of about 70 percent grasses, 25 percent shrubs and 5 percent forbs promote infiltration and reduce runoff. The average distance to the nearest perennial plant (fetch) is 2 inches, with the majority ranging from 0 to 3 inches, but occasionally as far as 5 inches.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: Grasses (60 to 75%) >> Shrubs (25 to 40%) > Forbs (5 to 10%).
    Sub-dominant:
    Other:
    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Due to the relatively droughty nature of these soils, drought, even short term, will result in plant mortality. In "normal" precipitation years mortality will be less than 10 percent.

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14. **Average percent litter cover (35-40%) and depth (1/8-1/4 inches):**

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** Average annual production on this site is expected to be 600 to 700 lbs/ac. in a year of average annual precipitation.

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Broom snakeweed (Gutierrezia sarothrae) is natural on the site, but disturbance may cause an increase in its abundance.

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17. **Perennial plant reproductive capability:** All plants native to this site are adapted to the climate and are capable of producing seeds, stolons, and/or rhizomes except during the most severe droughts.

Reference Sheet Approval:

Approval	Date
S. Cassady	5/30/2008

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Gypsum Upland 7-11" p.z.

/ *Atriplex cordifolia* - *Atriplex canescens* / *Pleuraphis jamesii* - *Sporobolus nealleyi*
(/ - fourwing saltbush / galleta - gyp dropseed)

Site ID: R035XD405AZ

Major Land Resource Area: 035 - Colorado Plateau

Physiographic Features

This site occurs in an upland position on fan terraces, cuestas and undulating plains. It does not benefit from run-in moisture, nor suffers from excessive runoff.

Land Form: (1) Cuesta
(2) Fan
(3) Plain

	Minimum	Maximum
Elevation (feet):	3800	5300
Slope (percent):	0	15
Water Table Depth (inches):		
Flooding:		
Frequency:	Rare	Occasional
Duration:	Very brief	Brief
Ponding:		
Depth (inches):		
Frequency:	None	Occasional
Duration:	Very brief	Very brief

Runoff Class:	Low	Medium
Aspect:	No Influence on this site	

Climatic Features

Winter-Summer moisture ratios are typically 70:30 on the west side of this LRU and shift to 60:40 on the east side. Late spring is usually the driest period, and early fall moisture can be sporadic. Summer rains fall June-September; moisture originates in the Gulf of Mexico and creates convective, usually brief, intense thunderstorms. Cool season moisture October-May tends to be frontal; it originates in the Pacific and the Gulf of California and falls in widespread storms with longer duration and lower intensity. Precipitation generally comes as snow December-February. Accumulations above 10 inches are not common, but can occur. Snow usually lasts 3-4 days, but can persist much longer. Summer daytime temperatures are commonly 95-100 F and, on occasion, exceed 105F. Winter air temperatures can regularly go below 15 F and have been recorded below -15 F.

	Minimum	Maximum
Frost-free period (days):	180	220
Freeze-free period (days):	130	150
Mean annual precipitation (inches):	7.0	11.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	1.2	0.73	0.83	0.58	0.47	0.33	0.77	1.2	0.68	0.87	0.88	0.75
Precip. Max.	1.23	1.25	1.08	0.75	0.52	0.37	0.91	1.4	0.89	0.91	0.9	0.85
Temp. Min.	18.6	20.5	25.3	31.4	37.7	45.9	54.7	53.3	44.5	34.9	25.5	19.0
Temp. Max.	47.6	53.5	61.0	68.8	78.9	89.6	94.7	91.7	84.7	73.3	58.2	48.7

Climate Stations: (1) 023250, Fredonia, AZ. Period of record 1948 - 2005
(2) 026616, Pipe Springs, AZ. Period of record 1963 - 2005

Influencing Water Features

Wetland Description:	System	Subsystem	Class

Representative Soil Features

Soils characterizing this site are usually moderately deep or deep to any plant root restricting layer. Although the profiles are quite variable, gypsum is apparent somewhere in the upper two feet of the profile and acts as the common factor in determining the plant community. The gypsum may be visible in powdery or crystalline forms. The water erosion hazard is severe.
Taxonomic units include: SSA623 - Shivwits Area, MU22 Dutchman & McCullan, 24 Gyppocket, 32 Gypsiorthids, 58 Nutter & gyppocket; SSA625 - Mohave County NE part, MU10 & 19 Clayhole, 15 Gypsids, 54 Saido; SSA629 - Coconino County North Kaibab part, MU8 & 9 Clayhole.

Predominant Parent Materials:
Kind: Alluvium
Origin: Shale

Surface Texture: (1) Fine sandy loam
(2) Silty clay

Subsurface Texture Group: Loamy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):	15	35
Surface Fragments > 3" (% Cover):		
Subsurface Fragments <=3" (% Volume):	0	15
Subsurface Fragments > 3" (% Volume):		

Drainage Class: Well drained To Excessively drained
Permeability Class: Slow To Moderate

	Minimum	Maximum
Depth (inches):	40	60
Electrical Conductivity (mmhos/cm):	0	2
Sodium Absorption Ratio:	0	5
Calcium Carbonate Equivalent (percent):	5	30
Soil Reaction (1:1 Water):	7.6	9.0
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	0.0	7.0

Plant Communities

Ecological Dynamics of the Site

The plant communities found on an ecological site are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites. Other plant communities described here represent plant communities that are known to occur when the site is disturbed by factors such as grazing, fire, or drought.

Production data provided in this site description is standardized to air-dry weight at the end of the summer growing season. The plant communities described in this site description are based on near normal rainfall years.

NRCS uses a Similarity Index to compare existing plant communities to the plant communities described here. Similarity Index is determined by comparing the production and composition of a plant community to the production and composition of a plant community described in this site description. To determine Similarity Index, compare the production (air-dry weight) of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total normal year production shown in the plant community description. If rainfall has been significantly above or below normal, use the total production shown for above or below normal years. If field data is not collected at the end of the summer growing season, then the field data must be corrected to the end of the year production before comparing it to the site description. The growth curve can be used as

a guide for estimating production at the end of the summer growing season.

Historic Climax Plant Community

This site is made up of short and mid grasses and shrubs. In the original plant community there is a mixture of both cool and warm season plants. Lichens are common on some areas.

When disturbed, plant species most likely to invade this site are annuals. This site readily deteriorates to bare ground and lichens.

Historic Climax Plant Community Plant Species Composition:

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				11	39
		 Forb, annual		11	39

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				115	350
		 black grama	*Bouteloua eriopoda*	28	83
		 blue grama	*Bouteloua gracilis*	0	28
		 squirreltail	*Elymus elymoides ssp. elymoides*	28	55
		 James' galleta	*Pleuraphis jamesii*	55	138
		 gyp dropseed	*Sporobolus nealleyi*	6	55

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				40	110
		 shadscale saltbush	*Atriplex confertifolia*	20	70
		 bastardsage	*Eriogonum wrightii*	10	28
		 slender goldenweed	*Machaeranthera gracilis*	10	28

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High

1				80	135
		 Indian ricegrass	*Achnatherum hymenoides*	80	135
		 needle and thread	*Hesperostipa comata ssp. comata*	80	135
2				6	28
		 spike dropseed	*Sporobolus contractus*	6	28
		 sand dropseed	*Sporobolus cryptandrus*	6	28

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
3				11	39
		 Forb, perennial		11	39
		 globemallow	*Sphaeralcea*	11	39

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
4				55	110
		 fourwing saltbush	*Atriplex canescens*	55	110
		 jointfir	*Ephedra*	55	110

Annual Production by Plant Type:

Plant Type	Annual Production (lbs/AC) Low	Representative Value	High
Forb	28	41	55
Grass/Grasslike	330	358	385
Shrub/Vine	110	151	193
Total:	468	550	633

Plant Growth Curve:
Growth Curve Number: AZ0001
Growth Curve Name: 35.4 7-11" p.z. galleta
Growth Curve Description: Growth begins in the spring, most growth occurs during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	3	15	5	25	40	10	2	0	0

Plant Growth Curve:
Growth Curve Number: AZ0004
Growth Curve Name: 35.4 7-11" p.z. fourwing saltbush
Growth Curve Description: Some growth in spring, most growth in summer to early fall rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	10	15	30	40	5	0	0	0

Plant Growth Curve:
Growth Curve Number: AZ0005
Growth Curve Name: 35.4 7-11" p.z. Indian ricegrass
Growth Curve Description: Most growth occurs in the spring, some growth occurs in the fall.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	10	40	40	0	0	0	5	5	0	0

Plant Growth Curve:
Growth Curve Number: AZ3541
Growth Curve Name: 35.4 7-11" p.z. all sites
Growth Curve Description: Most growth occurs in the spring and during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	9	20	15	5	16	25	6	2	1	0

Plant Growth Curve:
Growth Curve Number: AZ3562
Growth Curve Name: 35.4 7-11" p.z. bottlebrush squirreltail
Growth Curve Description: Most growth occurs in the spring, plants may remain green during the winter.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	5	30	35	15	5	0	0	0	5	5	0

Plant Growth Curve:
Growth Curve Number: AZ3570
Growth Curve Name: 35.4 7-11" p.z. Nevada Mormon tea
Growth Curve Description: Growth occurs mostly in spring and early summer using stored winter moisture.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	5	25	25	20	15	10	0	0	0	0

Ecological Site Interpretations

Animal Community:
This site is difficult to restore once the plant has been altered. Infiltration is usually slow because of the resulting surface structure. Stocking rates should carefully controlled to avoid overgrazing.

The site is moderately productive for a few wildlife species. Plant diversity is poor to fair. Water is present only in widely sattered stock ponds. Cover is poor.

Plant Preference by Animal Kind:

Hydrology Functions:

Recreational Uses:
This site is located on undulating plains, mesas and fans with an open grassland and a few interspersed shrubs. Vegetation is patchy with bare ground exposed.
Winters are cold and summers are very warm. Spring and fall are usually cool, windy and dry.
Recreation is limited due to the above factors but includes cross country riding, hunting and rock collecting.

Wood Products:

Other Products:

Other Information:
Threatened and Endangered Species: Golden eagles and Prairie falcons occasionally use the site for feeding areas.

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative

Similar Sites:

Site Name	Site ID	Site Narrative

State Correlation:
This site has been correlated with the following states:
AZ

Inventory Data References:

Type Locality:

State:	AZ
County:	Mohave
Township:	40N
Range:	10W
Section:	36
General Legal Description:	About 12 miles south of Utah-Arizona state line and west of Hurricane Cliffs, Section 36, T40N, R10W; Mohave County.
Universal Transverse Mercator (UTM) system:	

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
Steve Barker	6/10/2002	Steve Cassady	3/14/2007

Site Description Revision Approval:

Author	Date	Approval	Date
Larry D. Ellicott	3/14/2007	Steve Cassady	3/14/2007

Reference Sheet

Author(s)/participant(s): Kyle Spencer, Steve Cassady

Contact for lead author: Steve Cassady

Date: 4/28/2008 **MLRA:** 035X **Ecological Site:** Gypsum Upland 7-11" p.z. R035XD405AZ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

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1. **Number and extent of rills:** None

2. **Presence of water flow patterns:** In areas of < or = 5 percent slope no water flow patterns occur. In areas of > 5 percent slope water flow patterns are common, but they show no signs of erosion and little litter movement.

3. **Number and height of erosional pedestals or terracettes:** Long lived perennial grasses and shrubs show signs of turf building. No pedestalling is seen on galleta, but some is seen on bunch grasses such as alkali sacaton.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground ranges from 65 to 70 percent.

5. **Number of gullies and erosion associated with gullies:** None

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Litter naturally accumulates under shrubs. Little movement occurs due to wind or water transport.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** The soil has a natural crust which is very resistant to wind and water erosion.

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9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Thin platy structure; slightly hard, friable, sticky and plastic. Color is yellowish red (5YR 5/6) dry; reddish brown (5YR 4/4) wet.

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10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Randomly scattered plants consisting of about 65 percent grasses, 25 percent shrubs and 10 percent forbs promote infiltration and reduce runoff. The average distance to the nearest perennial plant (fetch) is 9 inches, with the majority ranging from 2 to 14 inches, but occasionally as far as 24 inches.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** The soils associated with this ecological site have a high percentage of clay and silt making the soil “hard”, but this is natural and is not a compaction layer.

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: Grasses (60 to 70%) >> Shrubs (20 to 35%) > Forbs (5 to 10%)
    Sub-dominant:
    Other:
    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Shadscale (Atriplex confertifolia) will naturally die back (dead branches as well as dead plants) during periods of drought. Galleta (Pleuraphis jamesii) will also show a substantial number of dead plants. During “normal” precipitation years the overall number of dead plants on the site should not be more than 10 percent.

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14. **Average percent litter cover (20-25%) and depth (1/8-1/4 inches):**

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** Average annual production is expected to be 500 to 600 lbs/ac. in a year of average precipitation.

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Blue mustard (Chorispora tenella), Russian thistle (Salsola kali), and cheatgrass (Bromus tectorum) are commonly found in small amounts on the site (< 2 percent). During years of above average winter

and spring moisture the composition of these may increase slightly. Severe disturbance may cause an increase in one or all of these plants creating a potential for a shortened fire frequency on the site which could result in crossing a threshold to a state with increased introduced annual plants and fewer native shrubs.

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17. **Perennial plant reproductive capability:** All plants native to this site are adapted to the climate and are capable of producing seeds, stolons, and/or rhizomes except during the most severe drought

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Reference Sheet Approval:

Approval	Date
S. Cassady	4/28/2008

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Sandy Loam Upland 7-11" p.z. Calcareous

/ *Atriplex canescens* - *Krascheninnikovia lanata* / *Pleuraphis jamesii* - *Sporobolus cryptandrus*
(/ fourwing saltbush - winterfat / galleta - sand dropseed)

Site ID: R035XD413AZ

Major Land Resource Area: 035 - Colorado Plateau

Physiographic Features

This site occurs in an upland position on ridges, plateaus and mesas. It does not benefit greatly from run-in moisture. Wind erosion is a moderate hazard especially when the vegetative cover is removed.

Land Form:	(1)	Ridge
	(2)	Mesa
	(3)	Structural bench

	Minimum	Maximum
Elevation (feet):	4500	5100
Slope (percent):	0	5
Water Table Depth (inches):		
Flooding:		
Frequency:	None	Occasional
Duration:	None	None
Ponding:		
Depth (inches):		
Frequency:	None	Rare
Duration:	None	None

Runoff Class:	Low	Medium
Aspect:	No Influence on this site	

Climatic Features

Winter-Summer moisture ratios are typically 70:30 on the west side of this LRU and shift to 60:40 on the east side. Late spring is usually the driest period, and early fall moisture can be sporadic. Summer rains fall June-September; moisture originates in the Gulf of Mexico and creates convective, usually brief, intense thunderstorms. Cool season moisture October-May tends to be frontal; it originates in the Pacific and the Gulf of California and falls in widespread storms with longer duration and lower intensity. Precipitation generally comes as snow December-February. Accumulations above 10 inches are not common, but can occur. Snow usually lasts 3-4 days, but can persist much longer. Summer daytime temperatures are commonly 95-100 F and, on occasion, exceed 105F. Winter air temperatures can regularly go below 15 F and have been recorded below -15 F.

	Minimum	Maximum
Frost-free period (days):	180	220
Freeze-free period (days):	130	150
Mean annual precipitation (inches):	7.0	11.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	1.2	0.73	0.83	0.58	0.47	0.33	0.77	1.2	0.68	0.87	0.88	0.75
Precip. Max.	1.23	1.25	1.08	0.75	0.52	0.37	0.91	1.4	0.89	0.91	0.9	0.85
Temp. Min.	18.6	20.5	25.3	31.4	37.7	45.9	54.7	53.3	44.5	34.9	25.5	19.0
Temp. Max.	47.6	53.5	61.0	68.8	78.9	89.6	94.7	91.7	84.7	73.3	58.2	48.7

Climate Stations: (1) 023250, Fredonia, AZ. Period of record 1948 - 2005
(2) 026616, Pipe Springs, AZ. Period of record 1963 - 2005

Influencing Water Features

Wetland Description:	System	Subsystem	Class

Representative Soil Features

Soils characterizing this site are very deep and well drained. They were formed in eolian sediments on ridges, fan terraces, plateaus and mesas. The sand content is greater than 35 percent. These soils may occur over calcareous sandstone or above gypsum accumulations at depths greater than 15 inches. The soil is calcareous at the surface. Typical taxonomic units include: SSA625 - MU 8 Brinkerhoff & Grieta, MU 42 Monue.

Predominant Parent Materials:
Kind: Alluvium
Origin: Sandstone and shale

Surface Texture: (1) Sandy loam
(2) Fine sandy loam
(3) Loamy fine sand

Subsurface Texture Group: Loamy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):	0	5
Surface Fragments > 3" (% Cover):		
Subsurface Fragments <=3" (% Volume):	5	30
Subsurface Fragments > 3" (% Volume):		

Drainage Class: Well drained To Somewhat excessively drained
Permeability Class: Moderate To Moderately rapid

	Minimum	Maximum
Depth (inches):	40	60
Electrical Conductivity (mmhos/cm):	0	2
Sodium Absorption Ratio:	0	5
Calcium Carbonate Equivalent (percent):	1	35
Soil Reaction (1:1 Water):	7.9	9.0
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	2.5	10.0

Plant Communities

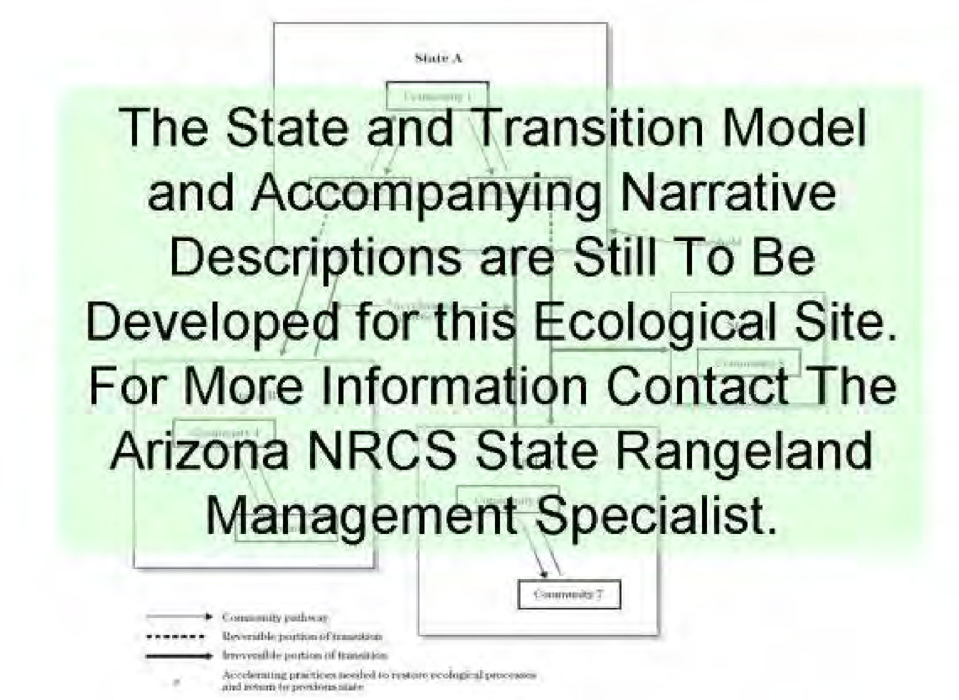
Ecological Dynamics of the Site

The plant communities found on an ecological site are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites. Other plant communities described here represent plant communities that are known to occur when the site is disturbed by factors such as grazing, fire, or drought.

Production data provided in this site description is standardized to air-dry weight at the end of the summer growing season. The plant communities described in this site description are based on near normal rainfall years.

NRCS uses a Similarity Index to compare existing plant communities to the plant communities described here. Similarity Index is determined by comparing the production and composition of a plant community to the production and composition of a plant community described in this site description. To determine Similarity Index, compare the production (air-dry weight) of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total normal year production shown in the plant community description. If rainfall has been significantly above or below normal, use the total production shown for above or below normal years. If field data is not collected at the end of the summer growing season, then the field data must be corrected to the end of the year production before comparing it to the site description. The growth curve can be used as

a guide for estimating production at the end of the summer growing season.



Historic Climax Plant Community

This site has a plant community made up primarily of mid and short grasses with a relatively small percentage of forbs and shrubs. The dominant aspect is desert grassland with scattered shrubs. In the original plant community there is a mix of cool season and warm season grasses with shrubs and half shrubs.

Plant species most likely to invade or increase on this site when it deteriorates are broom snakeweed and annuals.

Historic Climax Plant Community Plant Species Composition:

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				5	14
		 Forb, perennial		5	14
		 milkvetch	*Astragalus*	0	5
		 mariposa lily	*Calochortus*	0	5
		 larkspur	*Delphinium*	0	5
		 pepperweed	*Lepidium*	0	5
		 phlox	*Phlox*	0	5
		 ragwort	*Senecio*	0	5
		 globemallow	*Sphaeralcea*	0	5
		 vetch	*Vicia*	0	5

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				270	383
		 Grass, annual		23	45
		 Indian ricegrass	*Achnatherum hymenoides*	23	48
		 threeawn	*Aristida*	5	23
		 blue grama	*Bouteloua gracilis*	14	23
		 squirreltail	*Elymus elymoides ssp. elymoides*	0	5
		 needle and thread	*Hesperostipa comata ssp. comata*	23	45
		 James' galleta	*Pleuraphis jamesii*	90	135
		 sand dropseed	*Sporobolus cryptandrus*	23	68

		 sixweeks fescue	Vulpia octoflora	0	23

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				65	150
		 fourwing saltbush	Atriplex canescens	23	45
		 Greene's rabbitbrush	Chrysothamnus greenei	5	9
		 yellow rabbitbrush	Chrysothamnus viscidiflorus	4	8
		 jointfir	Ephedra	0	9
		 rubber rabbitbrush	Ericameria nauseosa ssp. nauseosa var. glabrata	5	9
		 broom snakeweed	Gutierrezia sarothrae	23	45
		 winterfat	Krascheninnikovia lanata	14	23

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				5	14
		 Forb, annual		5	14
		 aster	Aster	0	5
		 mustard	Brassica	0	5
		 lambsquarters	Chenopodium album	0	5
		 crossflower	Chorispora tenella	0	5
		 flatcrown buckwheat	Eriogonum deflexum	0	5
		 fleabane	Erigeron	0	5
		 stork's bill	Erodium	0	5
		 spurge	Euphorbia	0	5
		 sunflower	Helianthus	0	5
		 lupine	Lupinus	0	5
		 blazingstar	Mentzelia	0	5
		 popcornflower	Plagiobothrys	0	5
		 plantain	Plantago	0	5

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
2				5	9
		 Shrub (>.5m)		5	9
		 Bigelow sage	Artemisia bigelovii	0	5
		 sand sagebrush	Artemisia filifolia	0	5
		 pale desert-thorn	Lycium pallidum	0	5
		 plains pricklypear	Opuntia polyacantha	1	5
			Opuntia whipplei (Syn)	1	5
		 banana yucca	Yucca baccata	1	5

Annual Production by Plant Type:

Plant Type	Annual Production (lbs/AC) Low	Representative Value	High
Forb	9	16	23
Grass/Grasslike	270	326	383
Shrub/Vine	68	113	158

Total:	347	455	564

Structure and Cover:

Ground Cover (%)

Vegetative Cover						Non-Vegetative Cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments > 1/4 & <= 3"	Surface Fragments > 3"	Bedrock	Water	Bare Ground
10 to 20	0 to 1	1 to 5									

Structure of Canopy Cover (%)

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
<=0.5 feet		0 to 1		
> 0.5 - < 1 feet				
< 1 - >= 2 feet	10 to 20		1 to 5	

Plant Growth Curve:
Growth Curve Number: AZ0001
Growth Curve Name: 35.4 7-11" p.z. galleta
Growth Curve Description: Growth begins in the spring, most growth occurs during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	3	15	5	25	40	10	2	0	0

Plant Growth Curve:
Growth Curve Number: AZ0002
Growth Curve Name: 35.4 7-11" p.z. sand dropseed
Growth Curve Description: Some growth in spring, most growth in summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	5	5	25	50	15	0	0	0

Plant Growth Curve:
Growth Curve Number: AZ0004
Growth Curve Name: 35.4 7-11" p.z. fourwing saltbush
Growth Curve Description: Some growth in spring, most growth in summer to early fall rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	10	15	30	40	5	0	0	0

Plant Growth Curve:
Growth Curve Number: AZ0005
Growth Curve Name: 35.4 7-11" p.z. Indian ricegrass

Growth Curve Description: Most growth occurs in the spring, some growth occurs in the fall.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	10	40	40	0	0	0	5	5	0	0

Plant Growth Curve:
Growth Curve Number: AZ3541
Growth Curve Name: 35.4 7-11" p.z. all sites
Growth Curve Description: Most growth occurs in the spring and during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	9	20	15	5	16	25	6	2	1	0

Plant Growth Curve:
Growth Curve Number: AZ3542
Growth Curve Name: 35.4 7-11" p.z. Needle and thread
Growth Curve Description: Growth occurs mostly in the spring.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	15	60	20	5	0	0	0	0	0	0

Ecological Site Interpretations

Animal Community:
This site responds relatively quickly to good management. It adapts well to grazing systems which provide for an occasional rest. Proper stocking rates are important. This site is very susceptible to erosion, particularly overgrazed areas, old roads, cattle trails, and concentration areas.

This site provides a good ground cover and fair diversity for wildlife species. It lacks open permanent waters.

Species seen here include; pronghorns, black-tailed jackrabbits, coyotes, badgers, kangaroo rats, deer mice, and a variety of snakes and lizards.

Plant Preference by Animal Kind:

Hydrology Functions:

Recreational Uses:
This site occurs on rolling hills or alluvial fans with grasslands interspersed with shrubs.

Winters are cold and summers are quite warm. Spring and fall are the dry seasons and are typically cool and windy.

Recreational activities most likely to occur are hunting, cross-country riding, photography and wildlife observation.

Wood Products:

Other Products:

Other Information:
Threatened and Endangered Species: Golden eagles and Prairie falcons occasionally use the site for feeding areas.

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative

Similar Sites:

Site Name	Site ID	Site Narrative

State Correlation:
This site has been correlated with the following states:
AZ

Inventory Data References:

Type Locality:

State:	AZ
County:	Mohave
Township:	40N
Range:	5W
Section:	22
General Legal Description:	Pipe Valley Quad; about four miles west of Pipe Springs, AZ; Section 22, T40N, R5W, Mohave County.
Universal Transverse Mercator (UTM) system:	

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
Steve Barker	6/10/2002	Steve Cassady	3/21/2007

Site Description Revision Approval:

Author	Date	Approval	Date
Larry D. Ellicott	3/21/2007	Steve Cassady	3/21/2007

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Sandy Upland 7-11" p.z.

/ *Artemisia filifolia* / *Achnatherum hymenoides* - *Hesperostipa comata*
(/ sand sagebrush / Indian ricegrass - needle and thread)

Site ID: R035XD412AZ

Major Land Resource Area: 035 - Colorado Plateau

Physiographic Features

This site occurs in an upland position, not benefiting from excess run-in moisture. I usually occurs at the foot of sandstone plateaus and mesas as rolling hills, dunes, or plains. It may also occur in bottom positions as alluvial fans or entrenched bottoms. May occur on structural benches and terraces.

Land Form:	(1)	Alluvial fan
	(2)	Plain
	(3)	Dune

	Minimum	Maximum
Elevation (feet):	3800	5300
Slope (percent):	0	15
Water Table Depth (inches):		
Flooding:		
Frequency:	None	Rare
Duration:	None	None
Ponding:		
Depth (inches):		
Frequency:	None	Rare
Duration:	None	None

Runoff Class:	Very low	Low
Aspect:	No Influence on this site	

Climatic Features

Winter-Summer moisture ratios are typically 70:30 on the west side of this LRU and shift to 60:40 on the east side. Late spring is usually the driest period, and early fall moisture can be sporadic. Summer rains fall June-September; moisture originates in the Gulf of Mexico and creates convective, usually brief, intense thunderstorms. Cool season moisture October-May tends to be frontal; it originates in the Pacific and the Gulf of California and falls in widespread storms with longer duration and lower intensity. Precipitation generally comes as snow December-February. Accumulations above 10 inches are not common, but can occur. Snow usually lasts 3-4 days, but can persist much longer. Summer daytime temperatures are commonly 95-100 F and, on occasion, exceed 105F. Winter air temperatures can regularly go below 15 F and have been recorded below -15 F.

	Minimum	Maximum
Frost-free period (days):	180	220
Freeze-free period (days):	130	150
Mean annual precipitation (inches):	7.0	11.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	1.2	0.73	0.83	0.58	0.47	0.33	0.77	1.2	0.68	0.87	0.88	0.75
Precip. Max.	1.23	1.25	1.08	0.75	0.52	0.37	0.91	1.4	0.89	0.91	0.9	0.85
Temp. Min.	18.6	20.5	25.3	31.4	37.7	45.9	54.7	53.3	44.5	34.9	25.5	19.0
Temp. Max.	47.6	53.5	61.0	68.8	78.9	89.6	94.7	91.7	84.7	73.3	58.2	48.7

Climate Stations: (1) 023250, Fredonia, AZ. Period of record 1948 - 2005
(2) 026616, Pipe Springs, AZ. Period of record 1963 - 2005

Influencing Water Features

Wetland Description:	System	Subsystem	Class

Representative Soil Features

The soils characterizing this site are moderately deep to deep to any plant root restricting layer. They are excessively drained. The surface soil is sand or loamy sand and the subsurface ranges from sand to sandy clay loam. Soluble salt accumulations are low. Cobble, gravel, or stones are generally less than 15 percent of the total soil volume. The soils are very susceptible to wind erosion especially when the vegetative cover is disturbed. Some Taxonomic units are: SSA625 - MU55 & 56 Sheppard, SSA629 - MU 1 Aneth.

Predominant Parent Materials:
Kind: Eolian sands
Origin: Sandstone

Surface Texture: (1) Sand
(2) Loamy fine sand
(3) Fine sand

Subsurface Texture Group: Sandy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):		
Surface Fragments > 3" (% Cover):		
Subsurface Fragments <=3" (% Volume):		
Subsurface Fragments > 3" (% Volume):		

Drainage Class: Somewhat excessively drained To Excessively drained
Permeability Class: Moderately rapid To Rapid

	Minimum	Maximum
Depth (inches):	20	60
Electrical Conductivity (mmhos/cm):		
Sodium Absorption Ratio:		
Calcium Carbonate Equivalent (percent):	0	10
Soil Reaction (1:1 Water):	7.4	8.4
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	0.0	2.5

Plant Communities

Ecological Dynamics of the Site

The plant communities found on an ecological site are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites. Other plant communities described here represent plant communities that are known to occur when the site is disturbed by factors such as grazing, fire, or drought.

Production data provided in this site description is standardized to air-dry weight at the end of the summer growing season. The plant communities described in this site description are based on near normal rainfall years.

NRCS uses a Similarity Index to compare existing plant communities to the plant communities described here. Similarity Index is determined by comparing the production and composition of a plant community to the production and composition of a plant community described in this site description. To determine Similarity Index, compare the production (air-dry weight) of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total normal year production shown in the plant community description. If rainfall has been significantly above or below normal, use the total production shown for above or below normal years. If field data is not collected at the end of the summer growing season, then the field data must be corrected to the end of the year production before comparing it to the site description. The growth curve can be used as

a guide for estimating production at the end of the summer growing season.

<u>Historic Climax Plant Community</u>

This site has a plant community made up primarily of mid and short grasses with smaller percentages of forbs and shrubs. In the potential plant community there is a mixture of both cool and warm season species.

Plants most likely to increase on this iste are shand sagebrush, snakeweed, goldenweed, sandhill muhly, rabbitbrush, and annuals. Invader species include russian thistle and cheatgrass.

Historic Climax Plant Community Plant Species Composition:

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				40	75
		 Forb, annual		8	20
		 Forb, perennial		10	20
		 desert trumpet	*Eriogonum inflatum*	5	15
		 globemallow	*Sphaeralcea*	10	20

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				70	150
		 squirreltail	*Elymus elymoides ssp. elymoides*	40	75
		 James' galleta	*Pleuraphis jamesii*	40	75

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
0				80	160
		 sand sagebrush	*Artemisia filifolia*	8	75
		 fourwing saltbush	*Atriplex canescens*	40	90
		 jointfir	*Ephedra*	35	80

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				225	340
		 Indian ricegrass	*Achnatherum hymenoides*	75	95
		 desert needlegrass	*Achnatherum speciosum*	60	90
		 thickspike wheatgrass	*Elymus lanceolatus*	55	85
		 needle and thread	*Hesperostipa comata ssp. comata*	65	90
2				40	75
		 sandhill muhly	*Muhlenbergia pungens*	10	20
		 spike dropseed	*Sporobolus contractus*	8	20
		 sand dropseed	*Sporobolus cryptandrus*	10	20
		 mesa dropseed	*Sporobolus flexuosus*	8	20
4				75	150
		 black grama	*Bouteloua eriopoda*	40	75
		 blue grama	*Bouteloua gracilis*	35	75

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
4				8	75
		 rabbitbrush	*Chrysothamnus*	5	25
		 broom snakeweed	*Gutierrezia sarothrae*	5	25
		 slender goldenweed	*Machaeranthera gracilis*	3	25

Annual Production by Plant Type:

Annual Production (lbs/AC)

Plant Type	Low	Representative Value	High
Forb	38	56	75
Grass/Grasslike	488	525	563
Shrub/Vine	150	188	225
Total:	676	769	863

Plant Growth Curve:
Growth Curve Number: AZ0001
Growth Curve Name: 35.4 7-11" p.z. galleta
Growth Curve Description: Growth begins in the spring, most growth occurs during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	3	15	5	25	40	10	2	0	0

Plant Growth Curve:
Growth Curve Number: AZ0004
Growth Curve Name: 35.4 7-11" p.z. fourwing saltbush
Growth Curve Description: Some growth in spring, most growth in summer to early fall rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	10	15	30	40	5	0	0	0

Plant Growth Curve:
Growth Curve Number: AZ0005
Growth Curve Name: 35.4 7-11" p.z. Indian ricegrass
Growth Curve Description: Most growth occurs in the spring, some growth occurs in the fall.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	10	40	40	0	0	0	5	5	0	0

Plant Growth Curve:
Growth Curve Number: AZ3541
Growth Curve Name: 35.4 7-11" p.z. all sites
Growth Curve Description: Most growth occurs in the spring and during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	9	20	15	5	16	25	6	2	1	0

Plant Growth Curve:
Growth Curve Number: AZ3542
Growth Curve Name: 35.4 7-11" p.z. Needle and thread
Growth Curve Description: Growth occurs mostly in the spring.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	15	60	20	5	0	0	0	0	0	0

Plant Growth Curve:
Growth Curve Number: AZ3562
Growth Curve Name: 35.4 7-11" p.z. bottlebrush squirreltail
Growth Curve Description: Most growth occurs in the spring, plants may remain green during the winter.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	5	30	35	15	5	0	0	0	5	5	0

Ecological Site Interpretations

Animal Community:
Ground cover should be maintained or impoved wherever possible to avoid blowing sand. This site is suitable for year-round grazing by all classes of livestock. Livestock watering facilities are lacking on large bodies of this site.

Ground cover is fair to good for wildlife. Plant diversity is fair. These areas lack permanent open waters. Some species of wildlife present are mule deer, pronghorn, and cottontail rabbits.

Plant Preference by Animal Kind:

Hydrology Functions:

Recreational Uses:
This site occurs as rolling hills and plains, usually dunelike. It is a grassland with a fair amount of shrubs.

Winters are cold and summers are quite warm. These are also the wet seasons. Spring and fall are usually dry, cool and windy.

Activities include hunting, cross-country riding, photography and wildlife observation.

Wood Products:

Other Products:
The sand is used for domestic activities by local people.

Other Information:
Threatened and Endangered Species: Golden eagles and Prairie falcons occasionally use the site for feeding areas.

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative

Similar Sites:

Site Name	Site ID	Site Narrative

State Correlation:
This site has been correlated with the following states:
AZ

Inventory Data References:

Type Locality:

State:	AZ
County:	Mohave
Township:	40N
Range:	3W
Section:	11
General Legal Description:	About 12 miles east-southeast of Moccasin AZ; Section 11, T40N, R3W.
Universal Transverse Mercator (UTM) system:	

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
Steve Barker	6/10/2002	Steve Cassady	3/21/2007

Site Description Revision Approval:

Author	Date	Approval	Date
Larry D. Ellicott	3/21/2007	Steve Cassady	3/21/2007

Reference Sheet

Author(s)/participant(s): Steve Cassady, Kyle Spencer

Contact for lead author: Steve Cassady

Date: 5/1/2008 **MLRA:** 035X **Ecological Site:** Sandy Upland 7-11" p.z. R035XD412AZ
This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

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1. **Number and extent of rills:** None

2. **Presence of water flow patterns:** None

3. **Number and height of erosional pedestals or terracettes:** No pedestalling, but turf building (1-2 inches) by long-lived grasses is common.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground is < 45%.

5. **Number of gullies and erosion associated with gullies:** None

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** No appreciable movement of litter

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soils associated with this site develop a thin cap that is resistant to erosion.

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9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** The surface 0 to 2 inches of soils associated with this site are single grained; loose. Color is yellowish red (5YR 5/6) dry, yellowish red (5YR 4/6) moist.

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10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Randomly scattered plants consisting of about 70 percent grasses, 25 percent shrubs and 15 percent forbs promote infiltration and reduce runoff. The average distance to the nearest perennial plant (fetch) is 4 inches, with the majority ranging from 2 to 6 inches, but occasionally as far as 14 inches.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: Grasses (65 to 75%) >> Shrubs (20 to 30%) > Forbs (5 to 10%).
    Sub-dominant:
    Other:
    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Due to the droughty nature of the soils associated with this site plant mortality is common, but should never be more than 10 percent except in severe drought conditions.

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14. **Average percent litter cover (45-50%) and depth (1/8-1/4 inches):**

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** Average annual production on this site is expected to be 700 to 800 lbs/ac. in a year of average annual precipitation

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Cheatgrass (Bromus tectorum) and Russian thistle (Salsola kali) are commonly found in small amounts on the site (< 2 percent). During years of above average winter and spring moisture the composition of these may increase slightly.

17. **Perennial plant reproductive capability:** All plants native to this site are adapted to the climate and are capable of producing seeds, stolons, and/or rhizomes except during the most severe droughts.

Reference Sheet Approval:

Approval	Date
S. Cassady	5/1/2008

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

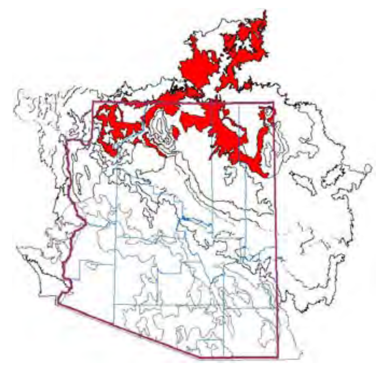
ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Sedimentary Cliffs 10-14" p.z.

/ *Artemisia tridentata ssp. wyomingensis* - *Atriplex canescens* / *Hesperostipa comata* - *Poa fendleriana*
(/ Wyoming big sagebrush - fourwing saltbush / needle and thread - muttongrass)



Site ID: R035XC302AZ

Major Land Resource Area: 035 - Colorado Plateau

Physiographic Features

This ecological site occurs as steep canyon walls, small plateaus and breaks. It typically suffers from excessive drainage. Slopes are over 30 percent. Elevations range from 4,800 feet to 5,800 feet.

Land Form: (1) Canyon
(2) Escarpment

	Minimum	Maximum
Elevation (feet):	4800	5800
Slope (percent):	30	70
Water Table Depth (inches):		
Flooding:		
Frequency:	None	None
Duration:	None	None
Ponding:		
Depth (inches):		
Frequency:	None	None
Duration:	None	None
Runoff Class:	High	Very high

Aspect: No Influence on this site

Climatic Features

Winter summer moisture ratios range from 70:30 to 60:40. Late spring is usually the driest period, and early fall moisture can be sporadic. Summer rains fall from June through September; moisture originates in the Gulf of Mexico and creates convective, usually brief, intense thunderstorms. Cool season moisture from October through May tends to be frontal; it originates in the Pacific and the Gulf of California and falls in widespread storms with longer duration and lower intensity. Precipitation generally comes as snow from December through February. Accumulations above 12 inches are not common but can occur. Snow usually lasts for 3-4 days, but can persist much longer. Summer daytime temperatures are commonly 95 - 100 F and on occasion exceed 105 F. Winter air temperatures can regularly go below 10 F and have been recorded below - 20 F.

	Minimum	Maximum
Frost-free period (days):	137	168
Freeze-free period (days):	164	193
Mean annual precipitation (inches):	10.0	14.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.68	0.69	0.84	0.66	0.47	0.32	1.21	1.6	1.06	1.02	0.8	0.85
Precip. Max.	1.44	1.62	1.58	0.97	0.63	0.41	1.38	1.66	1.27	1.16	1.2	0.98
Temp. Min.	14.5	19.1	23.9	29.7	37.7	45.9	54.6	53.6	45.9	34.8	23.3	15.6
Temp. Max.	47.7	52.3	58.6	66.4	76.8	87.4	92.7	90.2	82.7	71.7	57.6	48.8

Climate Stations: (1) 21920, Colorado City, AZ. Period of record 1963 - 2005
(2) 23303, Ganado, AZ. Period of record 1963 - 2005

Influencing Water Features

Wetland Description:	System	Subsystem	Class

Representative Soil Features

The soils of this ecological site are generally very shallow to shallow. The complex geologic strata associated with the site has created a multitude of soil textures, depths, and developments. The soils range from coarse to fine loams. Parent material is typically limestone or sandstone with prominent calcium carbonate influence. Permeability is moderate to rapid, and the avaiable water capacity is very low. The erosion hazard is moderate to severe, depending on slope, soil texture, and the plant cover.

Predominant Parent Materials:
Kind: Alluvium
Origin: Limestone and sandstone

Surface Texture: (1) Gravelly Sand
(2) Cobbly Loam
(3) Sandy clay loam

Subsurface Texture Group: Loamy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):		
Surface Fragments > 3" (% Cover):		
Subsurface Fragments <=3" (% Volume):	45	65
Subsurface Fragments > 3" (% Volume):	0	10

Drainage Class: Well drained To Well drained
Permeability Class: Moderate To Moderate

	Minimum	Maximum
Depth (inches):	6	10
Electrical Conductivity (mmhos/cm):	0	2
Sodium Absorption Ratio:	0	0
Calcium Carbonate Equivalent (percent):	5	35
Soil Reaction (1:1 Water):	7.9	8.4
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	0.7	0.9

Plant Communities

Ecological Dynamics of the Site

The historic climax plant community (HCPC) for a site in North America is the plant community that existed at the time of European immigration and settlement. It is the plant community that was best adapted to the unique combination of environmental factors associated with the site. The historic climax plant community was in dynamic equilibrium with its environment. It is the plant community that was able to avoid displacement by the suite of disturbances and disturbance patterns (magnitude and frequency) that naturally occurred within the area occupied by the site. Natural disturbances, such as drought, fire, grazing of native fauna, and insects, were inherent in the development and maintenance of these plant communities. The effects of these disturbances are part of the range of characteristics of the site that contribute to that dynamic equilibrium. Fluctuations in plant community structure and function caused by the effects of these natural disturbances establish the boundaries of dynamic equilibrium. They are accounted for as part of the range of characteristics for an ecological site. Some sites may have a small range of variation, while others have a large range.

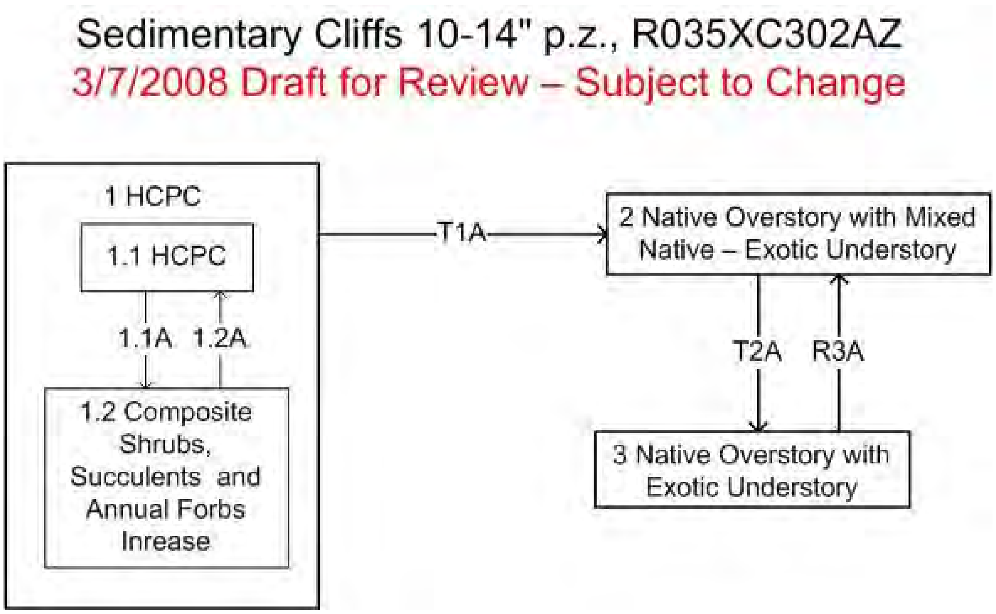
The historic climax plant community of an ecological site is not a precise assemblage of species for which the proportions are the same from place to place or from year to year. In all plant communities, variability is apparent in productivity and occurrence of individual species. Spatial boundaries of the communities; however, can be recognized by characteristic patterns of species composition, association, and community structure. The HCPC for this ecological site has been estimated by sampling relict or relatively undisturbed sites and/or reviewing historic records.

Plant communities that are subjected to abnormal disturbances and physical site deterioration or that are protected from natural influences, such as fire and grazing, for long periods seldom typify the historic climax plant community. The physical site deterioration caused by the abnormal disturbance results in the crossing of a threshold or irreversible boundary to another state, or equilibrium, for the ecological site. There may be multiple thresholds and states possible for an ecological site, determined by the type and or severity of abnormal disturbance. The known states and transition pathways for this ecological site are described below and in the accompanying state and transition model.

1 Historic Climax Plant Community (HCPC)
1.1 HCPC – The plant community is composed of relatively equal amounts of shrubs, grasses, and forbs. It can be variable due to site conditions.
1.1A – Fire is the primary factor in this pathway but extreme herbivory may push this pathway as well. Due to slope, this site is not usually heavily grazed.
1.2 Composite Shrub, Succulents, and Annual Forbs – Composite shrubs such as broom snakeweed, and succulents such as prickly pear increase over shadscale saltbush and other palatable shrubs. Perennial bunchgrasses decrease in relation to annual grasses and forbs.
1.2A – Proper grazing practices and/or rest, especially after a fire.
T1A – Exotic grass species such as cheatgrass and red brome are introduced into the site.
2 Native Overstory with Mixed Native – Exotic Understory – Exotic annual grasses are present in the plant community but the amount and composition of native perennial grasses remains unchanged.
T2A – Extreme herbivory favors exotic annual grasses and forbs over native grasses and forbs. Fire is unlikely on this site but if it occurs, it could drive this pathway as well.
3 Native Overstory with Exotic Understory Exotic annual grasses dominate the understory within the plant community.
R3A – Proper grazing practices combined with relevant herbicide treatments and reseeding. Usually not feasible for larger areas.

The Plant Community Plant Species Composition table provides a list of species and each specie's or group of species' annual production in pounds per acre (air-dry weight) expected in a normal rainfall year. Low and high production yields represent the modal range of variability for that species or group of species across the extent of the ecological site.

The Annual Production by Plant Type table provides the median air-dry production and the fluctuations to be expected during favorable, normal, and unfavorable years. The present plant community on an ecological site can be compared to the various common vegetation states that can exist on the site. The degree of similarity is expressed through a similarity index. To determine the similarity index, compare the production of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total representative value shown in the Annual Production by Plant Type table for the reference plant community. Variations in production due to above or below normal rainfall, incomplete growing season or utilization must be corrected before comparing it to the site description. The Worksheet for Determining Similarity Index is useful in making these corrections. The accompanying growth curve can be used as a guide for estimating percent of growth completed.



Historic Climax Plant Community

This site is a complex of trees, shrubs, forbs, and grasses. In the original plant community there is a mixture of cool and warm season plants.

Plants most likely to increase or invade when the site deteriorates are big sagebrush, snakeweed, juniper and cacti.

Historic Climax Plant Community Plant Species Composition:

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				40	120
		 muttongrass	*Poa fendleriana*	40	120
		 muttongrass	*Poa fendleriana ssp. longiligula*	40	120
2				40	120
		 desert needlegrass	*Achnatherum speciosum*	40	120
		 needle and thread	*Hesperostipa comata ssp. comata*	40	120
3				40	80
		 Indian ricegrass	*Achnatherum hymenoides*	40	80
4				0	40
		 squirreltail	*Elymus elymoides ssp. elymoides*	0	40
5				0	40
		 black grama	*Bouteloua eriopoda*	0	40
6				40	80
		 blue grama	*Bouteloua gracilis*	40	80

Group	Group Name	Common Name	Scientific Name	Low	High
7				0	40
		 sideoats grama	Bouteloua curtipendula	0	40
8				16	40
		 spike dropseed	Sporobolus contractus	16	40
		 sand dropseed	Sporobolus cryptandrus	16	40
		 mesa dropseed	Sporobolus flexuosus	16	40
9				8	40
		 James' galleta	Pleuraphis jamesii	8	40
10				0	16
		 sandhill muhly	Muhlenbergia pungens	0	16
11				0	40
		 threeawn	Aristida	0	40
		 ring muhly	Muhlenbergia torreyi	0	40
12				0	40
		 bush muhly	Muhlenbergia porteri	0	40

Forb

Annual Production in Pounds Per Acre

Group	Group Name	Common Name	Scientific Name	Low	High
13				40	160
		 Forb, annual		10	40
		 Forb, perennial		10	40
		 prairie sagewort	Artemisia frigida	10	40
		 buckwheat	Eriogonum	10	40
		 globemallow	Sphaeralcea	10	40

Shrub/Vine

Annual Production in Pounds Per Acre

Group	Group Name	Common Name	Scientific Name	Low	High
14				40	80
		 Wyoming big sagebrush	Artemisia tridentata ssp. wyomingensis	40	80
15				8	80
		 fourwing saltbush	Atriplex canescens	8	80
16				8	80
		 jointfir	Ephedra	8	80
17				0	40
		 Gambel oak	Quercus gambelii	0	40
18				0	40
		 creeping barberry	Mahonia repens	0	40
19				8	40
		 Mexican cliffrose	Purshia mexicana	8	40

20				0	24
		 bitterbrush	*Purshia*	0	24
21				0	40
		 skunkbush sumac	*Rhus trilobata*	0	40
22				0	40
		 Sonoran scrub oak	*Quercus turbinella*	0	40
23				0	16
		 manzanita	*Arctostaphylos*	0	16
24				0	16
		 sand sagebrush	*Artemisia filifolia*	0	16
25				0	24
		 brickellbush	*Brickellia*	0	24
26				0	24
		 bastardsage	*Eriogonum wrightii*	0	24
27				0	8
		 roundleaf buffaloberry	*Shepherdia rotundifolia*	0	8
28				0	40
		 rabbitbrush	*Chrysothamnus*	0	40
29				8	40
		 snakeweed	*Gutierrezia*	8	40
30				16	40
		 agave	*Agave*	16	40
		 hedgehog cactus	*Echinocereus*	16	40
		 globe cactus	*Mammillaria*	16	40
		 pricklypear	*Opuntia*	16	40
		 yucca	*Yucca*	16	40
31				0	40
		 serviceberry	*Amelanchier*	0	40

Tree

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
32				80	160
		 juniper	*Juniperus*	80	160
		 twoneedle pinyon	*Pinus edulis*	80	160

Annual Production by Plant Type:

Plant Type	Annual Production (lbs/AC) Low	Representative Value	High
Forb	40		160

Grass/Grasslike	200		400
Shrub/Vine	280		360
Tree	80		160
Total:	600	0	1080

Plant Growth Curve:
Growth Curve Number: AZ3511
Growth Curve Name: 35.1 10-14" p.z. all sites
Growth Curve Description: Growth begins in the spring and continues through the summer, most growth occurs during the summer rainy season.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	1	5	11	18	25	24	13	3	0	0

Plant Growth Curve:
Growth Curve Number: AZ3531
Growth Curve Name: 35.3 10-14" p.z. all sites
Growth Curve Description: Growth begins in the spring and continues through the summer.

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	3	17	18	10	19	20	10	1	1	0

Ecological Site Interpretations

Animal Community:
This site is typically quite steep which severely restricts use by livestock. Proper distribution is often impossible to attain, and heavy use occurs in the limited access areas frequented by livestock.

This site provides a great deal of habitat diversity because of the topography, exposures, plant community variation, and rockiness. Permanent waters are lacking however. It is very important cover for many wildlife species.

Plant Preference by Animal Kind:

Animal Kind: Mule Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E
sideoats grama	*Bouteloua curtipendula*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E
black grama	*Bouteloua eriopoda*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E
blue grama	*Bouteloua gracilis*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E
squirreltail	*Elymus elymoides ssp. elymoides*	Leaves	U	U	U	U	U	U	U	U	U	U	U	U
buckwheat	*Eriogonum*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa comata ssp. comata*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E
juniper	*Juniperus*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
western wheatgrass	*Pascopyrum smithii*	Leaves	D	D	D	D	D	D	D	D	D	D	D	D
twoneedle pinyon	*Pinus edulis*	Leaves	E	E	E	E	E	E	E	E	E	E	E	E

muttongrass	*Poa fendleriana*	Leaves	U	U	U	U	U	U	U	U	U	U	U	U

Legend: P = Preferred D = Desirable U = Undesirable N = Not consumed E = Emergency T = Toxic X = Used, but degree of utilization unknown

Hydrology Functions:

Recreational Uses:
This site consists of canyon walls and plateau breaks. It has a highly diversified plant complex including trees, grasses, forbs, and shrubs. Winters are cold and spring is dry and windy. Late spring, summer, and fall provide pleasant recreation weather. Sport hunting is the major recreation activity of the site.

Wood Products:

Other Products:

Other Information:

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative

Similar Sites:

Site Name	Site ID	Site Narrative

State Correlation:
This site has been correlated with the following states:

Inventory Data References:

Type Locality:

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
Steve Barker	4/1/1982	Steve Barker	12/7/2005

Site Description Revision Approval:

Author	Date	Approval	Date
Stephen Cassady	12/7/2005	Steve Barker	12/7/2005

Reference Sheet

Author(s)/participant(s): Kevin Williams

Contact for lead author: NRCS Page Soil Survey

Date: 1/9/2007 **MLRA:** 035X **Ecological Site:** Sedimentary Cliffs 10-14" p.z. R035XC302AZ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

---

Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

---

1. **Number and extent of rills:** Rills may be common on talus slopes and other areas of soil accumulation due to runoff from adjacent rock outcrop and steep slopes. Much of the soil surface on talus slopes is armored by rock fragments.

2. **Presence of water flow patterns:** Water flow patterns are occasional but may be common on talus sopes and other areas of soil accumulation due to runoff from adjacent rock outcrop and steep slopes. These patterns are usually short and discontinuous due to the frequency of rock fragments on the surface.

3. **Number and height of erosional pedestals or terracettes:** Pedestals and terracettes are occasional but may be common on talus slopesand other areas of soil accumulation due to runoff from adjacent rock outcrop and steep slopes. Much of the soil surface on talus slopes is armored by rock fragments.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground ranges from 5-10%. Areas with a greater cover of rock fragments and/or rock outcrop will have less bare ground. Drought may cause an increase in bare ground. The talus slopes have 3.7 inches of available water capacity (rock outcrop would have close to 0), so the potential to produce plant cover is low.

5. **Number of gullies and erosion associated with gullies:** None

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous, fine woody, and some course woody litter will be transported in water flow pathways. Most coarse woody litter will remain under shrub and tree canopies. There may be moe litter movement in areas that are adjacent to large expanses of rock outcrop.

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface txtures are variable on the site. All surface horizons contain a significant amount of rock outcrops(gravel and/or boulders). Most soils have 40-80% ground cover of rock fragments (mostly gravels and boulders with some cobbles and stones). When well vegetated or covered with rock armor, the soils have a high resistance to both water an wind erosion. When well vegetated, these soils have a low to moderate resistnce to water erosion depending on amount of rock fragment and vegetative cover.

---

9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Soil surface structure is strong fine granular. The thickness of the A-horizon is 1 inch. The color of the A-horizon is not significantly different from the subsurface soil horizons.

---

10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The vegetation communities on this site are scattered and patchy. They are present where there has been some accumlation of soil, such as a talus slope, or in cracks in the bedrock where they can access water. This site is characterized byshrubs, grasses, then forbs, in descending order of dominance. There may be an occasional overstory of trees. Vegetative anopy cover ranges from 5-10% (grasses > forbs = shrubs > trees). Basal cover ranges 0-2% (shrubs > rasses = forbs > trees) for vascular plants and 0-1% for biological crust (cyanobacteria > lichen > moss). Both canopy and basal cover values decrease during a prolonged drought.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None. Most of the soils are not easily compacted. Rock fragmets are common on the soil surface and within the soil profile.

---

12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: none
    Sub-dominant: shrubs > perennial bunchgrasses > perenial colonizing grasses
    Other: forbs > trees > annual forbs > annual grasses
    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** All plant functional groups are adapted to survival in all but the most severe droughts. Severe winter droughts affect shrubs andtrees the most. Severe summer droughts affect grasses the most.

---

14. **Average percent litter cover (5-10%) and depth (1/8-1/4 inches):** Of the total litter amount, it would be expected that approximately 80-90% would be herbaceous litter and approximately 10-20% would be woody litter. Litter amounts increase during the first few years of drought, then

decrease in later years.

---

15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** 50-100 lbs/ac dry years; 100-200 lbs/ac median years; 200-300 lbs/ac wet years.

---

16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Pricklypear, Whipple"s cholla and hairy false goldenweed are native to the site and have the potential to increase and dominate after heavy grazing. Cheatgrass is a exotic grass that has the potential to invade this site, with or without heavy grazing.

---

17. **Perennial plant reproductive capability:** All plants native to the site are adapted to the climate and are capable of producing seeds, stolons and/or rhizomes except during the most severe droughts.

Reference Sheet Approval:

Approval	Date
S. Cassady	1/9/2007

Appendix 7

VegSpec Results

VegSpec is an online tool provided by the BLM, NRCS, USGS, and U.S. Army Corps of Engineers. Parameters such as location, climate, soils type and treatment goals are entered into the data base, producing a list of potential species for a particular restoration project. Specific data can then be entered to summarize the amount of each plant required for the restoration and additional implementation strategies. The final result is a report summarizing the entire process.

VegSpec may be found at: http://vegspec.sc.egov.usda.gov/vegSpec/report.action

An example of a final report is reproduced below. The parameters entered in this report include:

1. State: AZ
2. Soils
    a. Soil Survey Area: Mohave Country, NE part
    b. Soil Map Unit: Gypsiorthids-gypsiorthids shallow complex, 1-50% : 15
    c. Soil Component: Gypsiorthids 60%
       (Note, the above information relates directly to the NRCS Ecological Site Descriptions. A VegSpec analysis should be done for each of the 5 soil types described by the soil map and NRCS Ecological Site Descriptions in Appendix 5)
3. Climate
    a. Climate Station: Pipe Springs National Monument
4. Landscape
    a. Aspect: SE
    b. No additional Water
    c. Not Irrigated
    d. Full Sun
5. Practice/Treatment
    a. Critical Area Planting
6. Purpose/Goals
    a. Native Plant Community Restoration
    b. No sub purpose chosen
7. Plant Type: Grass, Forb, Shrub
8. All Plant, Regardless of Availability
9. Native Plants Only

This example does not include specific implementation information, though the empty charts are provided in the report as an example of what parameters are available.

VegSpec Critical area planting Report

User Name:		**Site Name:**	Pipe Spring
Project Location:		**State:**	AZ

Landscape Information

Site Aspect:	SE
Water Receiving:	N
Irrigation:	None
Exposure:	Full Sun

Soil Information

Soil Survey Area ID:	MOHAVE COUNTY AREA, AZ, NORTHEASTERN PART, AND PART OF COCONINO COUNTY: 625
Soil Map Unit:	gypsiorthids-gypsiorthids, shallow complex, 1 to 50 percent slopes: 15
Soil Component:	GYPSIORTHIDS:60%

Soil Attributes

	Begin	End	Duration	Frequency	Depth
Annual Flooding:				NONE	
Ponding:					
Water Table:					6.0

	Low	High	Average	Salinity
Pan Depth:	None	None		
Rock Depth:	60	60		
Slope Percent:	1	50	25.5	
Salinity (mmhos) most saline layer in 12 inches:	0	0	0	N
pH (lowest and highest):	7.9	8.4		

MLRA:	0035:Colorado and Green River Plateaus
Hydric Soil:	U
Surface Texture:	SIL
Surface Texture Class:	M
Tax Class:	NON-AQUIC
Average Water Capacity (avg. layer, top 40 inches, perm;.06 inches/hr)	4.35
Soil Classification:	NON-UDIC

Climate Information

Climate Station:	**Id:** AZ6616 **Name:** PIPE SPRINGS NATL MONUM
Last Frost Date:	4/26
First Frost Date:	10/22
Growing season length(days):	179

Climate Attributes

Avg. Annual Precipitation:	10.44		
Estimated Annual Average Precipitation (EAAP) inches:	7.93	**Average derived from:**	2IN10
Minimum temperature	-1.0		

Average Temperature and Precipitation by Month

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature	34.2	39.0	44.9	51.6	60.6	70.3	76.5	74.1	66.9	56.1	43.9	35.3
Precipitation	1.05	0.99	1.04	0.7	0.57	0.34	0.9	1.39	0.81	0.77	1.03	0.83

Planting Objectives

Practice: 342-Critical area planting

Purpose(s) Selected

Native Plant Community Restora

Landscaping

Tree Shrub Products

Optional Plant Characteristics

Plant Type: Forbs, Grass, Shrub

Plant Selection

Potential Plants

Common Name	Scientific Name	Release Name
antelope bitterbrush	Purshia tridentata	n.a.
Arizona cottontop	Digitaria californica	n.a.
banana yucca	Yucca baccata	n.a.
basin wildrye	Leymus cinereus	n.a.
beardless wheatgrass	Pseudoroegneria spicata ssp. inermis	Whitmar
beardless wildrye	Leymus triticoides	Rio
bigseed biscuitroot	Lomatium macrocarpum	n.a.
black grama	Bouteloua eriopoda	n.a.
bluebunch wheatgrass	Pseudoroegneria spicata ssp. spicata	Goldar
bluebunch wheatgrass	Pseudoroegneria spicata ssp. spicata	n.a.
bluebunch wheatgrass	Pseudoroegneria spicata ssp. spicata	Secar
Colorado four o'clock	Mirabilis multiflora	n.a.
crested pricklypoppy	Argemone polyanthemos	n.a.
curl-leaf mountain mahogany	Cercocarpus ledifolius	n.a.
cutleaf daisy	Erigeron compositus	n.a.
Eaton's fleabane	Erigeron eatonii	n.a.
foothill deathcamas	Zigadenus paniculatus	n.a.
Hooker's evening-primrose	Oenothera elata ssp. hookeri	n.a.
Indian ricegrass	Achnatherum hymenoides	n.a.
Indian ricegrass	Achnatherum hymenoides	Paloma
Indian ricegrass	Achnatherum hymenoides	Rimrock
Nevada jointfir	Ephedra nevadensis	n.a.
prairie sagewort	Artemisia frigida	n.a.
scarlet globemallow	Sphaeralcea coccinea	n.a.
sideoats grama	Bouteloua curtipendula	n.a.
slender buckwheat	Eriogonum microthecum	n.a.
slender wheatgrass	Elymus trachycaulus ssp. trachycaulus	San Luis
squirreltail	Elymus elymoides	n.a.
streambank wheatgrass	Elymus lanceolatus ssp. lanceolatus	n.a.
tall woolly buckwheat	Eriogonum elatum	n.a.

western wheatgrass	Pascopyrum smithii	n.a.
yellow rabbitbrush	Chrysothamnus viscidiflorus	n.a.

Selected Plants

Plant	Purpose(s)	Sub-Purpose(s)
antelope bitterbrush:Purshia tridentata:n.a.:PUTR2	Native Plant Community Restora	
Arizona cottontop:Digitaria californica:n.a.:DICA8	Native Plant Community Restora	
banana yucca:Yucca baccata:n.a.:YUBA	Native Plant Community Restora	
basin wildrye:Leymus cinereus:n.a.:LECI4	Native Plant Community Restora	
beardless wheatgrass:Pseudoroegneria spicata ssp. inermis:Whitmar:PSSPI	Native Plant Community Restora	
beardless wildrye:Leymus triticoides:Rio:LETR5	Native Plant Community Restora	
bigseed biscuitroot:Lomatium macrocarpum:n.a.:LOMA3	Native Plant Community Restora	
black grama:Bouteloua eriopoda:n.a.:BOER4	Native Plant Community Restora	
bluebunch wheatgrass:Pseudoroegneria spicata ssp. spicata:Goldar:PSSPS	Native Plant Community Restora	
bluebunch wheatgrass:Pseudoroegneria spicata ssp. spicata:n.a.:PSSPS	Native Plant Community Restora	
bluebunch wheatgrass:Pseudoroegneria spicata ssp. spicata:Secar:PSSPS	Native Plant Community Restora	
Colorado four o'clock:Mirabilis multiflora:n.a.:MIMU	Native Plant Community Restora	
crested pricklypoppy:Argemone polyanthemos:n.a.:ARPO2	Native Plant Community Restora	
curl-leaf mountain mahogany:Cercocarpus ledifolius:n.a.:CELE3	Native Plant Community Restora	
cutleaf daisy:Erigeron compositus:n.a.:ERCO4	Native Plant Community Restora	
Eaton's fleabane:Erigeron eatonii:n.a.:EREA	Native Plant Community Restora	
foothill deathcamas:Zigadenus paniculatus:n.a.:ZIPA2	Native Plant Community Restora	
Hooker's evening-primrose:Oenothera elata ssp. hookeri:n.a.:OEELH2	Native Plant Community Restora	
Indian ricegrass:Achnatherum hymenoides:n.a.:ACHY	Native Plant Community Restora	
Indian ricegrass:Achnatherum hymenoides:Paloma:ACHY	Native Plant Community Restora	
Indian ricegrass:Achnatherum hymenoides:Rimrock:ACHY	Native Plant Community Restora	

Nevada jointfir:Ephedra nevadensis:n.a.:EPNE	Native Plant Community Restora	
prairie sagewort:Artemisia frigida:n.a.:ARFR4	Native Plant Community Restora	
scarlet globemallow:Sphaeralcea coccinea:n.a.:SPCO	Native Plant Community Restora	
sideoats grama:Bouteloua curtipendula:n.a.:BOCU	Native Plant Community Restora	
slender buckwheat:Eriogonum microthecum:n.a.:ERMI4	Native Plant Community Restora	
slender wheatgrass:Elymus trachycaulus ssp. trachycaulus:San Luis:ELTRT	Native Plant Community Restora	
squirreltail:Elymus elymoides:n.a.:ELEL5	Native Plant Community Restora	
streambank wheatgrass:Elymus lanceolatus ssp. lanceolatus:n.a.:ELLAL	Native Plant Community Restora	
tall woolly buckwheat:Eriogonum elatum:n.a.:EREL5	Native Plant Community Restora	
western wheatgrass:Pascopyrum smithii:n.a.:PASM	Native Plant Community Restora	
yellow rabbitbrush:Chrysothamnus viscidiflorus:n.a.:CHVI8	Native Plant Community Restora	

Planting Material Type

Species	Release	Planting Material Selected
antelope bitterbrush	n.a.	

Appendix 8

Rangeland Productivity and Plant Composition

In areas that have similar climate and topography, differences in the kind and amount of rangeland or forest understory vegetation are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

This table shows, for each soil that supports vegetation suitable for grazing, the ecological site; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. An explanation of the column headings in the table follows.

An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time throughout the soil development process; a characteristic hydrology, particularly infiltration and runoff that has developed over time; and a characteristic plant community (kind and amount of vegetation). The hydrology of the site is influenced by development of the soil and plant community. The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production. Descriptions of ecological sites are provided in the Field Office Technical Guide, which is available in local offices of the Natural Resources Conservation Service (NRCS).

"Total dry-weight production" is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation for favorable, normal, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture. Yields are adjusted to a common percent of air-dry moisture content.

"Characteristic vegetation" (the grasses, forbs, and shrubs that make up most of the potential natural plant community on each soil) is listed by common name. Under "rangeland composition," the expected percentage of the total annual production is given for each species making up the characteristic vegetation. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season. Range management requires knowledge of the kinds of soil and of the potential natural plant community. It also requires an evaluation of the present range similarity index and rangeland trend. Range similarity index is determined by comparing the present plant community with the potential natural plant community on a particular rangeland ecological site. The more closely the existing community resembles the potential community, the higher the range similarity index. Rangeland trend is defined as the direction of change in an existing plant community relative to the potential natural plant community. Further information about the range similarity index and rangeland trend is available in the "National Range and Pasture Handbook," which is available in local offices of NRCS or on the Internet.

The objective in range management is to control grazing so that the plants growing on a site are about the same in kind and amount as the potential natural plant community for that site. Such management generally results in the optimum production of vegetation, control of undesirable brush species, conservation of water, and control of erosion. Sometimes, however, an area with a range similarity index somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. (http://www.nrcs.usda.gov/technical/range.html)

Rangeland Productivity and Plant Composition

Mohave County Area, Arizona, Northeastern Part, and Part of Coconino County

[Only the soils that support rangeland vegetation suitable for grazing are rated]

Map symbol and soil name	Ecological site	Total dry-weight production: Favorable year	Total dry-weight production: Normal year	Total dry-weight production: Unfavorable year	Characteristic vegetation	Rangeland composition
		Lb/ac	Lb/ac	Lb/ac		Pct
5:						
Begay	---	---	---	---	---	---
15:						
Gypsiorthids	Gypsum Upland 7-11" p.z.	650	550	450	Pleuraphis jamesii	25
					Indian ricegrass	15
					Shadscale saltbush	15
					Fourwing saltbush	10
					Gyp dropseed	10
					Other perennial grasses	10
					Black grama	5
					Elymus elymoides ssp. elymoides	5
					Ephedra	5
Gypsiorthids, shallow	Gypsum Hills 7-11" p.z.	450	350	250	Gyp dropseed	15
					Shadscale saltbush	15
					Bigelow sagebrush	10
					Ericameria nauseosa ssp. nauseosa var. nauseosa	5
					Indian ricegrass	5
					Other perennial forbs	5
					Pleuraphis jamesii	5
					Stansbury cliffrose	5
					Utah serviceberry	5

Rangeland Productivity and Plant Composition

Mohave County Area, Arizona, Northeastern Part, and Part of Coconino County

Map symbol and soil name	Ecological site	Total dry-weight production: Favorable year	Normal year	Unfavorable	Characteristic vegetation	Rangeland composition
		Lb/ac	*Lb/ac*	*Lb/ac*		*Pct*
37:						
Mido	Sandy Upland 10-14" p.z.	900	650	400	Sand sagebrush	50
					Indian ricegrass	20
					Blue grama	15
					Dropseed	10
					Hesperostipa comata ssp. comata	10
					Ephedra	5
					Fourwing saltbush	5
					Other perennial forbs	5
					Other perennial grasses	5
					Sand buckwheat	2
42:						
Monue	Sandy Loam Upland 7-11" p.z. Calcareous	900	800	650	Other perennial grasses	15
					Black grama	10
					Ephedra	10
					Indian ricegrass	10
					Other perennial forbs	10
					Other shrubs	10
					Fourwing saltbush	5
					Globemallow	5
					Mesa dropseed	5
					Pleuraphis jamesii	5
					Sand dropseed	5
					Spike dropseed	5
					Winterfat	5

Rangeland Productivity and Plant Composition

Mohave County Area, Arizona, Northeastern Part, and Part of Coconino County

Map symbol and soil name	Ecological site	Total dry-weight production: Favorable year	Normal year	Unfavorable	Characteristic vegetation	Rangeland composition
		Lb/ac	*Lb/ac*	*Lb/ac*		*Pct*
55:						
Sheppard	Sandy Upland 7-11" p.z.	700	500	300	Indian ricegrass	25
					Fourwing saltbush	10
					Hesperostipa comata ssp. comata	10
					Pleuraphis jamesii	10
					Sand dropseed	10
					Sand sagebrush	10
					Black grama	5
					Ephedra	5
63:						
Torriorthents	Sedimentary Cliffs 10-14" p.z.	800	600	400	Hesperostipa comata ssp. comata	15
					Big sagebrush	10
					Blue grama	10
					Indian ricegrass	10
					Utah juniper	10
					Ephedra	5
					Muttongrass	5
					Pleuraphis jamesii	5
Rock outcrop	---	---	---	---	---	---

Appendix 9

Presettlement Vegetation

According to a presettlement vegetation survey done in 1998, the species composition of the grasslands characteristic of Pipe Spring may never be known, but grasses currently growing in the region may be indicative of the historic composition. (Alexander 1998).

Existing Regional Species (Alexander 1998, Appendix 7,9,10)

Pinion-Juniper Association

- *Bouteloua gracilis*
- *Boutelua curtipendula*
- *Bouteloua eriopoda*
- *Hilaria jamesii*
- *Sripta comata*
- *Stripta neomexicana*
- *Aristida purpurea*
- *Sitanion hystrix*
- *Sporobolus ramulosus*
- *Cyperus fendlerians*

Atriplex-Artemisia Association

- *Agrostis stolonifera*
- *Bouteloua barbata*
- *Bouteloua curtipendula*
- *Bouteloua eriopoda*
- *Bouteloua gracilis*
- *Erioneron pilosum*
- *Hilaria jamesii*
- *Muhlenbergia porteri*
- *Oryzopsis hymenoides*
- *Pappophorum wrightii*
- *Polypogon iutosus*
- *Polypogon monspeliensis*
- *Sprobolus airoides*
- *Tridens pulchella*

Aristida-Bouteloua Association

- *Aristida purpurea*
- *Bouteloua eriopoda*
- *Bouteloua gracilis*
- *Hilaria jamesii*
- *Aristida purpurea*
- *Bouteloua curtipendula*
- *Muhlenbergia porteri*
- *Oryzopis hymenoides*
- *Sporbolus airoides*
- *Stipa neomexicana*

Appendix 10

Capitol Reef National Park List of Fruit and Nut Varieties

The following document from Capitol Reef National Park describes the orchard species found within the Park. Several of these species are local historic varieties that may be available to Pipe Spring National Monument.

Capitol Reef National Park
List of Fruit and Nut Varieties, Including Heirlooms

Prepared for the National Park Service through the Colorado Plateau Cooperative Ecosystems Studies Unit by Kanin Routson and Gary Paul Nabhan, Center for Sustainable Environments, Northern Arizona University, Flagstaff, Arizona

ALMONDS (*Prunus dulcis)*

(Texas) Mission. Almonds first came into the Southwest in a delivery to Juan de Oñate at San Gabriel (near Taos) New Mexico in 1698. But it was not until 1891 that someone spotted a chance seedling in Texas with unique characteristics. It was first called Texas or Texas Prolific, but later became known as Mission, Texa or Texas Mission due to its association with old Spanish era churches. It was soon introduced to other parts of the Southwest, and its production took off on a large scale when it was introduced to Acampo, California.

This heirloom has hard-shelled nuts with relatively small kernels inside—roughly 25 to 28 per ounce. The trees are prolific bearers and extremely vigorous when young, but growth and yield decline markedly with age. The tree has an upright growth habitat, and is easy to train to facilitate production, which occurs mostly on the spur branches rather than the shoots. Because it is susceptible to mallet wound canker, it is short-lived wherever this *Ceratocystis* infection occurs. It is also sensitive to alkaline soils and saline irrigation. Its tendency to bloom well after frost in the spring keeps it popular among dwellers in river valleys where temperature inversions freeze the blossoms of earlier blooming varieties.

We believe that the almonds in the Mott Orchard of Capitol Reef National Park are Mission Almonds. However expert knowledge or DNA are necessary to confirm this.

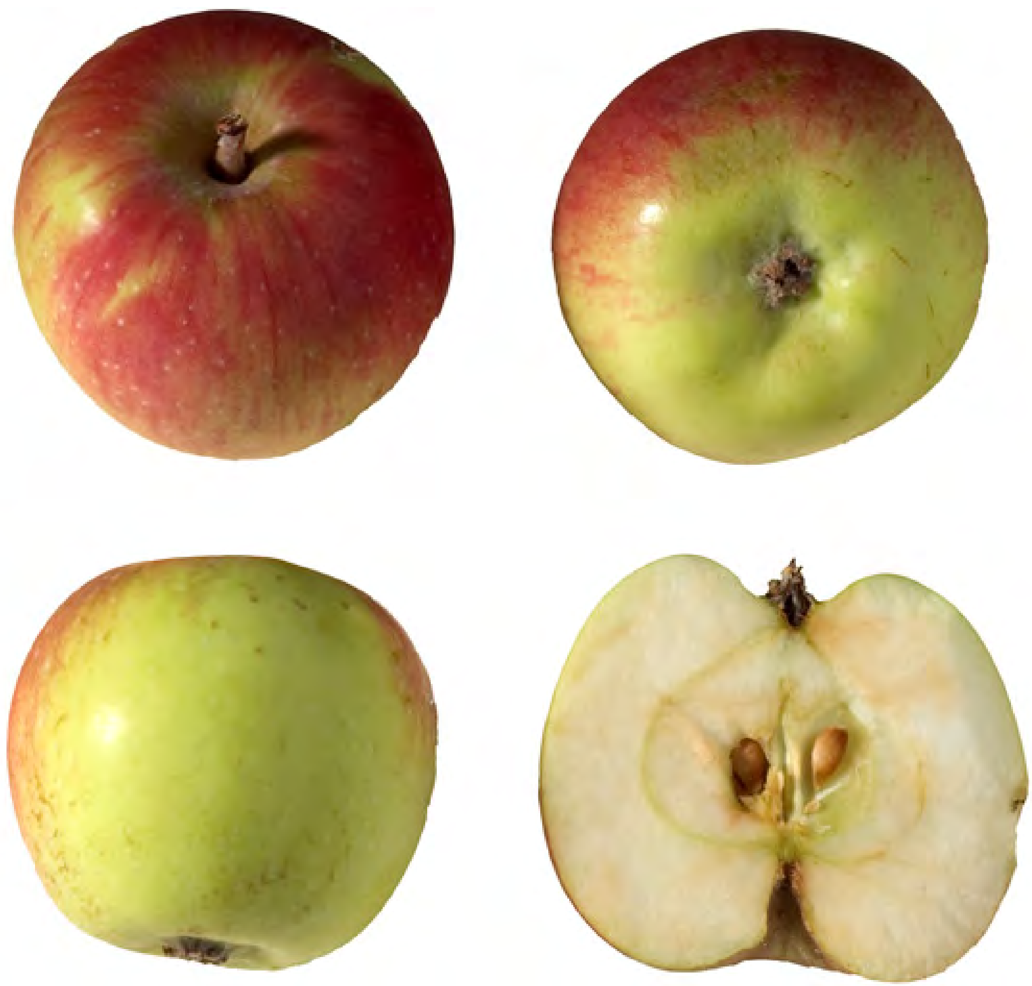
APPLES (*Malus X domestica)*

Ben Davis. The origin of the Ben Davis apple dates back to 1799 when William Davis and John Hills brought a young seedling from either Virginia or North Carolina to where they settled at Berry's Lick in Butler County, Kentucky. Others have placed its origin in Washington County, Arkansas, about 1880. Captain Ben Davis, kin to the other two men, planted the tree on his land where it began to attract attention. They took root cuttings and planted them out as a full orchard, which provided root suckers to many others passing though Kentucky. By the end of the Civil War, millions of Ben Davis suckers had spread throughout the South and Midwest.
Apple historian Tom Burford reminds us that this tree was called Mortgage Lifter by growers who got out of debt by shipping this apple down the Mississippi and out on ships from New Orleans. As it spread south, north and west, many of its growers forgot the Ben Davis epithet for this apple, and offered it a different folk name in each locale where it took root. Many local synonyms for this variety include Baltimore Pippin, Baltimore Red, Baltimore Red Streak, Ben Davis, Carolina Red Cheek, Carolina Red Streak, Funkhauser, Hutchinson's Pippin, Joe Allen, Kentucky Pippin, Kentucky, Kentucky Red Streak, Kentucky Streak, New York Pippin, Red Pippin, Robinson's Streak, Tenant Red, Victoria Pippin, Victoria Red, and Virginia Pippin. It is grown in northern Arizona as well as southern Utah, where the fruiting season is long enough to mature the variety properly.

The fruit of Ben Davis is typically uniform in shape and size, which is medium to large. Its shape is usually round, especially at the base, though infrequently it is elliptical, conic or oblong. While maturing, its clear yellow or greenish skin is tough, and thick enough that it seldom bruises. Its skin is quite waxy, glossy or bright, and smooth. The green or yellow basal color is overwhelmed by a wash of splashes and stripes of bright carmine, often with subtle dots of white or brown. At maturity, it is a deep carmine or red striped apple. The flesh is whitish, tinged slightly yellow. It is somewhat coarse, dry and wooly, not very crisp, but firm, slightly aromatic, juicy, mildly sub-acidic, and keeps for over a year. However, its rather unspectacular taste and texture has long been the butt of jokes among apple enthusiasts. Madonna Hunt of Boulder Utah quipped, "Those Ben Davis apples? Yes, they were good keepers, because no one wanted to eat them!" Tom Vorbeck put it bluntly, "It keeps like a rock, but it's not a very good rock." Keith Durfey apprenticed to an apple expert who claimed he could be blindfolded and still tell any variety by flavor. His students at the end of a long sampling gave him a piece of cork. He sat blindfolded for a long while, then quipped, "You may have stumped me for once, but I believe that's the flavor of one of those old Ben Davis apples!"

Although never rating high in flavor, nurserymen like Ben Davis because of its free-growing habit and the rapidity with which trees produce fruit of marketable size. The tree is hardy when exposed to a range of climatic extremes, remaining healthy and vigorous. Although not particularly long-lived, it bears annually and abundantly from an early age. Its top growth can be rather dense, so when pruning young trees, special care should be taken to keep its shape open and spreading. This offers its fruit an opportunity to color well.

At Capitol Reef National Park, Ben Davis apple trees are located in the Nels Johnson Orchard.



Ben Davis

Braeburn. The Braeburn heirloom originated in New Zealand and was introduced into North America in 1952. Though the parentage is unknown, it is speculated to be a chance seedling or triploid sport of Lady Hamilton.

The high quality fruit is medium to large in size. The skin is yellow, overlain by an orange-red blush. The flesh is crisp with a tangy flavor. The triploid tree is fast growing, matures and bears fruit very early, but has low vigor, and is susceptible to scab, mildew, and fire blight.

Braeburn apple trees are located in the Jackson Orchard of Capitol Reef National Park.

Capitol Reef Red. This is a newly recognized variety known only from Capitol Reef National Park's historic Fruita orchards near Torrey, Utah. Scion wood has been propagated by the Van Well nursery in Wenatchee, Washington, and by Dan Lehrer of Flatwood Flower Farm, of Sebastopol California for future distribution. It was discovered in the Fruita orchards around 1994, and propagated to produce some 80 trees.
Capitol Reef Red is similar to the Golden and Red Delicious apples in its conic shape with deep calyx basin and distinct bumps on its base. Fruits are colored with a pale yellow background, overlain with a bright crimson splash on the exposed cheek and shoulders. The pleasantly sweet, crisp, and juicy flesh is best suited for fresh eating, but is also a good candidate for pies. It is not tart enough for use in cider making. The trees are spur-type fruiting similar to Oregon Spur or other spur-type Red Delicious sports. It is a prolific bearer that can become so heavily laden with nearly stem-less fruit that its limbs bend toward the ground. This "new" heirloom" is uniquely adapted to the canyon microclimates of Utah's slickrock country. It is honored on the Slow Food Ark of Taste.

The Capitol Reef Red apple trees are growing in the Jackson Orchard at Capitol Reef National Park. The last few rows on the north side of the Jackson Orchard all appear to be Capitol Reef Red apples. However, there are either numerous similar, but distinct varieties there, or the genetics of the Capitol Reef Red apple are not completely stable. Either way, apple trees 852 and 853 are what we consider to be the "true" Capitol Reef Red, and are the trees that were genetically analyzed.

Capitol Reef

Red

Empire. This apple is a cross between McIntosh and Red Delicious, developed in 1945 by Dr. Roger Way at the New York Experiment Station in Geneva. Dr. Way introduced it in 1966. This apple is easy to grow and produces annual crops of attractive fruit that keep fairly well. Empire is best suited for fresh eating and dessert, but it is also a good apple for cider.

The Empire apple is medium in size, but small if not thinned. Its shape is round to roundish conical. The typically dark red fruit may turn yellow on the under-side, and has creamy white, sweet, crisp, juicy flesh. It ripens in mid September.

The trees of Empire are vigorous, upright, and come into bearing at an early age. Their branches form wide angles and strong crotches between branches that help to reduce limb loss during heavy fruit set. The tree has the tendency towards a spur-type habit, producing fruit close to the branch.

Empire apple trees can be found in the Jackson Orchard of Capitol Reef National Park.

Fuji. Modern apple geneticist H. Niitsi of the Horticultural Research Institute of Morioka, Japan developed the Fuji cultivar from two reputable and deeply rooted American parents, Ralls Janet and Red Delicious. Ralls originated, according to Beach in *The Apples of New York*, 1905, in the nursery of Caleb Ralls, an acquaintance of Thomas Jefferson, in Amherst County, Virginia, before 1805. Fuji quickly became an international success, first in Japan and China, then in warmer regions of the United States that have sufficiently long growing seasons.

Not much to look at compared to some varieties, its sweet taste and crisp texture are sufficiently appealing in the modern market. Its cream-colored flesh is firm, fine-grained and altogether distinctive, filling the mouth with sweetness and juiciness. Fuji comes out on top in many flavor competitions among late-maturing varieties. However, Fuji requires a long, relatively warm frost-free season for it to be ready for harvest, and is therefore considered a “desert” not a “dessert” apple. Fuji is regarded as the best keeper of any sweet variety, and the apples retain their toothsome firmness for up to a year if refrigerated.

Fugi apple trees are located in the Jackson Orchard of Capitol Reef National Park.

Ginger Gold. Ginger Gold is a patented cultivar that appeared as a chance seedling in the orchards of Clyde and Ginger Harvey of Lovingston, Virginia. The story is told by the Harveys that it appeared in a young Winesap orchard after the devastating hurricane Camille that killed more than 100 in the Lovingston area in 1969.

Its large, somewhat oblong but uniform fruit has a thin skin that can bruise. Upon ripening, its skin turns an attractive yellow tinged with beige-pink, with a blush on the exposed cheek. Ripening six weeks before its kin, the Gibson Golden, its flavor has a distinctive spice-like aftertaste. A fair keeper, Ginger Gold keeps in storage for up to six months.

Ginger Gold apple trees can be found in the Jackson Orchard, and in The Mott orchard of Capitol Reef National Park.

Ginger Gold

Golden Delicious. Unrelated to Red Delicious, the Golden Delicious also began as a volunteer seedling, perhaps of Grimes Golden, on the hillside farm of A.H. Mullins near Bomont in Clay County, West Virginia. It was originally called Mullin's Yellow Seedling. In 1914, William P. Stark bought rights to the tree's legacy for five thousand dollars, renamed it, and began to offer Golden Delicious through the Stark Brothers Nursery out of Missouri. Sure that it would be commercially in demand, Stark protected his investment in a rather formidable, locked cage that was equipped with a burglar alarm to discourage would-be bio-pirates. Some nurseries that offer the apple under the name Yellow Delicious breached the Stark patent.

Tall and almost conical in shape, this apple tends to be large. The skin of a ripened Golden Delicious is pale yellow and thin. It will, however, have a chartreuse hue if picked prematurely or a darkened yellow hue if picked when over ripe. Its flesh is firm, crisp and juicy, but may be stained with red. Once you've been introduced to it, its flavor and fragrance remain unmistakable. The Golden Delicious strikes some cooks as somewhat bland for use in cooking, but it can be used for pies and sauce with little or no sugar. Its distinctive aroma imbues sweet ciders, both hard and soft.

It ripens relatively late in many places, from mid-September through late October. Its skin is quick to shrivel if the harvest is left at room temperature, but Golden Delicious often keep well if refrigerated in a crisper or in a plastic bag.

Golden Delicious trees are located in the Amasa Pierce Orchard, the Chesnut Orchard, Gifford Farm, Jackson Orchard, Max Krueger Orchard, and The Mott Orchard at Capitol Reef National Park.

Gibson Golden. This is a smooth-skinned selection of Golden Delicious apple that shows less russeting than the standard Golden Delicious. The tree is vigorous, productive and easy to handle. The fruit ripens in October. For further details, see Golden Delicious (above).

At Capitol Reef, the Gibson Golden is planted in the Jackson Orchard.

Granny Smith. The first green apple to become well known among American consumers, Granny Smith was discovered by Mrs. Anne "Granny" Smith growing on a creek in Ryde, New South Wales, Australia in the early 1860s. It appears to have been a chance seedling from some discarded French crab apples that Granny and her husband Thomas Smith brought back from either Sydney, or the island of Tasmania, depending on who told the tale. When it fruited in 1868, Granny used its fruit for cooking, but her grandson claimed it was better eaten fresh. The Smith family began to propagate it in their orchard and market its fruit in Sydney, where it rapidly gained popularity. It began to be exported to England in the 1930s, and soon afterward was introduced to France, Spain, Italy and the United States.

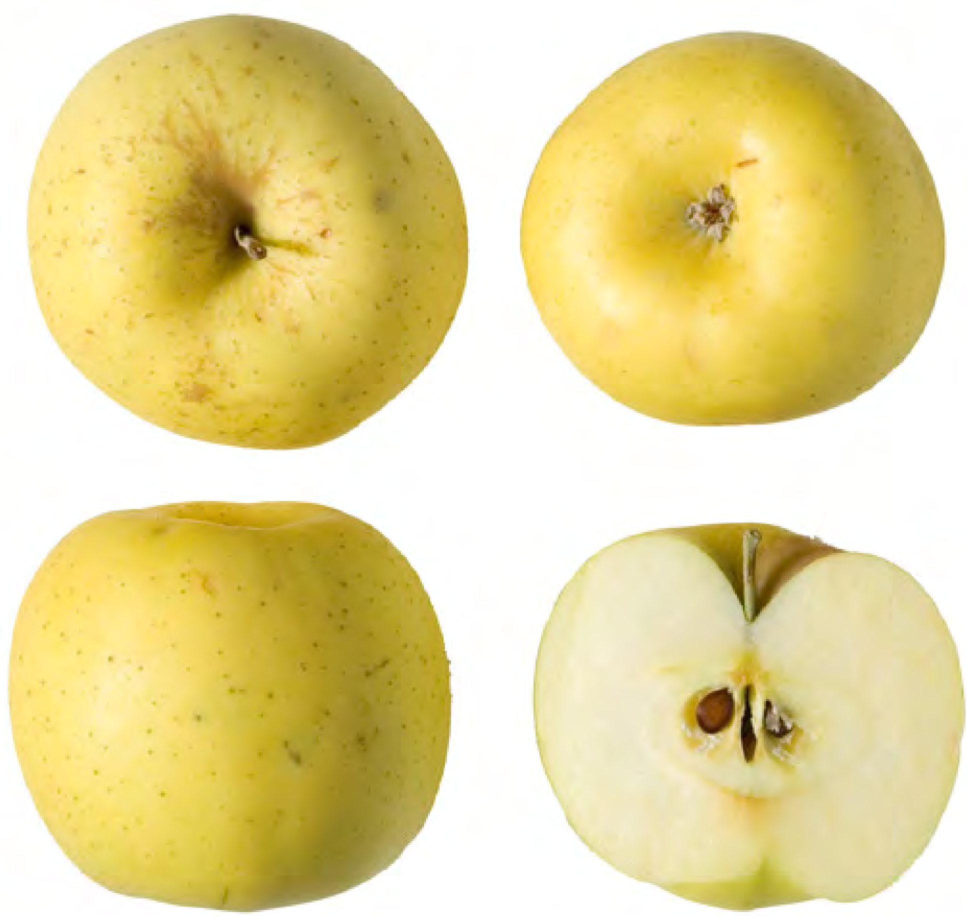
Granny Smith fruit are medium to large sized, with a somewhat rectangular or truncate conical shape. Its bottom is convex, and ribbed at the eye. Its skin ranges from a grassy green to yellow green, with a fine-netted russet appearing at the time of ripeness. Its flesh is greenish to yellowish white in color, and its texture is crisp, and so firm that it is bruise-resistant. Its mild flavor is subacid, and moderately sweet. The harvest season for Granny Smith is relatively late in the fall. Considered to be excellent both for eating fresh and for cooking, Granny Smith keeps its texture during baking and does not get mushy. Regarding its firmness, apple historian Roger Yepsen goes further, by claiming that it is "resilient as a tennis ball…holds up well in shipping [and] will tolerate a half year of cold storage." Not suited for cider, it is fine for pies.

At Capitol Reef, a Granny Smith apple tree can be found in the Max Krueger Orchard.

Grimes Golden. New Orleans traders, who obtained the variety from Thomas Grimes of West Virginia in 1804, brought this notable cider variety to the nursery trade. The medium to large-sized golden-yellow fruit is crisp, juicy and sugary. Grimes Golden is a highly esteemed dessert apple, as well as a highly prized cider variety. It is noted for its high alcohol content (12% in unblended ciders), and excellent flavor. The apple does not keep well, making it undesirable for commercial orchards.

The medium-vigor tree is self-fruitful, and produces abundant crops biennially, or semi-annually beginning at a young age.

At Capitol Reef, there is a single Grimes Golden apple tree growing in the Chesnut Orchard.



Jonathan. This classic American apple, kin to Esopus Spitzenburg, originated in 1826 as a sport on the farm of Mr. Philip Rick of Woodstock, Ulster County, New York, where the original tree stayed alive at least until 1845. The first published account, which we find of the Jonathan, is that given by Judge J. Buel of Albany, New York, who then listed it as the (New) Esopus Spitzenburg, with the synonym Ulster Seedling. A bit later, Buel simply called it the New Spitzenburg, but the next name he gave it superseded all others: Jonathan, in honor of Jonathan Hasbrouck, who had first called the judge's attention to the unique traits of this sport, which he had noticed growing on a scrubby hillside on the old Rick farm. It spread quickly after that, soon ranking in the top six of American apples in terms of sales. It is now grown not only in North America, but in Italy, Austria and Poland as well.

This popular heirloom and commercially-renowned apple can be exceedingly beautiful at maturity, though it is not as large or as good of a keeper as its Esopus Spitzenburg parent. The shape of this apple may be round, slightly conic or ovate, and medium to small in size, or somewhat truncate with a deep furrowed bottom basin or cavity. Its tough but thin, smooth skin may be pale yellow in undertones that are completely covered with deep carmine hues. These hues deepen into lively reddish-purples on the side exposed to the sun, and clear pale yellows on its shaded side and in its basin. If it does not get full exposure to the sun, the skin may be red-striped in appearance, exposing minute dots. Its flesh may be whitish or pale yellow, tinged with a bit of red. The flesh is usually firm, stained with red, moderately fine, crisp, tender and juicy. Its flavor varies from tart to mild, often aromatic, sprightly subacidic. It is usually of excellent quality whether eaten fresh as a dessert, cooked into sauces, or used for tart ciders.

Jonathan exceeds many of its Spitzenburg kin in hardiness, productivity, health and vigor. It is widely adaptable for growth in a wide range of climates, where the trees can be either moderately vigorous or slow in their growth and maturation. The trees may have a round or spreading shape, sometimes with drooping, dense branches.

The Jonathan can be found in the Jackson Orchard, the Max Krueger Orchard, The Mott Orchard, and Nels Johnson Orchard of Capitol Reef National Park.

Jonathan

Lodi. Also known as Improved Transparent, R. Wellington selected Lodi in 1911 at the New York Testing Association, which later became the New York State Agricultural Experiment Station of Geneva. It appears to have been a cross between Montgomery and White Transparent. It remains extremely popular in some regions, and is available from more than three-dozen nurseries.

Lodi is a large green cooking apple whose skin is actually clear yellow when examined closely. It has firm white flesh that is mildly subacidic, so that it is simultaneously sweet and tart; it is crisp and juicy. When it reaches full size, the fruit is irresistible for pies, for fine, frothy white applesauce, and fresh eating.

It ripens early on large, dependably productive trees that require cross-pollination. They are resistant to apple scab. The fruit are less vulnerable to bruising than are Yellow Transparent.

The Lodi apple historically grew in Fruita, but is currently extinct in the area.

McIntosh. This heirloom is originally from Dundela, Dundas County, Ontario, Canada. It was discovered by immigrant John McIntosh near Dundela in 1811. Its local nursery propagation began around 1835, but John's son, Allan McIntosh, did not introduce it into trade until 1870. The McIntosh is derived either from a Saint Lawrence seedling, or a cross between a Fameuse and a Detroit Red. McIntosh has in turn fathered many well-known varieties, such as Cortland, Empire, Macoun, and Spartan. The fruit is good for fresh eating, pies, and makes an aromatic cider. It was the replacement variety for the great Baldwin orchards of New England that were destroyed by the 40 degrees below zero temperatures during the winter of 1933-1934.

McIntosh fruit are medium to large, and quite uniform in shape and size. It is typically round or oblate, somewhat angular, and strongly or weakly ribbed. Its skin is thin and readily separates from the flesh. The skin is noticeably tender, smooth and therefore easily bruised. Its underlying skin color is clear whitish-yellow or greenish, but it is deeply blushed with bright red, and striped with carmine. Fruit exposed to the sun is richly colored, dark, almost purplish-red, so much so that the carmine stripes may be completely obscured. The flesh of a McIntosh is white or slightly tinged with yellow, sometimes veined with red. This apple is firm, fine-textured, crisp, tender, very juicy, agreeably aromatic, perfumed, sprightly, and subacidic. It becomes mild and a bit sweet when very ripe, but then lacks firmness suitable for packing and long distance transport. It is among the best apples.

Maturing from October to December in late-frosting zones, the McIntosh produces a reliable crop that begins to bear early, before offering an extended season of fruit. It may yield good crops biennially or even annually. However, the crop ripens unevenly, making it suited for two or three periodic pickings two to three weeks apart.

At Capitol Reef, McIntosh trees can be found in the Nels Johnson Orchard.

Prime Gold. This patented cultivar appears to have fallen out of favor with nurserymen, and was last available from Van Well Nursery in Wenatchee, Washington, which has recently dropped it from its catalog. The fruit are elongated, golden yellow, and russet free. The tree tends to be well structured with wide branch angles.

Prime Gold can be found in the Jackson Orchard at Capitol Reef National Park.

Red Astrachan. This widely distributed heirloom originated on the Volga River in Russia several centuries ago. Swedish botanist P.J. Bergius first noted it in 1780, having been grown in Sweden for some time. It was introduced to Western Europe and England by 1816, and then crossed the ocean to the US in 1835. Since its arrival in the United States, this heirloom has picked up some 75 additional folk names as synonyms: Abe Lincoln, American Red, American Rouge, Anglesea Pippin, Anglese Pippin, Astracan, Astracan Rosso, Astracan Rouge, Astrachan, Astrakhan, Beauty of Whales, Carmin de Juin, Castle Leno Pippin, Cerven Astrahan, Deterding's Early Deterling's Early, Duke of Devon, Hamper's American, Rother Astrachan, Transparent Rouge, and Waterloo. The name Abe Lincoln came from its long association with the Lincoln home in Springfield, Illinois, where this apple became available during Lincoln's own lifetime, and two trees have continued to be grown in the backyard at the Lincoln Home National Historic Site near the Visitors Center at South Seventh Street in Springfield and at a nearby nursery.

Red Astrachan is a medium size, very beautiful early summer apple. Valued for home use as a culinary apple before it is fully ripe, and as it ripens and mellows, as a dessert apple. Tree comes into bearing at a young age and is a reliable, often biennial cropper. The fruit lacks uniformity, perishes quickly, and the crop matures unevenly, making it ill adapted for commercial planting. The fruit is medium, sometimes large, but not very uniform in size or shape. Roundish to oblate, inclined to conical, somewhat ribbed, and a little unequal. Thin skin, moderately tender, smooth, pale yellow or greenish, overspread with light and dark red splashes, and irregularly striped with deep crimson or carmine, and covered with a distinct bluish bloom. Flesh is white, and often tinged with red. Rather fine, tender, crisp, juicy, brisk subacid, aromatic, sometimes astringent, good to very good. Its season is from late July to September.

Red Astrachan apple trees are located in the Nels Johnson Orchard of Capitol Reef National Park.

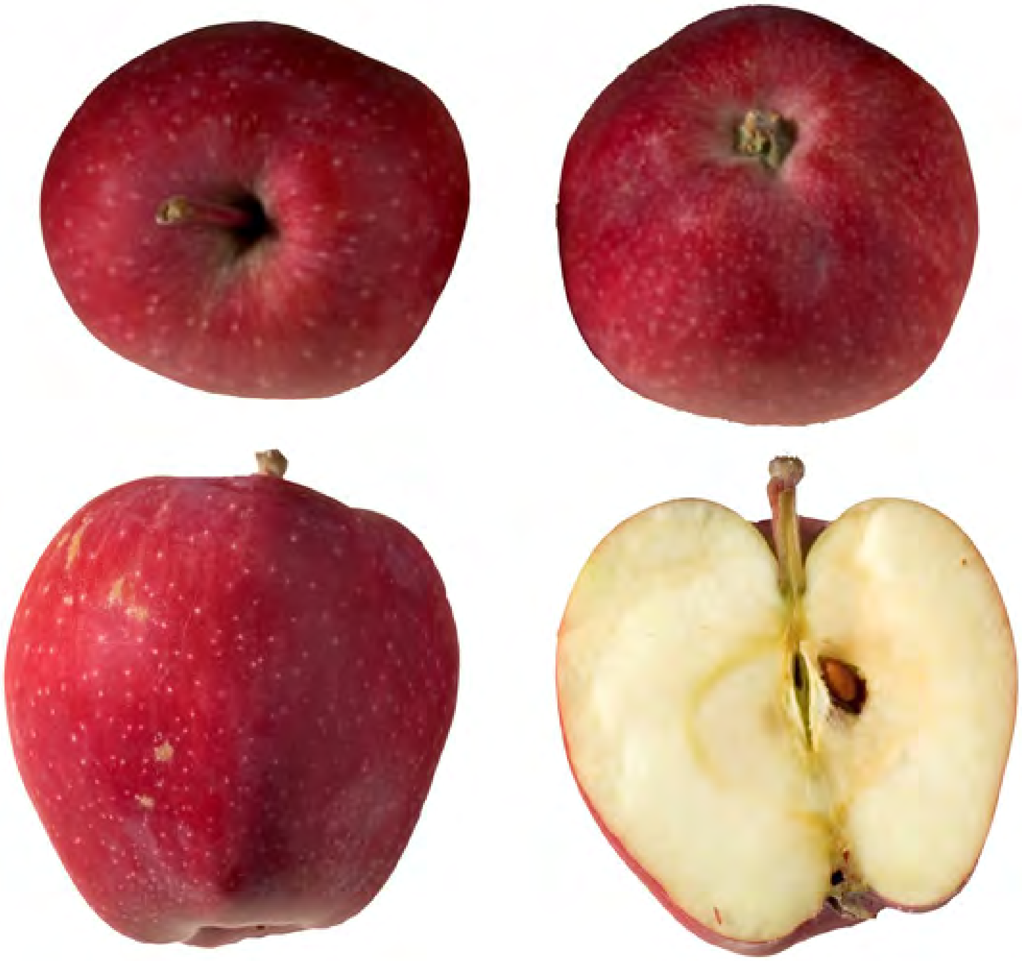
Red Delicious. One variety that needs no introduction is Red Delicious, the most widely grown apple in the world. It possibly originated from a seedling rootstock after the scion had broken off a graft on the farm of Jesse Hiatt of Peru, Iowa. It was first called Hawkeye for the Hawkeye State of Iowa, and other lesser-known selections of Hawkeye still persist. This particular selection, championed by the Stark Brothers of Missouri after 1895, has been called "a triumph of style over substance, good looks over taste." More than thirty-five variants of the Red Delicious are now marketed, from Ace Spur and Bisbee, to Roan and Ultra Red, but most of them have the same fatal flaw of exuding more glamour than flavor.

This is a big apple, with thick, bitter skin that remains intensely red even when it has turned to mush inside. As it matures, its round shape becomes elongated, so that at maturity it is tall and tapered. It has fine-grained, crisp, slightly tart, juicy, yellow flesh that becomes tender, then tastelessly pulpy as it undergoes the extended storage that commercial markets put it through. This apple ranks at the bottom of the barrel when cooked, but remains popular as a dessert apple among those who have never ventured to taste anything else. Because these trees are prolific and fast growing, it plagues the continent and displaces many worthier apples. Like an over-the-hill Hollywood actor, Delicious retains its cheerful good looks long after all real taste has departed from the mealy pulp beneath its thick skin.

The Red Delicious has been planted in the following orchards of Capitol Reef National Park: Amasa Pierce, Behunin Grove, Chesnut Orchard, Gifford Farm, Holt Orchard, the Jackson Orchard, the Max Krueger Orchard, the Merin Smith Place, The Mott Orchard, and the Tine Oyler Place.

Red Delicious Oregon Spur II. This cultivar is a patented selection of Red Delicious. The fruit are large and of excellent shape. The skin is bright red with dark striping. The pure white flesh is of better quality than its parent. Trees are vigorous and early bearing. Tend to be of the spur type. For further detail, see Red Delicious (above).

Oregon Spur apple trees are planted in the Jackson Orchard of Capitol Reef National Park.



Oregon Spur II

Rhode Island Greening. The Rhode Island Greening originated in the vicinity of Newport, Rhode Island. Here, there is a place known as Green's End, where Mr. Green, an orchardist who loved to raise apple trees from seed, kept a tavern. Among the trees that came up in Green's orchard was one which bore a large green apple, hence the double meaning of this heirloom's name. Scions from this tree were in such demand in the early 1700s by Green's tavern's guests that his prized tree died eventually from excessive cutting. As its scions were dispersed far and wide, they were called by the following folk names: Burlington Greening, Greening, Green Newton Pippin, Jersey Greening, and just plain Rhode Island. Cuttings were sent to London and, from there, to many parts of Western Europe in the early 1800s, and it was widely grown throughout the United States in the nineteenth century.

This medium to large-sized apple begins autumn as a waxy, deep grass green, but later, as it ripens, it develops yellow hues with brownish-red blushes and greenish-white dots. It may take on a dull blush and occasionally develops a rather bright red cheek but never stripes. Its shape varies from round to oblate to conical and elliptical. It is slightly ribbed. Its skin is moderately thick, tough, and smooth. The firm yellow flesh is moderately fine-grained, crisp, tender, juicy, rich, and sprightly subacidic, with its own peculiar flavor suitable for tart ciders.

The Rhode Island Greening produces reliable, abundant crops in many localities. It is generally regarded because of its acidity as one of the very best cooking apples grown in the U.S., nearly on par with Esopus Spitzenburg and its more recent kin, Jonathan. It is used for many culinary purposes and for fresh desserts. Hovey claimed that:

> *As a cooking apple, the Greening is unsurpassed; and as a dessert fruit of its season, has few equals. To some tastes it is rather acid; but the tenderness of its very juicy flesh, the sprightliness of its abundant juice, and the delicacy of its rich fine flavor is not excelled by any of the numerous varieties that we at present possess. It ripens up of a fine mellow shade of yellow, and its entire flesh, when well matured, is of the same rich tint.*

A triploid, it is a poor pollen producer that should be grown with two different pollen-producing varieties. The tree does not come into bearing when it is young, but is vigorous and long-lived. Its form is wide spreading, somewhat drooping, and rather dense. The fruit hangs well on the tree until it begins to ripen. The tree has the tendency to form a rather dense canopy in fertile soils, so special care should be taken while pruning in order to keep the head sufficiently open so that the light may reach the foliage in all parts of the tree. However, the orchard keeper should avoid cutting out large branches from the center of the tree thereby exposing the remaining limbs to injury by sunscald. It is better to thin the top every year, by removing many of the smaller branches to make it uniformly open. This keeps the longest fruit-laden branches from ending up so close to the ground that they interfere with the free circulation of the air beneath the tree.

At Capitol Reef, Rhode Island Greening apple trees can be found in the Mott Orchard.

Rhode Island Greening

Rome Beauty. Originating with Zebulon, Joel and H.N. Gillett in Rome Township, Lawrence County, Ohio, the original Rome Beauty tree was bought in 1827 from Israel Putnam, a nurseryman in nearby Marietta. It was first brought to the attention of fruit growers at an Ohio Fruit Convention in 1848, and later distributed across the United States, Europe and Australia. Its synonyms include Rome, Starbuck, and Gilette's Seedling. There are at least nine commercially available variants of Rome Beauty, with Red Rome being the most popular one in nursery trade. It was popular with orchardists because it is late blooming and thus a dependable producer in areas with late frosts.

Rome Beauty fruit are medium to very large, round to slightly conical to oblong, and often faintly ribbed. They can be symmetrical or slightly unequal but almost always have a large deep, furrowed cavity. Their thick skin changes from solid yellow-green to carmine red, without ever becoming russeted. Rome Beauty skin is thick, tough, smooth, and highly colored, with numerous small dots. Its flesh may be almost pure white, or have a hint of yellow- green; it is firm-fleshed, fine-grained or a little coarse, always crisp and juicy. However aromatic Rome Beauty flesh becomes, it is mildly subacid, passing in flavor but never really excellent in quality. Rome Beauty stands handling and is a good keeper, maintaining its qualities in cold storage as late as May. Beauty trees are strong growers and attain good size in the orchard. At first, the tree form is upright but later it rounds out, becoming spreading and drooping, with many slender, bending lateral branches.

Rome Beauty apples grow in the Gifford Farm and the Nels Johnson Orchards of Capitol Reef National Park.

Rubinette. Walter Hauenstein of Rafz, Switzerland near the German border, raised this hybrid**.** Also known as the Rafzubin cultivar, this is a patented cross between Golden Delicious and Cox's Orange Pippin. These medium-sized handsome fruit have a thin skin of a golden color that is overlain with bright red striping and subtle russeting. Handsome when sliced, with a rich blend of sugars and acids, its yellow flesh has an intense honeyed flavor. Its growth characteristics are similar to Golden Delicious, and like its parent, it is a good pollinator. Only two nurseries currently carry this variety, one in Canada, the other, in Washington State.

Rubinette apple trees have been planted in the Jackson orchard at Capitol Reef National Park.

Sixteen Ounce Cooking. This triploid variety is not synonymous with the diploid 20 Ounce Cooking. However, there is no written documentation for an apple named the 16 Ounce cooking. Whether this apple is a local variety or a misnamed variety remains unclear at this point, however additional genetic work may lend further insight into this apple. Regardless, the tree is heavy bearer of medium-sized green fruits splashed with red on the exposed cheek. Tart fruits are well suited for cooking as implied by the name.

The Sixteen Ounce Cooking tree grows in the Merin Smith Place in Capitol Reef National Park.

Sixteen Ounce Cooking

Winesap. Although it is one of the oldest and most popular apples in America, the origin of the Old Fashion Winesap has been obscured. Dr. James Mease of Moore's Town, New Jersey first recorded it in 1804, who noted that Samuel Coles had already grown it there for some time. It had appeared in trade by 1817, when Coxe spoke of it as being "the most favored cider fruit in West Jersey." Also, it was known in colonial times in Virginia. Other folk names suggest different origins: Holland's Red Winter, Royal Red of Kentucky, and Texan Red. Like various other older heirlooms, the Winesap has produced many seedlings, which have been selected for characters slightly different from those of their parental stock. The best known of these are Arkansas or Arkansaw, Arkansas Black, Paragon, also known as Black Twig and Stayman.

This is a round, medium-sized apple. Its skin is moderately thick, tough, smooth, glossy, and deeply red. It may have purplish-red stripes and blotches that are even darker, and rather small, scattered, whitish dots, especially toward the cavity, but the prevailing effect remains a bright deep red. Its flesh is crisp and juicy, tinged with yellow, with reddish veins; it remains very firm, rather coarse, and sprightly subacid. The tree can be vigorous and is a remarkably regular cropper. It grows best on light but rich, deep soils and does not fare well on heavy clays or in low, damp locations. It is a good shipper and stands heat well before going into storage. Winesaps are great for cooking applesauce, dessert, and cider. It is one of the few apple varieties that grow well throughout all apple-growing regions.

Winesap apple trees can be found in the Mott Orchard and the Nels Johnson Orchard of Capitol Reef National Park.

Winesap

Winter (Yellow) Banana. The Winter Banana originated on the farm of David Flory near Adamsboro, Cass County, Indiana, where it was first selected as an heirloom around 1876. The Greening Brothers of Monroe, Michigan introduced it into commercial trade in 1890. Its most common synonym is simply Banana.

Winter Banana was one of the most popular varieties for pollination, especially for the pollen-sterile Winesap and its kin. At one time Winter Banana was a variety selected for dehydrating because the slices would stay bright and white after processing.

Its fruit are large and variable in shape, often elliptical and ribbed, with a distinct suture line. Its smooth, tough, waxy skin is colored a clear pale yellow, with beautiful contrasting pinkish-red blush. Its whitish flesh is tinged with yellow, with a characteristic aroma of bananas, and is moderately firm, coarse, crisp, tangy to mildly sub-acid and juicy, of good dessert quality, but is too mild in flavor to excel for culinary uses. The medium-sized tree grows well, has a rather flat, open form with branches that tend to droop. It comes into bearing while young, and then continues to bear modest crops almost annually. In ordinary storage, it keeps until March, but its color is so pale that any bruises show easily.

The Winter Banana apple grows in the Nels Johnson Orchard of Capitol Reef National Park.

Winter Banana

Winter Pearmain. This may be the oldest known apple in the English-speaking world, dating back to at least 1200 A.D. in the British Isles. In 1822, Thatcher gave the following account of the Winter Pearmain of the old Plymouth Colony in Massachusetts:

> *The Winter Pearmain is among the first cultivated apples by the fathers of the old Plymouth colony, and is, undoubtedly, of English descent. Many trees of this kind are now supposed to be more than one hundred years old, and grafted trees from them produce the genuine fruit in great perfection.*

Its synonyms include Autumn Pearmain, Campbell, Ducks Bill, Great Pearmain, Green Winter Pearmain, Hertfordshire Pearmain, Old English Pearmain, Old Pearmain (Lindley), Parmain D'Angleterre of Knoop, Parmain d'Hiver, Paramain-Pepping, Pearmain, Pearmain Herefordshire, Pepin Parmain d'Angleterre, Pepin Parmain d'Hiver, Permenes, Permaine, Permein, Platarchium, Sussex Scarlet Parmain, White Winter Pearmain. Unfortunately, several other, distinctive varieties have gone under the name Winter Pearmain both in Europe and in the United States. There is a Red Winter Pearmain that originated in North Carolina and described by the pomologist Warder in 1867.

Its fruit are medium in size, uniform, and tapering to the crown. The skin is smooth, with a grass-green base color that can be a little red on the sunny side, maturing to a pale yellow or a red apple with numerous dots. Its flesh is a rich yellow, fine-grained, crisp, tender and juicy; its flavor is slightly aromatic, pleasantly rich, and always agreeable. It has been the favorite dessert apple in the Midwest for nearly two hundred years, and remains one of the best all-purpose heirlooms. The tree is tall and upright, forming a handsome regular top. It is hardy, widely adaptable and vigorous, and will flourish in a light soil.

At Capitol Reef, Winter Pearmain apple trees grow in the Mott Orchard.

Yellow Transparent. Imported from Russia by the United States Department of Agriculture in 1870, its value was first brought to the attention of Americans by Dr. T. H. Hoskins of Newport, Vermont. It has been disseminated throughout the more northerly apple-growing regions of this country, from New England and the Northern Plains clear to the Pacific Northwest, and is now commonly listed by nurserymen in those regions. Its synonyms include White Transparent and Sultan.

Its fruit is medium to large in size, round ovate to round conic, and slightly ribbed, with unequal sides and a narrow cavity. Its skin is thin, tender, smooth, waxy, dotted and is always transparent but changes color from pale greenish-yellow to an attractive yellowish-white. Its flesh is a crisp, juicy white, moderately firm, fine-grained, tender, sprightly subacid with a light, pleasant flavor. Sliced, it can easily be solar-dried, and is excellent for culinary use and acceptable for dessert.

Maturing early in northern climes, it is a more reliable cropper than many other apples where growing seasons are short. It yields good crops nearly every year, ripening continuously over a period of three or four weeks, so that two or more pickings are required. However, it bruises easily so fruit must be secured while in prime condition and carefully stored. The tree is somewhat vigorous, hardy, healthy, and comes into bearing very young. At first, its form is rather vertical, but with age, it becomes spreading and rather dense.

Yellow Transparent apple trees can be found at the Group Campsite and in the Mott Orchard of Capitol Reef National Park.

APRICOTS (*Prunus armeniaca)*

(Chinese) Sweet Pit. Also called Chinese Golden, Sweet Pit, Mormon Chinese, Large Early Montagemet or Chinese Mormon, this apricot may have been brought into Utah from Chinese immigrants that carried it into the Great Basin from California, while working on railroads and in mines. It spread northern from there, well into British Columbia, at the limits of where apricots can survive. It is called a "sweet pit" because you can eat the oil-rich kernel like you would an almond, as well as enjoying the flavorful fruit. It is available from ten nurseries.

This clingstone is medium in size—up to two and a half inches in diameter-- and has yellow to deep orange skin that is nearly free of fuzz. Its sweet, firm fruit are juicy, and their flavor, texture and quality are good, but the fruit ripen on the tree over an extended period, making a single harvest difficult. The fruit are good for home-use, drying, and roadside markets. They are susceptible to moth and insect damage, but well suited to both northern climes and high elevations. The trees are early bearing, heavy producers except where frosts persist very late in the spring. The spreading tree grows fifteen to eighteen feet tall, is self-fruitful, and blooms somewhat later than most varieties.

Chinese apricot trees can be found in the Nels Johnson Orchard, Capitol Reef National Park.

Moorpark. Originating as a chance seedling of a Nancy apricot, this heirloom was selected by Admiral Anson at his estate in Hartford, England around 1860. It remains widely available from nurseries.

This is a very large, round freestone apricot with fuzz-free, deep yellow skin that blushes orange. Its deep orange flesh is juicy and delectable. Good for shipping, canning, or drying, it is a good shipper. Its trees have showy pinkish white blossoms and are self-fertile. The dwarf version of Moorpark grows up to ten feet tall and is an early, dependable producer.

Moorpark apricot trees grow in the Mulford Orchard and in the Nels Johnson Orchard of Capitol Reef National Park.

CHERRIES (*Prunus avium* and hybrids)

Bing. The selection of the most-widely loved cherry in the United States from a Black Republican planting in 1875 was the crowning achievement of Seth Lewelling of Milwaukee, Oregon. He also originated several other fine cherries in the Salem Oregon area. Mr. Lewelling named the variety after Mr. Bing, his Chinese-American assistant who faithfully helped him develop this prize. When Bing cherries were first exhibited at the 1876 Centennial Exposition in Philadelphia, people at first thought they were crab apples, judging from their enormous size!

Bing fruit are one inch in diameter, broadly chordate, somewhat compressed, and slightly angular with deep cavities. Their color is very dark red, nearly black, with small russet dots. Their stems vary in thickness. Their tough skin is of medium thickness, and adheres to the pulp. Their flesh is purplish-red, rather coarse, firm, very meaty, brittle, and sweet. Their large stones are semi-free, ovate or oval, blunt, with smooth surfaces. Bing cherry trees tend to be large, vigorous, and erect, but the branches spread with age, the canopy becoming rather open. The cherries hang well on the trees, and the crop ripens simultaneously so they can be harvested in one picking.

Bing cherry trees have been planted in the Holt Orchard and the Tine Oyler Orchard of Capitol Reef National Park.

Lambert. This cultivar was also developed in Salem, Oregon after the Lewelling property was sold to Joseph Hamilton Lambert in 1857. Its namesake, Mr. Lambert, found and introduced this cultivar in 1870. Lambert is second only to Bing in commercial trade in the United States. It has dark red, heart-shaped fruit that are smaller than Bings. They grow on strong, upright trees that are hardy and heavy-bearers. They require cross-pollination from another variety and appear to be resistant to spring frosts. However, they are not necessarily more productive than Bings.

Montmorency (*Prunus avium x P. tomentosa*). Montmorency originated in France in the 17th century, and came to the United States as early as 1760. Montmorency is known as the standard for pie cherries, because of its rich, tart and tangy flavor, and because it does not get mushy during processing. This cherry is renowned for pies, juice, preserves and jellies.

The fruit are medium to large, and bright red. The yellow flesh produces a fine clear juice. This heirloom ripens in late June. The trees are large and spreading, attaining a height of fifteen feet. This heirloom is self-pollinating.

At Capitol Reef, Montmorency cherry trees are planted in the Nels Johnson Orchard.

Royal Anne. This sweet cherry is an old French heirloom that has also been called Queen Ann, Napoleon, Napoleon Royal Ann, and Napoleon Bigarreau. As with Lambert and Bing, Royal Anne was made famous by Seth Lewelling, who brought it from Iowa as a Napoleon Bigarreau, but renamed "Royal Anne" for reasons now long forgotten. From this single misnamed tree, the most profitable cherry variety grown in the Pacific Northwest had its origin. It is still available from nearly two dozen nurseries.

The Royal Anne has large, firm tallow-skinned fruit that gain a rose blush when ripened. Their light flesh is firm, juicy and sweet, and holds its shape well. These cherries are excellent fresh, dried or brined and canned as maraschinos. These upright trees reach twenty-five feet in height and bear heavily in years when spring frosts do not persist too late.

Van. Introduced in 1944 by the Summerland Research Station of British Columbia, this sweet cherry is available from two dozen nurseries in the U.S. and Canada. It has shiny, almost mahogany, reddish black fruit that are not quite as large as Bing, but firmer. They tend to have a blocky shape, but stay firm, without cracking. Although they have a good flavor, they do not ship well for long distances. However, the strong, upright trees are excellent annual producers if another variety is available for cross-pollination.

GRAPES (*Vitis labrusca*)

Concord. Ephraim Wales Bull in Concord, Massachusetts, developed this classic American grape in 1849 just across the Lexington Road from the home of the distinguished American writer, Nathaniel Hawthorne. Bull, who is now acclaimed as the Father of the Concord, began his search for the perfect grape at an early age, growing more than 20,000 seedlings of wild *Vitis labrusca* for evaluation in his seventeen-acre garden. In 1843, he found one wild grape that interested him, planted its seeds, pulp, and skins in sandy soil on a southern exposure, and tended the plants for six years before deciding that it was the winner. The parent vine still grows next to his home in Concord, in a landscape now considered a National Historic Landmark. Four years later, in 1853, Bull took his seedling's grapes to the Boston Horticultural Society Exhibition, where they won first place in the exhibition. Bull introduced them into trade the following year, and they soon won the Greeley Prize, with Horace Greeley calling them "the grape for the millions." Today, Concord is considered to be the standard of quality for bluish-black table and juice grapes, and its production constitutes about 8% of the total grape production in the United States.

Concord is typically dark blue-black or purple, and large-seeded; however, a mutant white form has appeared in some vineyards. It is a slip skin grape that is highly aromatic. Its unique flavor is an identifiable characteristic of bottled grape juice and grape jelly, as well as many artificially flavored candies and sodas. While its primary commercial use is for grape juice, Concord is cherished as a table grape for desserts.

A Concord grape grows in the Doc Inglesby Picnic Grove at Capitol Reef National Park.

Niagara. Introduced into trade in 1882, Niagara is white grape that appeared as a chance seedling among blue-black Concords that were selected from wild grapes just four decades earlier. It not only has the white color mutation, but ripens a few days earlier than its Concord kin. It remains the most popular white *labrusca* grape, especially in the North, and is still offered by more than forty nurseries across the continent. In places such as Fruita, Utah, it has been called White Concord instead of Niagara, and in this way, its genealogy can be more widely celebrated.

The fruit of this heirloom are enormous, and come in large compact clusters. Their slipskins are thick, and range from pearly white to anemic green. Their flavor, as one would expect from recent origins, remains somewhat foxy, but can be tangy and delicate at the same time. Niagara is fine to eat as a table grape, but makes a distinctive white wine as well. Its vines are incredibly hardy and resilient in cold weather, and can be trellised to climb arbors in attractive patterns. This New England original has been cultivated in New Mexico for no less than seventy years.

At Capitol Reef, Niagara grapes grow along the fence between the Doc Inglesby Picnic Grove and the Nels Johnson Orchard.

PEACHES (*Prunus persica)*

Elberta. Now the most popular of all peaches in the markets, Elberta emerged as a selection grown by Samuel H. Rumph, Marshallville, Georgia, from a seed of Chinese Cling planted in the fall of 1870. The most appealing feature of Elberta is wide adaptability, or as one author has said, “freedom from local prejudices of either soil or climate,” creating the most cosmopolitan of its species.

Its fruits average two and three-fourths inches long, two and one-half inches wide, are round, slightly oblong or chordate, usually with a slight bulge at one side. Its cavity is deep, flaring, and often mottled with red, while its suture is shallower. The fruit skin is thick and tough and easily separates from the pulp. Its immature color is greenish-yellow, ripening to orange-yellow, with half of the skin overspread with red. Its hairs are densely fuzzy and coarse. The flesh of Elberta is deep yellow, but it is stained with red near the pit. The sweet pulp is juicy, somewhat stringy, firm but tender, mildly subacidic, and separates free from the stone. Some fully ripened Elberta peaches leave a bitter, tangy aftertaste in the mouth, which some peach connoisseurs find disagreeable. They claim that because Elberta is now picked green and allowed to ripen not on the tree but in refrigerated market bins, it is deemed scarcely edible by those who know good peaches.

What Elberta lacks in flavor it makes up for in fruitfulness. If frosts or freezing winds do not force it to drop its blossoms, the trees are laden with fruit year after year. Elberta trees routinely withstand insects and fungi, and grow to be large, vigorous, upright-spreading, densely topped specimens.

The Elberta peach has been planted in the Carrell and the Max Krueger orchards.

Garnet Beauty. A bud mutation of Red Haven, this cultivar was selected in the Garnet Bruner Orchard, of Ontario, Canada. Introduced to the United States in 1958, it is sometimes simply called Garnet. A dozen nurseries continue to offer it.

The fruit has red, almost fuzz-free skin, is medium to large sized, and slightly elongated. Garnet is similar to its parent except that it ripens somewhat earlier. The semi-freestone flesh is yellow, with red streaks near the pit. The texture is smooth, fine grained, and firm, making it a good candidate for most culinary uses: pies, preserves, canning, and freezing.

The Garnet Beauty peach has been planted in the Max Krueger Orchard.

J.H. Hale. This variety began its career as a chance seedling found by its namesake J.H. Hale of South Glastonbury, Connecticut. Judging from its characters, it is clearly either an offspring or a close kin to Elberta; in fact, to the untrained eye, they are identical. Nevertheless, after J.H. Hale evaluated its performance in Connecticut and Georgia, he deemed it worthy of introduction, selling his rights to the William P. Stark Nurseries in Stark City, Missouri. The Stark nursery began to distribute the Hale variety in 1912.

In fruit size and shape, J.H. Hale is on the average larger and more perfectly spherical than Elberta. They are lemon yellow washed with a dark red blush and splashes of carmine. The skin of J.H. Hale is lightly fuzzy, but firmer and tighter, and although it is a freestone, its skin does not separate as easy from the pulp. Its trees are as productive as Elberta, being vigorous, upright spreading, and open-topped. Like Elberta, it is widely adapted to a variety of climes and soils.

J. H. Hale peaches have been planted in the Carrell and the Max Krueger orchards.

Redhaven. This cultivar is a cross between Hale Haven and Kalhaven that was introduced by Michigan State Agricultural Experiment Station in 1940. Redhaven is now considered the standard for early red peaches, and is available from dozens of nurseries. Its name is also spelled Red Haven.

This is a medium sized fruit that lacks any fuzz. Its skin is bright crimson red all over. The firm yellow flesh becomes freestone as it ripens. Redhaven is well suited for desserts, canning and freezing. The fruit handle well and resist browning or bruising.

The trees set fruit abundantly, if they are not exposed to leaf curl, brown rot, Oriental fruit moth or twig borer. In other words, they are not very tolerant to many pests, diseases or to cold winters.

Redhaven peaches grow in the Max Krueger Orchard.

Rosa. Also spelled Roza, this cultivar was developed at the Washington State Agricultural Experiment Station in Prosser, Washington. Its availability has been in decline, and it is available only from three U.S. nurseries.

A large, round freestone peach, its skin is faintly streaked over a medium red blush across three-quarters of its surface. It has firm yellow flesh that is coarse textured but highly flavored. It typically ripens somewhat later than Redhaven. It is best for home use but moderately tolerates shipping for market trade. Its vigorous trees are productive and self-fertile.

Rosa peaches grow in the Max Krueger Orchard.

PEARS (*Pyrus communis)*

Bartlett. This pear was brought to North America from England in the 1790's. In parts of the British Isles, this classic heirloom was, and is still known as the William pear. Once in the U.S., this name was gradually forgotten, and by 1817, the variety had become better known as the Bartlett pear. It did not take long for the Bartlett to become the most widely planted pear in America. Its fruits remain more common in American grocery stores and roadside markets than any other pear.

The Bartlett attains a rather large size for a pear. Its shape is oblong-obtuse-pyriform, tapering toward the apex. The skin is thin, tender and easy to bruise, but smooth. The surface of the skin is subtly pitted and somewhat uneven. As it ripens from a pale green, the color of the skin turns toward clear yellow, and gains a faint rosy blush on the exposed cheek. The skin is often thinly russetted around the basin, with scattered dots that are small and green or russet. The mature flesh can be fine-grained, but is often slightly granular near the center of the fruit. Fully ripened, a Bartlett can be buttery, juicy, vinous, and mildly aromatic, but today it is often picked, shipped, sold and eaten before these qualities accumulate.

Bartlett trees are adapted to a wide range of soil types, climates and growing conditions. They bear many large fruit from a rather early age, and can be long-lived. The disadvantages of the Bartlett are that the trees are very vulnerable to blight, extreme winter cold and summer heat. They are simply not as cold hardy or as heat-resistant as some newer varieties. Furthermore, other pears are better flavored more richly perfumed than the reliable but commonplace Bartlett. There is, however, no other pear that is so easily grown in North America, and so readily available for canning.

The Bartlett pear has been planted in the Behunin Grove, the Chesnut Orchard, the Group Campsite, the Holt orchard, the Merin Smith Place, the Mott Orchard, the Nels Johnson Orchard, and the Tine Oyler Place of Capitol Reef National Park.

Flemish Beauty. The parent to Flemish beauty is said to have been a seedling found growing in the woods near Alost, Eastern Flanders, Belgium. It was first brought into trade under the name of Bosc peer, or "pear of the woods." Flemish Beauty was introduced in 1810 under another name, Fondante des bois, under which it was grown in England for many years. Lindley, writing in 1831, was the first to describe this heirloom variety under the name of Flemish Beauty.

The fruit of Flemish Beauty is large, two and three-fourths inches long and two and a half inches wide and rather uniform in shape, which is as round as it is ovate pyriform. Its skin is thick, tough, and dull rather than glossy. Skin color is a clear yellow, overspread on the exposed cheek with a dotted and marbled reddish blush. These underlying colors are overlain with numerous russet dots. Its flesh is creamy yellow, firm and smooth. As it fully ripens, it becomes melting and tender, rather granular but juicy. The Flemish Beauty has a sweet, aromatic musky flavor of the finest quality.

To attain its most exquisite flavor and fragrance, these pears must be picked just as they reach their fullest size, and then they must after-ripen, wrapped in paper, in a cold cellar. It is said that a slowly after-ripened Flemish Beauty is incomparable in the pleasure it offers, for its rich flavor is delicately balanced between sweetness and sourness, with a musky aftertaste not unlike certain dessert wines.

Flemish Beauty trees are late bearing, but remain vigorous and fruitful for many years. This heirloom was at one time the leading commercial fruit variety in certain regions of the eastern U.S. renowned for their pears. However, because of its susceptibility to pear blight and scab fungus, the Flemish Beauty has been replaced by other, disease-resistant varieties in all but the most remote locales that are isolated from the spread of these diseases.

Flemish Beauty pears grow at the Gifford house, the Holt Orchard, the Jackson Orchard, and the Nels Johnson Orchard.

Flemish Beauty

Winter Bartlett. Sometimes known simply as Winter Pear, this heirloom appears to have originated around 1880 in or near Eugene Oregon. It was then introduced into trade by D.W. Coolidge, a Pasadena California nurseryman. Its superficial resemblance to other Bartletts is the basis of the assumption that it was a chance seedling derived from that variety.

Larger in size but showing the characteristic pyriform shape of Bartletts, this winter pear has yellow uneven skin that blushes red on the sun-exposed cheek, while being splashed with russets on the other sides. The firm flesh is creamy yellow white, fine-grained and tender. Sweet and pleasant in flavor, the pulp is juicy and of good to very good keeping quality. The fruit are typically harvested later than classic Bartletts, and fully ripen in storage between December and January. The trees are unusually large, with loose spreading canopies that mature to fruiting size quite rapidly. The Greenmantle Nursery in Garberville, California is the only mail-order outlet still known to carry this heirloom.

We believe the two unknown pears #672 and #673 in the Cook Orchard are the variety Winter Bartlett, though this will need genetic verification.

Winter Bartlett

PECANS *(Carya illinoisensis)*

Native. Native or seedling pecans are those that have not been grafted and do not have a varietal name. Native pecans have been widely used by indigenous peoples within its native range, from northeastern Mexico through most of the southeastern US, and their shells occur in many archaeological sites in the Mississippi watershed. Their formal cultivation began around the 1700s, but then declined with the development of named cultivars and improved grafting techniques in the mid-nineteenth century.

Native pecans are small, difficult to shell, and have a low percentage of edible kernels relative to their thick shells. The nuts have high oil content, an excellent flavor, and are preferred by many rural folks because of these characteristics. They are excellent for pastries and candies because of this rich flavor, but their small size and thick shells preclude their widespread use.

A row of Native Pecan trees is planted in the Tine Oyler North Orchard, to the east of the Holt House.

PLUMS (*Prunus* species)

Duarte (*Prunus salicina*). A Japanese plum now offered by just two nurseries in the United States, the Duarte has also been the raw material for an improved cultivar of the same name. It has very large, heart-shaped fruit with blood-red skin and flesh. Among the best-tasting plums found in western fruit markets, they are both sweet and tart, dry well and have long storage lives. The semi-dwarf trees seldom grow beyond a height of twelve feet, begin bearing in as little as three years, but are short-lived. They require the presence of another Japanese plum variety as a cross-pollinator to bear well.

The Duarte tree has been planted in the Mott Orchard of the Capitol Reef National Park.

Italian Prune (*Prunus domestica*). The Italian Prune is one of the most widely grown of all plums. As its name implies, it originated in northern Italy at least a century ago, where it was historically popular in the hills surrounding Milano. According to the London Horticulture Society, it had arrived in England by 1831. The following year, Prince described it as an excellent prune recently introduced to North America from Europe. Within decades, it was among the top four most popular plums along the Atlantic seaboard of America and the leading plum for drying into prunes in the Pacific Northwest.

The fruit are nearly two inches by an inch and a half in size, long oval, enlarged on the suture side, and slightly compressed, with the halves unequal. Their color is purplish-black, overspread with very thick bloom. The skin of Italian plums is thin, but somewhat tough, and separates readily from the flesh. The tart flesh is at first greenish-yellow, changing to bright yellow, and is juicy, firm, subacidic, and slightly aromatic. It is free stone.

The Italian plum has a fine flavor whether eaten fresh, stewed or cured as a prune. With cooking its color changes from yellow to a dark, wine color, but keeps a most pleasant, sprightly flavor. When cured as a prune, the flesh is firm and meaty, yet elastic.

The low-topped trees can be large, spreading or upright, and are usually productive. They are well formed and bear regularly, but seem to be susceptible to many diseases, insects, and hot, dry weather.

Italian Prune Plums are planted in the Max Krueger and Nels Johnson orchards.

Italian Prune

Potawatomi (*Prunus munsoniana*). This plum is native to the middle Mississippi and lower Missouri watersheds, but was apparently translocated to the Colorado Plateau and Great Basin either by Mormons or miners. In southern Utah, it is restricted to hedgerows and vacant lots in small Mormon villages, rarely reaching beyond these anthropomorphic landscapes into truly wild habitats. Sometimes spelled Pottawattamie, or simply called the wild or hog plum, its horticultural potential first came under the notice of J.B. Rice of Council Bluffs, Iowa in 1875, who named it after one of the countries of his home state, thereafter making it available to nurserymen in many other states.

The fruit are variable in both color and size, ranging from seven-eights of an inch to an inch and an eighth inches in diameter. In shape, they are round to oval, and slightly compressed. There is a very shallow cavity on one side of them. Their skin color runs from a clear currant-red with thin bloom, to pale yellow and white. Over this basal color are a few whitish dots clustered about the apex. The skin of this plum is tough, cracking under conditions of high heat, separating readily from the flesh of the fruit. The stem of each fruit is slender, three-quarters inch long, and weakly adheres to the fruit itself. The flesh of this plum is deep yellow, juicy, tender and melting. Most Mormons familiar with Potawatomi plums described them as sweet next to the skin but sour at the center, with a memorable flavor. The plum pit or stone clings closely to the flesh, is five-eights by three-eights inch in size. The pit is flattened, smooth, somewhat oval and turgid. Its dorsal suture is faintly grooved.

The trees are really dwarfish, multi-stemmed shrubs at maturity, seldom more than seven feet tall, and often forming hedges that average less than five feet in height. They are vigorous in their branching, and especially productive when receiving irrigation tailwaters, or growing alongside a ditch or a road. They are considered to be among the hardiest of the native plums, growing without danger of winter injury to tree or bud far into cold winter climes.

The Potawatomi is lauded in *The Plums of New York* as "possibly of greater cultural value" than any other wild American plum, for the flavor of its flesh is "of high quality…, the texture of the fruit being especially pleasing in eating, and though melting and juicy, it keeps and ships very well because of a tough skin. It escapes both the curculio and the brown-rot to a higher degree than most of its kind…" Elderly Mormons claimed that as children during the Depression, they survived on this fruit more than any other grown in their villages of Mt. Carmel, Caneville, Henrieville and Torrey at that time. As Lulu More of Henrieville Utah told us,

> "*We didn't have much food in those days when I was growing up…There Were no big orchards around here then, so when us kids could find them Potawatomi plums, it was a real treat.*"

Potawatomi Plums grow in Adams Orchard, Behunin Grove, Holt Orchard, and along the River Trail near Hattie's Field.

Potawatomi Plum

Santa Rosa (*Prunus salicina*). Luther Burbank developed the Santa Rosa in 1906 from his trials of Japanese plums. Its place of origin, the Luther Burbank Home and Gardens in Santa Rosa, Sonoma County, California, is now a National Historic Landmark. This cultivar is widely available, and still distributed by more than forty nurseries in North America.

The Santa Rosa is very large for a plum, round, heart-shaped or slightly oval in shape, with purplish red skin carrying a thin bloom and light dots. Its clingstone flesh is purplish near the skin, but pink with yellow streaks near the pit. The flesh is fragrant and fine-textured with a flavor that remains memorable whether it has been eaten fresh or canned. The fruit ships well.

The trees are partially fertile, and bear best with cross-pollination in the presence of other Japanese plums. The trees grow vigorously and become quite large, but are susceptible to bacterial spot.

The Santa Rosa tree has been planted in the Mott Orchard of the Capitol Reef National Park.

Stanley. This is a European-type plum developed from a hybrid of Agen and Grand Duke cultivars that were introduced into trade by the New York State Agricultural Experiment Station in Geneva around 1926. It remains so popular that it is available from at least three-dozen nurseries across the United States. It may still be the most widely planted plum of its kind in the East, Midwest and South.

The dark blue Stanley plum carries a thick whitish bloom on its skin. It is medium to large in size, and oval in shape. Its freestone flesh is firm and fine-grained, and a yellowish-green that turns purplish red when canned. It has a sweet rich flavor excellent for eating fresh, for canning, drying or preserves.

Late bloomers but early bearers, Stanley trees are large and spreading. They are self-fertile but benefit from the presence of other varieties for cross-pollination, and either way, can be heavy bearers.

A Stanley Plum grows next to the Holt House in Capitol Reef National Park.

Yellow Egg. This cultivar sprang up as a chance seedling in the Tiddesly Woods near Pershore, Worcestershire, England. It became a very popular plum, but has since been largely replaced by other varieties. The fruit is good for both canning and fresh use. This plum is sometimes simply referred to as Pershore.

As the name implies, the Yellow Egg Plum is a large, oval plum that looks somewhat like an egg. The golden-yellow flesh is firm and juicy, with a semi- free stone pit. The flavor is rich and sweet when the fruit is fully ripe, but it is tart if eaten before maturity. The fruit ripens from mid-August to September, depending on location. The trees are vigorous, fast growing, and develop a tall and spreading habit. They are very productive and self-fruitful.

The Yellow Egg plum is planted in the Nels Johnson Orchard at Capitol Reef national Park.

Yellow Egg Plum

QUINCES (C*ydonia oblonga).*

Champion. Although this species is native to central and western Asia, it was introduced into the English-speaking world by 1275 A.D., and became a major raw material for marmalades in England by the sixteenth century. Because all quince cultivation declined as soft fruit became more storable in the nineteenth century, little is known of the origins of particular varieties. The fruit of this heirloom is bright yellow, and strongly russeted near the stem. The shape is described as obscure pyriform, that is, between the shape of an apple and pear. The calyx is set in a deep and strongly corrugated basin. The fruit is larger than the common quince, and ripens later and more tenderly than that any other quince. The flesh is yellow, only slightly astringent, sweet, and has a delicate flavor.

It fruits at a young age on vigorous, very productive trees that tend to produce ripe fruit by mid-season. The tree grows twelve to fifteen feet tall, is very vigorous and hardy. Its shoots have a very dark color, which is a feature that can be used to distinguish it from other varieties. The flowers are big, white and showy. This variety is known to be somewhat difficult to propagate from cuttings.

Champion Quince trees are planted in the Nels Johnson Orchard of Capitol Reef National Park.

Champion Quince

Van Damen. This variety, developed by Luther Burbank, was a popular quince variety offered by Stark Brother's Nursery of St. Louis, Missouri. Burbank developed the variety by crossing Orange and Portugal quinces. Over 700 crosses were required to produce the desired characteristics of the variety. It was introduced into the nursery trade in 1881. The fruits are large, oblong, and bright yellow. They are highly valued for cooking and making jellies.

When mature, this heavy bearing quince grows ten to twenty feet in height, forming a large shrub or small tree.

An old Van Damen quince grows at the Gifford Place of Capitol Reef National Park.

WALNUTS (*Juglans* species)

Black Walnut (*Juglans niger*). A native of eastern North America, the Black Walnut can be found growing wild along rivers and streams from central Texas northwards to Ontario, Canada.

The fruit is deeply furrowed and has a semi-fleshy husk that typically drops off the nut in October. The nuts are round, two inches or so in diameter, and the unimproved varieties may be difficult to crack. While the meaty nuts are highly flavorful, difficulties in shelling them preclude their widespread use as food. However, the Black Walnut is also highly valued for its beautiful dark brown wood, which is easily worked into furniture.

The Black Walnut is a large deciduous tree growing to heights of one hundred feet or more. The bark is dark grey-black and deeply furrowed. The twigs have pithy centers filled with air spaces. The pinnate leaves are alternate, with 15 to 23 leaflets per frond-like leaf. They are widely available from nurseries.

A lone Black Walnut persists along the road near the Nels Johnson Orchard at Capitol Reef national Park.

Carpathian Walnuts (*Juglans regia*). Introduced into the US and Canada in 1939 by Reverend Paul C. Crath, who obtained seed from the Carpathian Mountains of Poland. Crath first distributed his Persian Walnut-like seed nuts through the University of Guelph in Canada, and through the Wisconsin Horticultural Society, and they have continued to be dispersed by more than two-dozen nurseries in North America.

Plump but thin shelled, this heirloom is slightly smaller version of the English walnut. The nuts have a rich, full-bodied flavor and keep their excellent quality in storage. In late fall, the nuts fall free of their husks.

Carpathian walnuts are much hardier and more pest and disease resistant than their pampered English cousins. Their canopies are quite symmetrical and as much as forty feet wide, while growing up to fifty feet in height. The sturdy limbs are dark grey, with lacey dark green foliage. The self-fertile trees prefer sunny spots, with well-drained, deep and fertile soils.

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Appendix 11

Orchard Tree Pruning Techniques

The following techniques have been excerpted from the North Carolina Cooperative Extension guide to Pruning and Training Orchard Trees, located at http://www.ces.ncsu.edu/depts/hort/hil/ag29.html#open

Central Leader Training - Apple, Cherry, Pear, Pecan, Plum

A central leader tree is characterized by one main, upright trunk, referred to as the leader. Branching generally begins on the leader 24 to 36 inches above the soil surface to allow movement under the tree. The first year, 3 to 4 branches, collectively called a *scaffold whorl*, are selected. The selected scaffolds should be uniformly spaced around the trunk, not directly across from or above one another. Above the first scaffold whorl, leave an area of approximately 18 to 24 inches without any branches to allow light into the center of the tree. This light slot is followed with another whorl of scaffolds. Alternating scaffold whorls and light slots are maintained up the leader to the desired maximum tree height. See Figure 1.

The shape of a properly trained central leader tree is like that of a Christmas tree. The lowest scaffold whorl branches will be the longest and the higher scaffold whorl branches will be progressively shorter to allow maximum light penetration into the entire tree.

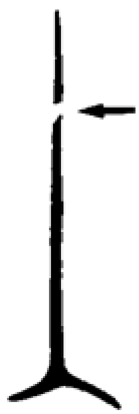
Developing a Central Leader Trained Tree At Planting

Fruit trees are frequently purchased as whips, which are unbranched trees ranging from 1/2 to 3/4 inch diameter. The tree should be planted in early winter with the graft union 2 inches above the soil surface. Just before the buds start to grow in the spring, the tree should be headed, or cut off, at 30 to 34 inches above the soil surface. The height at which the tree is headed depends upon where you want the first whorl of branches. Once the tree is headed, permanent branches will be selected from buds growing within 4 to 12 inches below the heading cut. See Figures 1 and 2.

Figure 1. Pruning a central leader tree

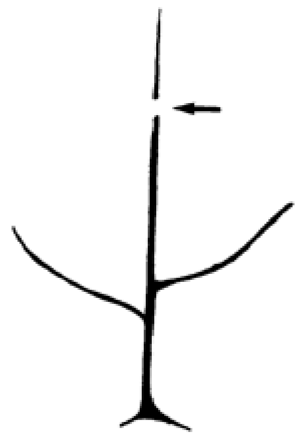
At Planting

As the buds begin to swell, head the tree at 30 to 34 inches above the soil surface.

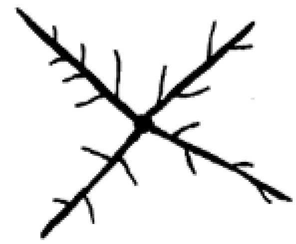


Dormant Pruning

Head the tree at 24 to 30 inches above the highest branch of the first scaffold whorl.

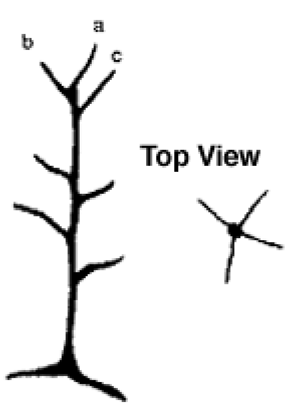


Top View



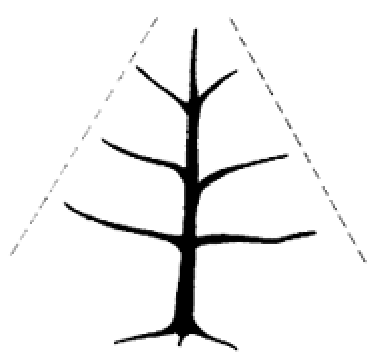
First-Year Summer Pruning

Summer prune when new growth is 3 to 4 inches long. Leave **a** as the new leader, and remove **b** and **c**. Select four uniformly spaced laterals for the first scaffold whorl, and remove the remaining lateral branches.



After pruning the third year

Three scaffold whorls have been developed with three to four branches uniformly spaced around the tree in each whorl. A light slot of 18 to 24 inches is left between each scaffold whorl. Note the Christmas-tree shape that allows light penetration to the lower branches and interior of the tree.



Steps in Pruning:

- Leave only one trunk for the central leader.
- Remove branches with crotch angles less than 60 degrees.
- Remove all branches directly across from one another on the leader.
- Space lateral branches uniformly around the leader to prevent crowding as the limbs grow in diameter.

Figure 2. Newly planted apple tree headed back

Summer Pruning

After the new vegetative growth has reached 3 to 4 inches in length, summer pruning should begin. The first step is to select one upright shoot near the top of the tree to be the leader. After selecting the leader shoot, remove all other competing shoots for approximately 4 inches below it; rehead the tree above this leader. See Figures 3 and 4.

Figure 3.
Left: Heading an apple tree at planting results in several competing shoots below the cut.

Right: For central leader tree, a single leader needs to be selected by removing the undesired shoots.

Figure 4. Central leader plum trees must also have competing shoots removed.

At this time, side shoots (laterals) should be spread out to form an angle of 60 to 70 degrees between the leader and the side shoot. This angle is referred to as the branch or crotch angle. Branches that do not have a wide branch angle are overly vigorous and have a weak point of attachment to the leader. These branches frequently break under a heavy fruit load. Spreading the lateral branches will also slow the growth of the branches to a manageable level and promote the development of secondary or side shoots on the scaffolds. When growth is only 3 to 4 inches, toothpicks or spring clothespins can be used to spread branches. See Figure 5. After a proper branch angle is attained, clothespins can be moved to the ends of longer limbs to weigh down the branches as they start to grow upward.

Figure 5. Central leader apple trees. Toothpicks are used to spread the lateral branches outward during the first growing season.

During the first year, minimize further summer pruning. Limit it to the removal of shoots growing upright or downward. Summer is the optimal time to select the leader and scaffold branches and remove undesirable growth. Branches lower than the desired height should also be removed. A young orchard or tree should be summer trained and pruned once a month through July to remove unwanted growth and to properly orient young branches. Summer pruning will greatly reduce the amount of dormant pruning needed.

Failure to summer prune the first year will result in an improperly trained tree, and drastic dormant pruning will be required to correct tree structure.

Succeeding Years

Managing the central leader is one of the most important aspects of dormant pruning. The leader should be headed at approximately 24 to 30 inches above the highest whorl of scaffolds to promote continued branching and scaffold whorl development. Dormant pruning should also eliminate dead, diseased, and damaged wood. Unwanted growth, such as upright growing shoots and laterals with sharp branch angles not removed during summer pruning, should also be removed at this time. Unbranched lateral branches should be headed back by approximately 1/4 of their length to encourage side branches and to stiffen lateral branches.

Summer pruning in succeeding years should eliminate competing shoots where dormant heading cuts were made (on the central leader and laterals) as in the first year. Summer is also the optimal time to remove unwanted side shoots and excessive growth. All laterals should have a wide branch angle, and spreading of lateral branches is essential for many varieties. Lateral branches will need to be spread for about the first five years, using a larger spreader each year.

Spreaders can be made with 1inchsquare wood pieces with a finishing nail driven in the end and cut off at an angle. Spreaders are frequently made in lengths of 6, 12, and 18 inches. See Figure 6.

Figure 6. Wooden limb spreaders can be made from wood and finishing nails in various lengths.

Spreading branches in later years reduces vigor and promotes fruit development on the lateral branches. The reduced growth rate and the weight of the crop load will also help pull the branches down to a proper angle. However, it is important that the young tree is not allowed to crop too early where the weight of the fruit pulls the branches below horizontal. Once the branches are below horizontal, they are weak and nonproductive and need to be removed and replaced. See Figure 7.

Figure 7. Well-trained apple trees. Note the branch angles and the development of scaffold whorls.

Another objective of dormant pruning is to control the length of the lateral branches. In order to maintain the Christmastree shape (Figure 1), lateral branches need to be cut back.

Once the tree has reached its desired height and lateral spread, it will be necessary to mold and hold the lateral branches and the central leader with heading cuts. This can be done by cutting the laterals and leader back into twoyearold wood to a sidegrowing shoot. It is a good rule to cut back to a side shoot that is close to the same diameter as the lateral or leader being cut.

Mature Trees

Mature trees that have been properly trained and summer pruned will require minimal pruning. The first step would be to remove dead, diseased, and damaged wood and then upright shoots and shoots below horizontal. To prevent shading, it is important to maintain the Christmastree shape by heading lateral branches with mold and hold cuts. See Figure 8. For quality fruit production, it is also essential that the light slots between the scaffold whorls be maintained.

Figure 8. Mature, well-trained apple trees, left, and pecan trees, right. Note that the distance between branches needs to be increased for larger trees.

Mature fruit trees that have not been properly trained frequently do not have a true central leader shape. For those trees, the objectives of training and pruning as discussed earlier must be considered. In many cases, too many lateral branches and upright limbs (some may be 6 or more inches in diameter) have been left and need to be removed to allow proper light penetration. This pruning needs to be done during the dormant season.

Neglected trees often have overgrown tops that act as an umbrella, shading the rest of the tree. The tops of these trees need to be cut back or removed. Remember, if the principles of pruning are followed, there are no perfect cuts and no incorrect cuts. However, do not remove more than 30 percent of the tree top to avoid shifting the tree into an excessively vegetative state with little fruit development.

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OpenCenter or Vase Training - **Peach, Nectarine, Plum**

With the opencenter system, the leader is removed, leaving an open center. Instead of having a central leader, the opencenter tree has 3 to 5 major limbs, called scaffolds, coming out from the trunk. This training system allows for adequate light penetration into the tree, which minimizes the shading problem prevalent in highervigor trees such as peach.

At Planting

At planting, peach trees should be set so that the graft union will be 2 inches above the soil surface. As the buds begin to swell, the unbranched trees (whips) are generally headed approximately 30 to 34 inches above the soil surface. As discussed with the central leader system, new branches will come from the buds that are 6 to 9 inches below the heading cut.

Trees that are branched at planting are handled differently than the whips. The work that needs to be done under the tree determines the appropriate height for branching, which is usually 24 to 32 inches. Remove branches that are too low. If there are 3 to 4 uniformly spaced branches around the tree that can be selected as scaffolds, the tree is headed just above the highest selected scaffold. Any remaining branches not selected as scaffolds should be removed. However, if there are less than 3 scaffolds the tree should be cut back to a whip and the side branches removed. See Figures 10a and 10b.

Summer Pruning

After the new vegetative growth is approximately 3 to 4 inches long, it is time to select the shoots that will become the major scaffolds. The lowest scaffold should be 24 to 32 inches above the soil surface to avoid interfering with cultural work under the tree, such as harvesting and weed control. It is best to select 3 to 4 scaffolds that are uniformly spaced around the tree, with wide branch angles, and not directly across from another scaffold. See Figure 10a.

Figure 10a. Training and pruning young peach trees.
Left: Well-branched peach tree to be trained to an open-center system
Right: 3 to 5 well-spaced scaffolds re selected and the tree is headed above the highest scaffold.

During the summer, these shoots should be spread out to a 45 to 60 degree angle and held in place with a toothpick or clothespin. All other upright growth should be removed. It is best to come back through every month during the summer to remove upright growth that is shading the primary scaffolds and to make sure that the scaffolds have been spread to a proper angle. Many times the crotch angle is proper initially, but as the scaffolds grow, they turn upright. A spring clothespin placed on or near the end of a shoot will pull the scaffold down to a proper angle. Extreme care must be taken when using the clothespins as weights. Periodic checking is essential to assure that the scaffolds are not too flat.

Figure 10b. Training and pruning young peach trees.
Left: Tree after heading, branches lower than 24 inches are also removed.
Right: Top view of uniformly spaced scaffolds.

Succeeding Years

After the first year of growth, the primary scaffolds should be selected and properly trained outward. Scaffolds should be headed during the dormant season of the first three years to promote continued lateral branching on the scaffolds and to stiffen and strengthen the scaffold. Scaffolds should be headed to outwardgrowing shoots similar in angle to those being removed. Bench cuts should be avoided. See Figure 11a.

Figure 11a. Dormant pruning a mature open-center peach tree.
Left: Tree before pruning.
Right: Heading a scaffold to an outward growing shoot.

If summer pruning is being practiced, undesirable shoot growth can be removed as soon as growth is 4 to 6 inches long. Summer pruning can also be used to direct scaffold growth outward to the desired growing points instead of waiting until the dormant season.

For bearing trees, the goal of dormant pruning is to remove vigorous upright growth on the scaffolds and trunk that was not removed during the summer. See Figure 11b.

Figure 11b. Dormant pruning a mature open-center peach tree.
Left: Removal of vigorous upright shoots in the center of the tree.
Right: Tree after pruning.

The upright growth left in the tree during the growing season may shade out lateral growth near the trunk. This shading causes lateral fruiting wood only on the ends of the scaffolds, which results in broken scaffolds under a heavy fruit load. It is best to keep the fruiting wood on the scaffolds as close to the tree trunk as possible to reduce tree breakage and to produce the highestquality fruit.

Also, during the dormant season, damaged, dead, and diseased wood, such as cankers, should be removed from the tree. Shoots with shriveled and dried fruit from the previous season, called mummies, should also be removed from the orchard to reduce disease pressure for the coming season.

Appendix 12

Removal of Undesirable and Invasive Plants

Overview of Undesirable Plants Management Process

1. Conduct a Weed Inventory
   a. Monitor the presence of invasive species (appendix 13), note the arrival of new invasive species, and identify local and regional trends.
   b. Identify problem areas within the Monument
2. Prevention
   a. Limit seed dispersal
   b. Minimize soil disturbance
   c. Manage desirable vegetation
3. Eradication
   a. Identify target species and select appropriate control methods
   b. Encourage replacement by desirable species

(Sheley 1999)

Inventory and Monitoring for Undesirable and Invasive Plants

Although it is especially prudent to monitor areas that have been disturbed by management activities, all areas of the Monument should be regularly monitored for invasive and undesirable species as well as overpopulated desired species (see appendix 13 for the Pipe Spring Invasive Plant List). Annual or biannual studies can provide the information necessary for maintaining a resilient and diverse natural plant community.

Data Collection

One of the simplest techniques is a quadrant or plot study. A mobile square perimeter (often $0.1m^2$-$1m^2$) can be constructed of PCV pipes or other light materials. The square is then placed in numerous areas representative of all the Monument's plant communities. The plots should be marked by GPS or ground markers in order to revisit them during future surveys. Within each plot, data including species presence/absence, number, and % cover, can be collected and used to evaluate the following metrics:

- Frequency (How often a plant is present)
  - Frequency = (# of plots in which the species is present/ total number of plots) X 100
- Density (Number of plants of a species per area)
  - Density = Mean # of individuals of the species for all plots/ area of one plot

- Cover (amount of the plot covered by the crown, or shadow of the species)
  - Cover is visually estimated and can be broken into intervals (1-10%, 11-20% etc.)
- Biomass (dry weight of the above-ground portions of herbaceous plants and the year's growth of leaves, twigs, and fruits of woody plants)

Data Application

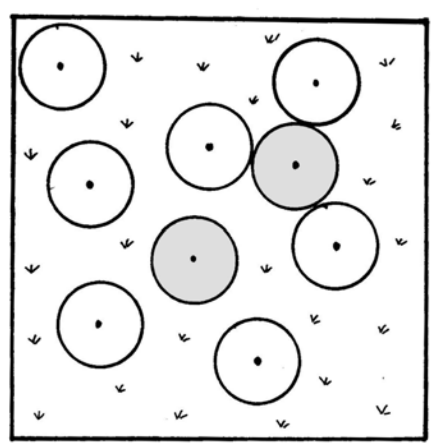
The information above can provide trends in species growth and decline, the presence and spread of invasive or undesirable species, succession, and community composition. In addition to indentifying invasive and undesirable species for treatment, a healthy community composition can be maintained by comparing species trends to information from sources such as Rangeland Productivity and Plant Composition Charts (appendix 8), Ecological Site Descriptions (appendix 6), and VegSpec reports (appendix 7). Although historic climax communities are often beyond feasibility (once disturbance has crossed a successional threshold), this data also provides information relating to potential present day climax communities under particular conditions.

Simplified Example Application for Grassland Revegetation Plots

A revegetation site is selected between the visitor center and the flood ditch. The soil type for this area is Monue: Sandy Loam Upland 7-11 p.z. Calcareous. The Ecological Site Description (ESD) for the soil type provides the following information:

Structure and Cover:
Ground Cover (%)
Vegetative Cover
Grass/Grasslike : 1-5%
Forb: 0-1
Shrub/Vines: 10-20%
Trees: 0

Upon conducting a quadrat study of the site, a mean density of 9 sagebrush per plot (1 m^2) and a relative cover of 40% is calculated (Appendix Figure 12.1). Sagebrush is the only shrub species associated with the plant community and the only species found on the site. The desired shrub composition of the community, according to the ESD is a maximum of 20%. Accordingly, the recommended treatment is the removal of approximately 20% of the sagebrush on the site and an estimated density of 7 sagebrush/ m^2 (Appendix Figure 12.1). This process is then repeated for each vegetative cover type and species within the cover type.



Appendix Figure 12.1: *Example of shrub thinning in a 1* m^2 plot *to produce 40% cover or 7 sagebrush/* m^2

Preventing the Establishment and Proliferation of Undesirable Plants

Niche Concept

The concept of an ecological niche is critical to maintaining a native species assemblage that will limit the potential for the establishment of undesirable and invasive species. Niches include all the abiotic and biotic requirements of a particular species. A community of species that maximize the use of niches in a particular location will also maximize resource efficiency and prevent the infiltration of additional undesirable species. Niches can be filled by combinations of species whose resource use varies both temporally and spatially. A plant community, for example, might be composed of plants with shallow roots, deep roots and intermediate roots. Although they may be extracting the same resources, their activity is spatially distributed. In the same community two species may both require he same nutrient in order to germinate. If one species germinates in the spring and the other in the fall, then they are using the same resource but their use is temporally separated. If a community fills the spectrum of available niches, few resources will remain for new species and the community as a whole may be more resilient through long-term environmental changes, disturbances, and invasions.

The concept of the niche can be applied to by maintaining a healthy natural species assemblage that varies in both spatial and temporal resource use. This includes features such as root form, nutrient requirements, germination season, reproductive strategy, photosynthetic pathways and growth rate. Revegetation projects and/or site treatments may be necessary in areas that have lost their integrity.

Overview of Eradication Treatment Methods

Generally, there are four treatment types that can be used to manage undesired plant species: Biological, Manual, Mechanical, and Chemical control. An integrated approach uses multiple treatment types to achieve more effective results.

Manual Removal

Manual removal is a labor intensive method through which undesired plants are removed without the use of chemicals or specialized equipment. Manual removal, by pulling, digging or chopping, is most efficient for very young plant seedlings which have not yet established deep taproots. This treatment does not apply to root suckers, which look similar to seedlings but are fused to an adult plant’s lateral roots. During manual removal, it is important to ensure that no roots or tree fragments remain, as many species can establish new plants through root suckering. Manual removal is easiest when the soil is moist, after a period of saturating rain.

Mechanical Removal

Mechanical removal, which includes cutting and girdling, requires the use of specialized equipment such as saws, disks, and tillers to remove woody plants. Mechanical removal poses some risk in certain species that respond by sprouting or root suckering, replacing the original plant with multiple offspring. Mechanical removal, when using large equipment, can injure desirable plants and harm biological soil crusts.

Cutting

Cutting (felling) is best applied when the species' food storage in the roots is depleted from leaf, shoot, and seed growth, reducing the energy available for sprouting. It is also important to cut plants as young as possible, before a large root system supporting sprouts and root suckers is developed.

Girdling

Girdling is an alternative mechanical treatment that kills individual plants (trees) without felling them, benefiting wildlife by leaving dead wood or snag habitat. Girdling cannot be applied in areas where standing dead trees are hazardous or unaesthetic, such as along paths or in public spaces. Girdling effectively severs the tree's nutrient and energy circulatory system, but it may take up to 2 years before the tree drains its remaining energy supply and succumbs to the treatment. To girdle a tree, the bark, cambrium and phloem must be severed over a large enough area around the circumference of the tree, essentially carving out a collar. Girdling is a fairly technical process, and incorrectly girdling trees can be hazardous and encourage root suckering and sprouting. Like cutting, even well executed girdling may encourage root suckering and resprouting, creating a more serious situation. For more technical information on girdling, see the referenced USDA publication "Tree Girdling Tools".

Chemical Treatments

Chemical treatments, or herbicides, are more aggressive and pose greater potential environmental and human health risks than other methods, however, applied correctly herbicide application is an efficient and labor-saving method. In some instances, less frequent chemical treatments may be less invasive and environmentally harmful than frequent long-term site disturbance through alternative treatments.

There are four common chemical treatments: foliar spraying, basal bark spraying, cut-stump treatments, and the hack & squirt method. There are particular herbicides that are most affectively used for each method. For each of these treatments, the directions, warnings, and safety precautions from the selected herbicide's manufacturer should always be consulted and followed. Climatic conditions should be carefully noted before application, as many chemicals have optimal temperature ranges, absorption times (before rain, for example) and wind mobility. Dyes are also available as additions to herbicide mixtures. These dyes allow the applicator to see where spray has been applied, avoiding excess herbicide and accidental overspray affecting desirable species.

Note: Herbicide resistance can occur when the same herbicide is applied over several seasons. Repeated applications can select for resistant plants, creating a more difficult population to manage and a potential long-term threat. Resistance can be avoided by limiting the frequent application of herbicides with a long residual soil lifespan, annually rotating the type of herbicide applied, and by adopting an integrated weed management program that utilizes a combination of control methods (Sheley 1999).

Foliar Spraying

Foliar spraying is perhaps the easiest chemical treatment, but it is only applicable when the entire crown of the plant is accessible. It should also be avoided when desirable plants are in very close proximity and where dead trees are hazardous or unaesthetic. During foliar spraying herbicide mixed with water and a non-ionic surfactant is applied to all of the plant's leaves and shoots with a herbicide sprayer or a brush (for small plants). Foliar spraying can be used as both a primary treatment and as a supplementary treatment to curb sprouting and root suckering following other treatments. Foliar spraying uses a larger volume of herbicide than other treatments, but at a diluted concentration.

Foliar spraying must be done after the plant has fully leafed out. It is important to reduce the treatment's impact on the environment and surrounding vegetation by carefully spraying or brushing only the leaves of the target plant and by completely coating the leaves with herbicide without oversaturating them and causing drips.

When treating herbaceous species, it is important to distinguish annual and perennial species that reproduce vegetatively. Annual species should be treated before flowering, preventing seed dispersal. Perennial species that reproduce vegetatively should be treated in the late fall (and late spring as a less effective alternative) when the herbicide will be most efficiently translocated through the roots, rhizomes etc (Sheley 1999).

Basal Bark Spraying

Basal bark treatments are effective on trees up to 12” in diameter in locations where standing dead trees are not hazardous or unaesthetic. In this treatment herbicide is mixed with oil (fuel, kerosene, or mineral), and sprayed onto the lower 12”-18” of the trunk, completely covering the bark around the full circumference of the tree and any emergent roots. Unlike foliar spraying, basal bark spraying has a much lower risk of affecting surrounding plants. The herbicides can, however, reach desirable plants through the soil if an area is sprayed heavily. It is also a fairly easy method that does not require cutting. The greatest disadvantage of basal bark treatments is that a greater volume of herbicide is needed to cover the entire lower trunk than is needed in other treatments, depending on the size of the tree.

Basal bark treatment is most affective in late winter and early spring as well as mid to late summer but can be used year round. Foliar spraying should be supplemented to treat any resulting sprouts or root suckers. When applying herbicides, the trunk must be free of debris and dry. Rainfall following the application will not affect the treatment. Dead trees should not be removed for at least 6 months after the treatment.

Cut Stump Treatment

Cut stump treatment is a highly effective but labor-intensive method in which the stump of a felled tree or shrub is treated with a concentrated herbicide, spreading into the roots and preventing suckering and sprouting. This method is ideal for treating trees and shrubs that must be fully removed (felled), especially larger trees. This method uses less herbicide than basal-bark or foliar treatments because a concentrated herbicide is applied. Cut stump treatment affects adjacent vegetation by the process of felling, but because the herbicide is applied directly to a small surface of the stump it is less likely to reach desirable plants.

The herbicide must be applied to the outer 1/3 of the cut surface, covering the entire circumference, within five minutes of cutting (longer if an oil mixture is used). The herbicide is easily applied with a spray bottle or paintbrush. Hand-help spray applicators are also available. Trees that have previously been cut may still be treated with the cut stump method after a second cutting.

The summer growing season is the most effective time during which to apply cut stump treatments, though the trees should be checked for bird nests before felling. Trees and shrubs selected for cut stump treatment should be examined for connectivity to desirable trees, as a treated sucker may kill a desirable adult through shared roots. Foliar spraying should be applied to root suckers and sprouts that emerge after the treatment.

Hack and Squirt Method

The hack and squirt method requires herbicide to be injected, or applied, to a series of cuts in the bark of the tree. The herbicide is then carried through the vascular system of the plant, killing the upper portion and inhibiting sprouting and root suckering. This method should be used on plants that can stand dead without creating a hazard or affecting site aesthetics. Hack and Squirt may more affectively kill roots systems than cut stump treatments. Along with cut stump treatments, the hack and squirt method uses less herbicide in a higher concentration than other treatments. Although root suckering and sprouting is inhibited during the growing season, foliar treatment will likely be necessary in the fall.

The hack and squirt method requires that a tree be punctuated by a series of downward angled cuts into the tissue of the tree made with a hand-axe. The cuts should be made at 1’-2” intervals around the entire circumference of the trunk at any height. It is recommended that 1 cut be made for each inch in diameter, plus one more cut. It is important to leave un-cut tissue between cuts, preventing a self-preservation response that sends nutrients to the roots of the tree.. A concentrated herbicide is then applied directly to the cuts with one or two squirts from a spray bottle or other had-held applicator. The herbicide should coat the cut without dripping. The herbicide should be applied within 1-2 minutes for the maximum effectiveness. Hack and squirt treatments are most affective during the summer growing season, especially in the fall, but can be used less effectively in the winter.

Recommended Treatment

The following guidelines can be used to select an appropriate treatment:

Conditions for use:

Foliar Spraying

- All leaves are accessible
- Target can be herbaceous or woody
- The tree or shrub is small or can stand dead
- Some potential impact on understory species is allowable
- Treatment can be applied in the late spring through the summer

Chemical Use: high
Ease of Application: Very easy

Basal Bark

- Tree is <6” DBH
- Tree is small or can stand dead
- Some potential impact on understory species is allowable
- Treatment can be applied in late winter- early spring or mid-late summer, though year-round use is acceptable.

Chemical Use: High
Ease of Application: Very easy

Cut Stump

- Complete removal of the plant is desired
- Tree or shrub is of any size
- Location permits safe felling
- Tree or shrub is clear of desired bird species nests
- Treatment can be applied during the summer

Chemical Use: Low volume, high concentration
Ease of Application: More difficult (felling)

Hack and Squirt

- Tree is > 2” dbh

- The tree can stand dead
- Foliar treatment can be applied following the treatment, late summer
- Treatment can be applied most affectively during the fall and summer growing season, but also may be used in the winter.

Chemical Use: low volume, high concentration
Ease of Application: Moderate- more difficult (size dependant)

Appendix 13

Pipe Spring Invasive Species List

The following list was compiled for Pipe Spring National Monument in 2004

Scientific Name	**Common Name**	***Present?***	***Comments***
Aegilops cylindrica	jointed goatgrass		
Agropyron cristatum	crested wheatgrass	*x*	
Agrostis stolonifera	redtop	*x*	
Ailanthus altissima	tree-of-heaven	*x*	
Alyssum alyssoides	yellow alyssum		
Amaranthus albus	tumble pigweed		
Amaranthus retroflexus	redroot pigweed		
Arctium minus	common burdock		
Arundo donax	giant reed		
Brassica tournefortii	Witch-wand		**WATCHLIST**
Bromus inermis	smooth brome	*x*	
Bromus rigidus	ripgut brome	*x*	
Bromus rubens	red brome	*x*	
Bromus tectorum	downy brome	*x*	
Capsella bursa-pastoria	shepard's purse		
Cardaria chalapensis	Orbicular whitetop		
Cardaria chalepensis	lens-podded whitetop		
Cardaria draba	hoary cress		
Carduus nutans	musk thistle		
Cenchrus longispinus	sandbur	*x*	
Centaurea diffusa	diffuse knapweed		**WATCHLIST**
Centaurea maculosa	spotted knapweed		**WATCHLIST**
Centaurea melitensis	Maltese starthistle		**WATCHLIST**
Centaurea pratensis	Meadow knapweed		**WATCHLIST**
Centaurea repens	Russian knapweed		**WATCHLIST**
Centaurea virgata	Squarrose knapweed		**WATCHLIST**
	Yellow starthistle		**WATCHLIST**
Chenopodium album	lambsquarter	*x*	
Chondrilla juncea	Rush skeletonweed		
Chorispora tenella	blue mustard	*x*	
Cirsium arvense	Canada thistle		**WATCHLIST**
Cirsium vulgare	bull thistle		**WATCHLIST**
Conium maculatum	poison hemlock		
Convolvulus arvenis	field bindweed		
Cynodon dactylon	Bermudagrass	*x*	
Cynoglossum officinale	houndstongue		
Dactylis glomerata	orchard grass		
Descurainia sophia	flixweed	*x*	
Descurainia sophia	redstem filaree		
Dipsacus sylvestris	common teasel		
Echinochloa crus-galli	Barnyardgrass	*x*	
Elaeagnus angustifolia	Russian olive		
Elymus elongatus	tall wheatgrass	*x*	
*Elymus hispidus**	intermediate wheatgrass		
Elymus repens	quackgrass		
*Eragrostis cilianensis**	stinkgrass		
Erodium cicutarium	storksbill	*x*	
Euphorbia esula	leafy spurge		**WATCHLIST**
Euryops subcarnosus spp.	sweet resin bush		**WATCHLIST**
Festuca arundinacea	tall fescue	*x*	
Festuca pratensis	Meadow fescue		
Halogeton glomeratus	halogeton		
Hordeum murinum	rabbit barley	*x*	
Hyoscyamus niger	black henbane		
Isatis tinctoria	Dyer's woad		
Lactuca serriola	prickly lettuce		
Lepidium latifolium	perrenial pepperweed		
Lepidium perfoliatum	clasping pepperweed	*x*	
Linaria dalmatica	Dalmation toadflax		

Linaria vulgaris	yellow toadflax		
Lythrum salicaria	purple loosestrife		**WATCHLIST**
Malcomia africana	African mustard	*x*	
Marrubium vulgare	common horehound	*x*	Target for control.
Marrubium vulgare	white horehound		
Melilotus alba	white sweetclover	*x*	
Melilotus officinalis	yellow sweetclover	*x*	
Moloccella laevis	bells of Ireland		
Onopordum acanthium	Scotch thistle	*x*	Target for control.
Pennisetum setaceum	crimson fountaingrass		
Phleum pratense	timothy		
Phragmites australis	common reed		
Poa bulbosa	bulbous bluegrass		
Poa pratensis	Kentucky bluegrass	*x*	
Polygonum aviculare	knotweed	*x*	
Polypogon semiverticillata	water polypogon		
Rubus discolor	Himalayan blackberry		
Rubus idaeus	wild raspberry		
Rumex crispus	curly dock	*x*	
Salsola iberica	Russian thistle	*x*	Target for control.
Saponaria officinalis	bouncingbet		
Sisymbrium altissimum	tumble mustard	*x*	
Solanum triflorum	cutleaf nightshade		
Sonchus arvensis	perrennial sowthistle	*x*	There's a question if we have all 3 Sonchus sp.
Sonchus arvensis L. ssp. u	marsh sowthistle		
Sonchus asper	spiny sowthistle	*x*	
Sonchus oleraceus	common sowthistle	*x*	
Sorghum halepense	johnsongrass		
Tamarix ramosissima	saltcedar	*x*	Maintenance mode on the monument - mostly eradicated.
Taraxacum officinale	dandelion	*x*	
Tragopogon dubius	goatsbeard	*x*	
Tribulus terrestris	puncturevine	*x*	Target for control.
Ulmus pumila	Siberian elm	*x*	
Verbascum thapsus	common mullein	*x*	Target for control.
Alhagi macrourum	**Camelthorn**		**WATCHLIST**

Appendix 14

Native and Water-Wise Plant Selection

Native Plants

The following sources are recommended for the selection of native plant species:

- Busco, Janice, and Nancy Morin. 2003. *Native Plants for High Elevation Western Gardens.* Fulcrum Publishing.
    - Focused on native plants of northern AZ, recommended by Barbara G. Philips (see references)
- Arizona Native Plant Society http://www.aznps.com/
    - Currently working on a native plants list for AZ (see web page). Also provides member publications and additional native plan information.
- Utah Native Plant Society http://www.unps.org/index.html
    - Offers a variety of native plant resources and information
- The Southwest Environmental Information Network (SEINet) http://swbiodiversity.org/seinet/ident/index.php
    - This web page provides species lists compiled from field studies across the state. Although the site does include non-native plants, it can be used to acquire additional specs for desired species.
- Local Public Agencies (Zion NP etc.)
    - May be a sources for native seed material
- The Association of Official Seed Certifying Agencies (AOSCA) http://www.aosca.org/
    - Provides inspection and labeling programs that ensure the selection of site-appropriate species for restoration projects utilizing purchased seed sources. The AOSCA requires that information including source, genetic identity, and genetic purity be available to the consumer.
- Ecological Monitoring and Assessment Program and Foundation (Northern Arizona University and Stewards of the Southwest) http://www.emaprogram.com/nansa.asp
    - Web page provides links to publications and organizations involved in Arizona grassland conservation efforts.
    - *Northern Arizona Native Plant Feasibility Report* publication offers copious information pertaining to seed sources, selection, and gathering in Arizona. Potential seed sources include:
        - Flagstaff Native Plant and Seed
            - Sells locally adapted (Colorado Plateau) plant material
        - The Arboretum at Flagstaff
            - Potential plant source, provides native plant material for internal restoration projects

        - Is currently working with Coconino, Kaibab, and Prescott National Forests as well as the Museum of Northern Arizona to establish a local genotype native seed source for restoration projects in northern Arizona *Feasibility Report*)
    - NRCS Plant Materials Center, Los Lunas NM.
        - Has contracted with NPS and NFS to produced native plant materials for restoration projects (collects local seeds, propagates offspring at Los Lunas and transplants them back into the restoration site as seedlings)

Water-Wise Plants

The following sources are recommended for the selection of water-wise plant species:

Note: Species should be selected for USDA Hardiness Zone 6

- Mee, Wendy, Jared Barnes, Roger Kjelgren, Richard Sutton, Teresa Cerny, and Craig Johnson. 2003. *Water Wise: Native Plants for Intermountain Landscapes.* Utah: Utah State University Press.
    - This publication is focused on water wise plants for the intermountain regions of the West but does provide information on water wise plants suitable to the Pipe Spring area. *Water Wise* provides species descriptions, habitat information, and landscape uses.
- Phillips, Judith. *Plants for Natural Gardens*. 1995. Santa Fe: Museum of New Mexico Press
    - Although not limited to water-wise plants, this publication provides native and adaptive species lists by ecosystem for the southwest. An appendix provides more specific information regarding water requirements and water-wise plants selections.

Appendix 15

Tree Planting Techniques for Sensitive Areas

The following techniques have been excerpted from USDOI, OCLP, and NAOP. "Clippings: Replacing Trees in Cultural Landscapes".

REPLANTING A TREE

Replacing trees that have been removed from cultural landscapes is an important part of preserving historic character. The procedures used to replant trees, however, if not carefully planned, can be disruptive and damaging to resources adjacent to the planting site.

Selecting planting techniques for replacing trees in cultural landscapes begins with considering many of the same factors used in choosing procedures for stump removal. For example, are there fragile resources near the planting site that will limit equipment access; will the planting process impede other site activities; and, is there adequate funding available to replace the plant using the desired procedure?

Considerations:

1. Site Management

- Do current planning and preservation objectives support the replacement of the tree?
- Does replacement of the tree support contemporary use and activities at the site?

2. Planting Location

- What size does the replacement tree need to be?
- Will preparing the planting hole require moving soil where it has not been previously disturbed?
- Has the stump and root system been adequately removed to prepare for planting a replacement?
- Since the removal of the original plant, have there been any changes to the site or environment that may adversely affect the replacement tree?
- Is there adequate light exposure, water for irrigation and space for the replacement tree to establish and grow?
- Did the previously removed tree have a root disease that could infect the replacement tree?
- Will the newly planted tree require staking or guying that could impede site circulation or activities?

3. Feasibility of Implementation

- Is there adequate funding and staffing to replace and maintain the replacement tree?
- Are there nursery sources available for the replacement plant or is it a unique type that is not commercially available?
- Are there any local, state or federal policies regarding the particular species to be planted?

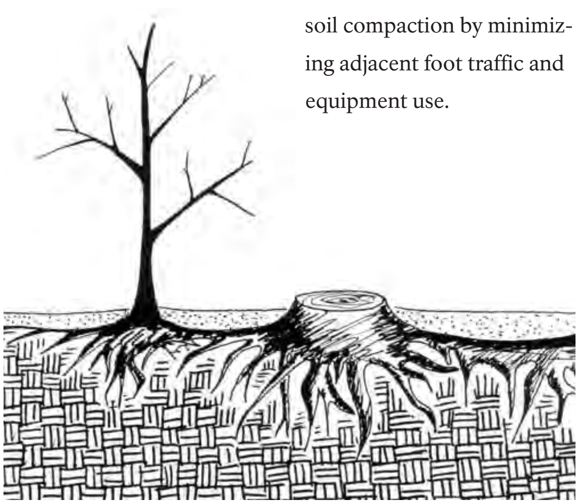
Using a horse drawn wagon to move a large tree for planting, c. 1860.

ROOT SPROUT

Encouraging growth of a healthy root sprout can be an ideal strategy for replacing deteriorated historic trees. The procedure retains the genetic authenticity of the original plant and requires no soil or site disturbance to implement. Before implementing this strategy, determine that the tree is not a grafted specimen. A tree that has been grafted will have a root system that is genetically different from the rest of the plant. A root sprout from a grafted tree may grow to be a completely different plant than desired. Grafted trees can often be determined by an enlarged "graft union" at the base of the trunk.

Procedures:

- Select a vigorous root sprout that has strong growth characteristics and is well anchored into the soil and connecting root system of the original tree. If possible, allow the original tree to remain in place until the root sprout is well established. This may take 2 to 4 years.
- After removing the original tree, allow the stump to remain and naturally decompose. Removal of the stump may cause damage to the root sprout.
- Mulch around the base of the root sprout to prevent weeds from growing and competing with the root sprout and to maintain soil moisture for optimum growth. Keep mulch 6 to 12 inches away from the trunk and bark of the root sprout.
- Protect the root sprout from problems associated with soil compaction by minimizing adjacent foot traffic and equipment use.



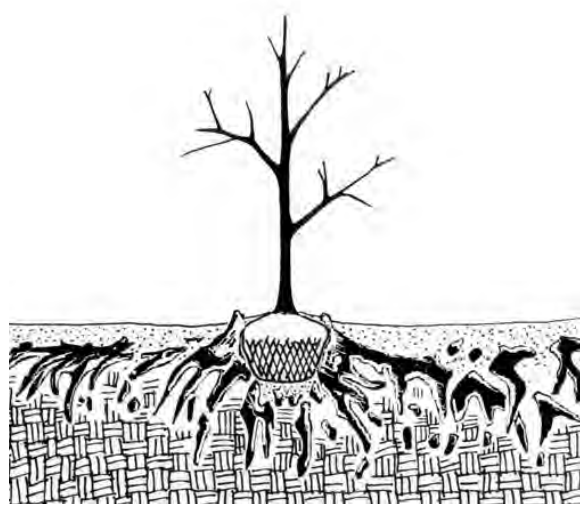
Encouraging the growth of a root sprout is ideal for replacing a tree in locations where site disturbance must be avoided.

PLANTING INTO A DECAYED STUMP

A tree can often be replanted in the location of a decayed stump. This can be an ideal method for replacing trees in areas that have rich archeological resources because it causes very minimal site disturbance. Replacement plants with small rootballs are best suited for this approach because preparation of a smaller hole is needed for planting.

Procedures:

- Assess the extent of decay within the stump. Replanting in the same location will only be effective if the decomposition is well advanced.
- Select the smallest acceptable plant size for replacement. The rootball must be small enough to fit into the decomposed area of the stump with at least 6 to 8 inches of additional space around the roots to backfill with soil.
- Using hand tools, break up and remove the decayed wood remaining from the stump. Create adequate space for planting the rootball and backfilling with soil.
- When planting, elevate the top 2 to 3 inches of the rootball above the surrounding grade.
- Backfill the hole with soil that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.



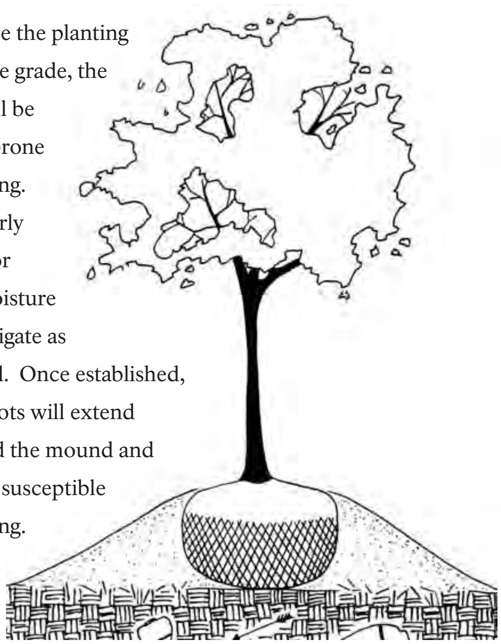
Planting in the same location as a decayed stump allows replacing trees in the exact location as the original.

MOUND PLANTING

Mound planting can be a very effective method for replacing a tree where it is necessary to minimize ground disturbance. This technique mounds soil around a root ball that is placed on the existing grade. The method does not affect underground resources, such as archeological materials or roots of adjacent plants; however, it alters site grading and can change the visual character of the landscape. It is best to use replacement plants with small root balls in order to reduce the amount of soil mounding needed for planting.

Procedures:

- Using a rake, scarify the parent soil to a depth of 2 inches.
- Place tree so that its rootball rests solidly on the ground and the trunk stands upright.
- Mound soil around rootball using fill that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible.
- Taper the mound into the surrounding grade a minimum distance of five times the width of the rootball. Using a replacement tree with the smallest acceptable rootball will minimize the size of the mound required. Mulch to prevent soil erosion.
- Because the planting is above grade, the soil will be more prone to drying. Regularly monitor soil moisture and irrigate as needed. Once established, tree roots will extend beyond the mound and be less susceptible to drying.



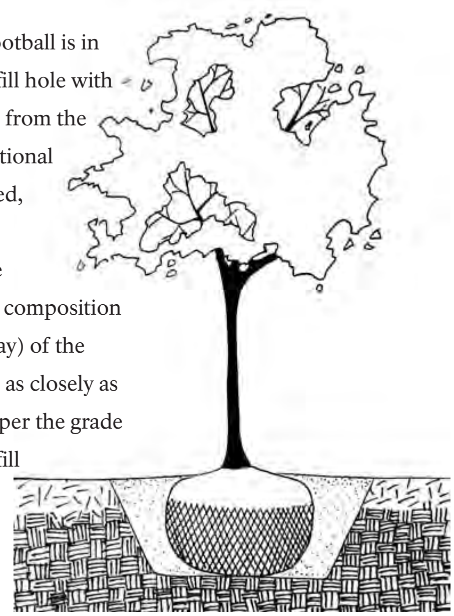
Mound planting is highly effective to minimize disturbance of archeological resources or roots of adjacent plants.

REDUCED TREE PIT

Preparing a smaller planting hole causes less disturbance to the site and adjacent resources as compared to the damage that can be caused by digging a larger planting pit. Traditional horticultural recommendations for planting a tree involve preparing a bowl shaped hole 2 to 3 inches shallower than the depth of the rootball and 3 to 5 times the width of the rootball to be planted. This approach, while good for the plant, can cause significant soil disturbance that damages archeological features, nearby plants, and other adjacent cultural resources. Preparing a planting hole with a reduced width combined with the traditional horticultural recommended bowl shape and shallow depth can significantly reduce disturbance to the site and adjacent cultural resources. Use this method when planting within the root zones of other important vegetation or where the preparation of a larger planting hole would damage adjacent resources.

Procedures:

- Select a replacement tree with the smallest acceptable rootball size.
- Prepare the planting site by digging a hole twice the width of the rootball at the grade surface, tapered slightly to the hole bottom in a bowl-like shape. The depth of the hole should allow for 2 to 3 inches of the top of the rootball to extend above the surrounding grade.
- Once the rootball is in place, backfill hole with original soil from the site. If additional soil is needed, use fill that matches the texture and composition (sand:silt:clay) of the original soil as closely as possible. Taper the grade of the backfill soil to the top of the rootball.



Reducing the size of the planting hole can help protect adjacent resources.

Appendix 16

Soil Survey Results

The following data were obtained in 2008 through a survey of 15 soil sample sites throughout the Monument. A map is provided to correlate with the survey “sample ID” column.

Soil Survey Locations

4/30/2008

Pipe Spring National Monument
Attn: Andrea Bornemeier
HC 65 Box 5
Fredonia, AZ 86022

Samples Received: 4/21/08

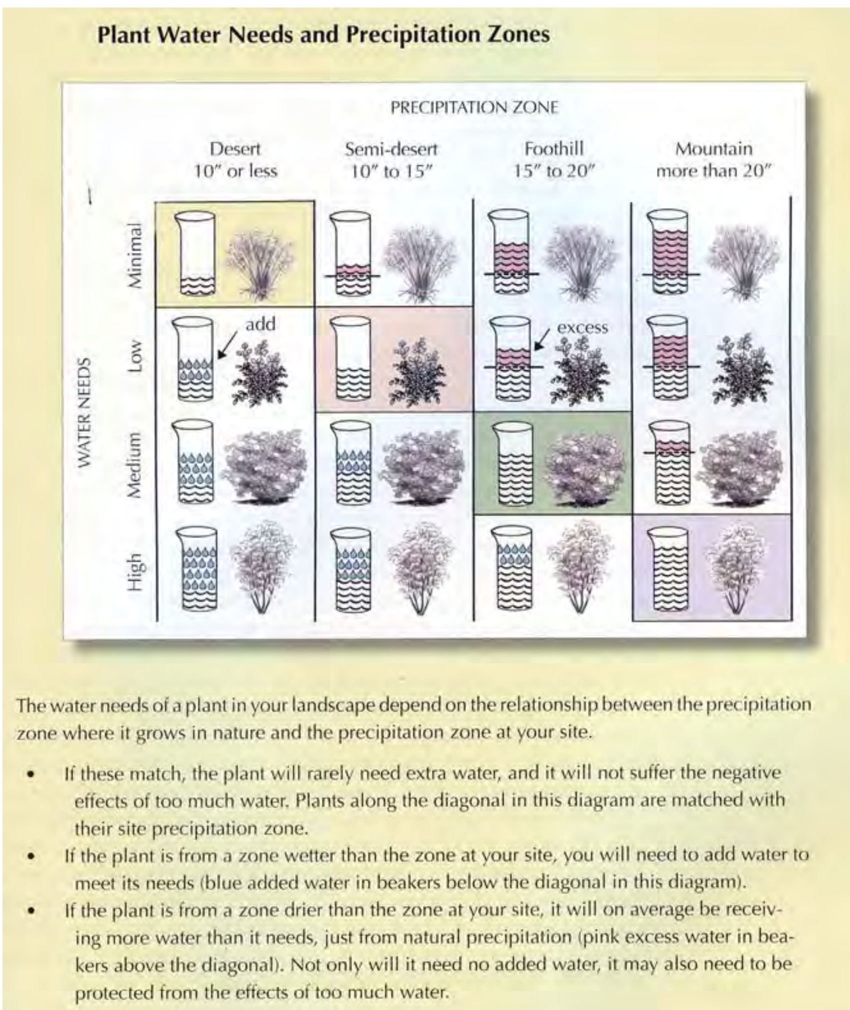
USU #	Sample ID	Texture	pH	EC dS/m	Phosphorus	Potassium	Nitrate-Nitrogen
					----------mg/kg----------		
8010775	1	SANDY LOAM	7.64	0.50	10.6	140	8.04
8010776	2	SANDY LOAM	7.70	0.49	16.5	272	6.14
8010777	3	SANDY LOAM	7.44	0.25	8.7	130	5.24
8010778	4	SANDY LOAM	7.48	0.45	25	169	7.44
8010779	5	SANDY LOAM	7.57	1.00	111	392	26.7
8010780	6	LOAM	7.49	2.37	45	281	92.5
8010781	7	SANDY LOAM	7.79	1.10	70	482	14.0
8010782	8	SANDY CLAY LOAM	7.60	0.80	32	167	7.37
8010783	9	SANDY CLAY LOAM	7.55	2.04	35	370	41.8
8010784	10	SANDY LOAM	8.07	0.65	41	176	13.9
8010785	11	SANDY LOAM	7.57	2.79	27	438	73.8
8010786	12	LOAM	7.34	2.13	14.6	253	73.1
8010787	13	SANDY LOAM	7.54	0.70	51	267	15.8
8010788	14	SANDY LOAM	7.70	0.50	15.5	223	5.04
8010789	15	SANDY LOAM	7.64	0.80	29	281	16.2

Appendix 17

Watering Monument Plants

Understanding Plant Water Needs

The first step in determining an irrigation schedule is to identify the water needs of each plant species. These needs are determined by the native habitat of the species and are usually listed on nursery tags (drought-tolerant, low, medium, high) and available by contacting a local nursery or plant expert. Generally, native or desert adapted plants will not require irrigation unless precipitation is below average. The purpose of irrigation is to supplement enough water to match the precipitation of a plant's native environment. Therefore, if a tree native to a region that receives 20" of precipitation a year is planted in a region that receives only 10", then 10" of water must be provided by irrigation (Appendix Figure 17.1, 17.2).



Appendix Figure 17.1: *Water needs and Precipitation (Meyer 2010)*

Watering Guidelines for Established Plantings in Different Landscape Watering Zones

Watering guidelines are based on average annual precipitation in inches at the site.

Site Precipitation Zone	Average Annual Precipitation (inches)	Inches of Water to Add in an Average or Better Water Year for Plantings in Each Landscape Water Zone			
		Minimal	Low	Medium	High
Desert	6	4	10	14	20
Desert	7	4	8	14	18
Desert	8	2	8	12	18
Desert	9	2	6	12	16
Desert	10	--	6	10	16
Semi-desert	11	--	4	10	14
Semi-desert	12	--	4	8	14
Semi-desert	13	--	2	8	12
Semi-desert	14	--	2	6	12
Semi-desert	15	--	--	6	10
Foothill	16	--	--	4	10
Foothill	17	--	--	4	8
Foothill	18	--	--	2	8
Foothill	19	--	--	2	6
Foothill	20	--	--	--	6
Mountain	21	--	--	--	4
Mountain	22	--	--	--	4
Mountain	23	--	--	--	2
Mountain	24	--	--	--	2
Mountain	25	--	--	--	--

1. The sum of natural precipitation and added water for each landscape water zone equals the high average value for that zone (10 inches for desert, 15 inches for semi-desert, 20 inches for foothill, and 25 inches for mountain).
2. Two inches are recommended at each irrigation, so the total irrigation amounts are adjusted upward to represent multiples of two.
3. To calculate the number of times to water, divide the total number of inches by two.
4. If precipitation at the site exceeds the water requirement for plantings in a particular landscape water zone, the irrigation value is left blank.

Appendix Figure 17.2: *Watering Guidelines for Established Plantings by zone (Meyer 2010)*

The following paragraphs have been excerpted from "Landscaping on the New Frontier", based on the Intermountain West (Meyer 2010):

> For native plants not regularly irrigated… "if winter and spring have been dry, with precipitation less than 80% of average, it is a good idea to apply two or three inches of water at the beginning of the summer, say in late May. This watering can be carried out at night with a portable sprinkler over a two or three day period, or each plant can be hand watered two or three times with the equivalent of an inch of water over the area of its root system. This will substitute for the recharging of deep soil water that usually occurs with adequate winter precipitation, and will usually be enough to get your plants through the summer in good shape. If really grim heart and drought conditions persist, you can water once in midsummer, again applying at least two inches."
>
> For non-native or adapted plants…. "to determine how much and how often to irrigate in the water zones in your landscape that require regular irrigation, you calculate the total number of inches you need to add, then divide this number by two, because you want to add about two inches each time you water. The total number of inches divided by two equals the number of times you will need to water during the course of the growing season. For example, if you are in the semi-desert with eleven inches of annual precipitation and you have a mountain planting in a high water zone, you need to add fourteen inches of water to top the water up to the twenty-five inches that mountain zone plants expect. If you add two inches each time you water, you would need to water seven times over the course of the growing season, starting when the soil starts to dry out in early summer. It is usually not necessary to begin supplemental irrigation until around the first of June in the semi-desert zone, and by mid-September, the weather has cooled off and autumn storms have often arrived. Seven irrigations spread across this fourteen-week period means that you would water approximately once every two weeks.
>
> If the winter and spring have been exceptionally dry, the best way to help out the plants in your higher water zones is to add extra water at the beginning of the season, just as you did for the plants in unirrigated zones, to help encourage the deep soil water. You could start watering a couple of week earlier, and add two or three inches of extra water before beginning the regular irrigation season. If the summer is brutally hot and dry, you could add an extra irrigation or two some time during the hottest part.
>
> It is also perfectly acceptable to let the plants tell you when they need extra water. This will not be as obvious as the wilting of a tomato plant, but with experience you will learn to recognize the signs. Resist the urge to add water in amounts greatly in excess of those recommended, however. Remember, there is such a

> thing as too much water. For example, penstemon plants that are dying of vascular wilt diseases aggravated by overwatering look a lot like penstemon plants that are wilting from lack of water. And be aware that yellowing leaves usually mean that your watering is excessive, not that the plants need more water."

Signs of too much or not enough water

A common mistake is to overwater native plants. These plants usually only require supplemental irrigation (rather than regular, permanent irrigation) when rainfall averages are below normal. It's recommended that Pipe Spring monitor precipitation rates from a local weather station and irrigate native and/or desert species only when precipitation is below average.

The Arizona Department of Water Resources provides the following guidelines for recognizing signs of water stress:

Signs of underwatering:

- Soil in the lower portion of the root zone is dry.
- Older leaves turn yellow or brown and drop.
- Leaves are wilted or drooping.
- Leaves curl.
- Stems or branches die back.

Signs of overwatering:

- Soil is constantly damp.
- Leaves turn lighter green or yellow.
- Young shoots are wilted or drooping.
- Leaves are green yet brittle.
- Algae and/or mushrooms are on or around plants.
- Growth is excessive.

Watering Schedule

The Arizona Municipal Water Users Association's publication "Landscape Watering by the Numbers: A Guide for the Arizona Desert", provides the following water schedule for Arizona (Appendix 17.3):

WATER USE IT WISELY.

LANDSCAPE WATERING GUIDELINES

How Much & How Often Water to the outer edge of the plant's canopy and to the depth indicated. Watering frequency will vary depending on season, plant type, weather and soil.		Seasonal Frequency — Days Between Waterings				Water This Deeply (Typical Root Depth)
		Spring Mar - May	Summer May - Oct	Fall Oct - Dec	Winter Dec - Mar	
Trees	Desert adapted	14-30 days	7-21 days	14-30 days	30-60 days	24-36 inches
	High water use	7-12 days	7-10 days	7-12 days	14-30 days	24-36 inches
Shrubs	Desert adapted	14-30 days	7-21 days	14-30 days	30-45 days	18-24 inches
	High water use	7-10 days	5-7 days	7-10 days	10-14 days	18-24 inches
Groundcovers & Vines	Desert adapted	14-30 days	7-21 days	14-30 days	21-45 days	8-12 inches
	High water use	7-10 days	2-5 days	7-10 days	10-14 days	8-12 inches
Cacti and Succulents		21-45 days	14-30 days	21-45 days	if needed	8-12 inches
Annuals		3-7 days	2-5 days	3-7 days	5-10 days	8-12 inches
Warm Season Grass		4-14 days	3-6 days	6-21 days	15-30 days	6-10 inches
Cool Season Grass		3-7 days	none	3-10 days	7-14 days	6-10 inches

These guidelines are for established plants (1 year for shrubs, 3 years for trees). Additional water is needed for new plantings or unusually hot or dry weather. Less water is needed during cool or rainy weather. Drip run times are typically 2 hours or more for each watering.

Appendix Figure 17.3: *Water Schedule for Arizona*

Watering New Plantings

New plantings will require more water than established plants in order to dvelope a firm root system. The following guidelines can assist with determining how much and for how long new plants must be watered (quoted from Meyer 2010):

- Perennials usually root in faster than shrubs, and shrubs root in faster than trees. In general, the larger the plant is at the time of planting, the longer it will take to root in.
- Planting in the fall, perennials and small shrubs will be well rooted by the end of the following spring while large shrubs and trees will require supplemental water through the first growing season
- Tress may not show signs of water stress if inadequately watered during establishment, but their growth rates will be much reduced. If you are interested in a rapid growth rate, then extra water during the first two growing seasons is a good idea for trees.
- If you plant when the weather is cool (spring or fall), fill the planting holes with water, and water in the plants, then you only need to water about once a week for the first month, and even less if there is substantial natural perception
    - You can cut this back to once every two weeks for the second month, then start the regular watering regime for plants that will receive regular irrigation. For plants that do not receive regular irrigation, water at least once a month for the remainder of the growing season.

- For large shrubs and trees in unirrigated zones, water once a month during the second growing season, starting when the weather warms up and the soil begins to dry.
- If you plant when the weather is hot, a practice that is not recommended but works better for natives than for many traditional garden plants, you will need to water more often, especially during the first month. Watering as often as every second day may be necessary.

Technical Guide:

*The following guidelines apply to drip irrigation systems, which are recommended for a water conscious landscape

Converting Inches to Gallons

The first step in determining irrigation needs is to correlate drip irrigation rates, expressed in gallons, with plant water requirements, expressed in inches. Research shows that, depending on soil type, water spreads in approximately a 1’ radius from an emitter (Meyer 2010). Therefore, one emitter waters the area of a circle that has 1’ radius. Appendix Figure 17.3, below, demonstrates how to relate gallons and inches for a single emitter.

Watering by the Numbers

4. Gallons Versus Inches

The approximate area watered by a single point-source drip emitter equals a circle with a radius of 1 foot. The area of a circle equals the radius squared times *pi* (3.14):

area watered: *1 × 1 × 3.14 = 3.14 square feet (or approx 3 square feet)*

The amount of water needed to apply 1″ of water to a square foot is 0.625 gallons. To add 1″ of water to the 3 square feet watered by a single emitter:

0.625 gallons × 3.14 square feet = 1.96 gallons (or approx 2 gallons)

To apply 1″ of water, the emitter needs to apply about 2/3 gallon × 3 square feet (or approximately 2 gallons of water).

Appendix Figure 17.4: *Converting Gallons to Inches(Meyer 2010)*

How Much Water?

A common mistake in irrigation practice is to adjust the volume of water applied rather than the frequency of the application. Generally, it is recommended that 2” of water be applied each irrigation, insuring that enough water can deeply penetrate the soil (Meyer, 2010). Plants with lower water requirements are then watered less frequently than those with higher water requirements.

Differences in watering needs occur between plants of different sizes or life stages. Use the following guidelines (Appendix Figure 17.4) for calculating water needs from plant size:

Watering by the Numbers

5. Figuring Water Needs from Plant Size

Gallons needed to apply 2″ of water to a plant depends on its size (crown area). To get the total gallons needed, multiply the crown area in square feet by 0.625 gallons × 2″. For a plant with a crown radius of 2 feet:

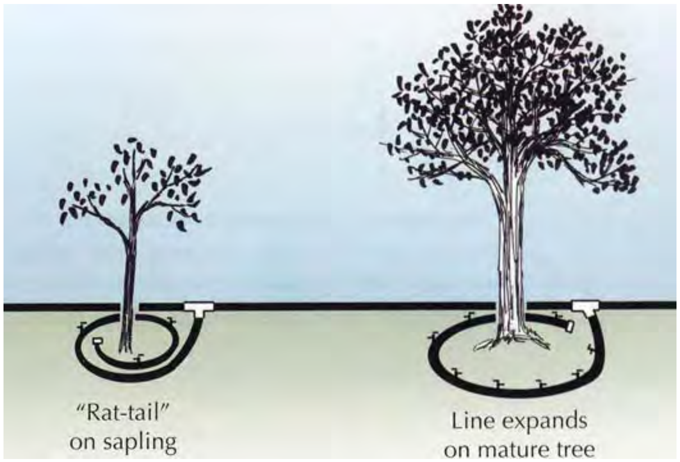
crown area: ***2 × 2 × 3.14 (pi) = 12.56 (or approximately 12 square feet).***

gallons needed to apply 2″: ***12.56 square feet × 0.625 gallons × 2 = 15.7 gallons (or approximately 16 gallons).***

Shortcut: To get the total gallons needed to apply 2″ of water to a plant of any size, just multiply its crown area by 1.25.

An even easier rule of thumb for the approximate number of gallons needed in order to apply 2″ of water to a plant of a given size is just to take the square of its crown diameter (multiply crown diameter by crown diameter).

Appendix Figure 17.5: *Calculating water needs by plant size (Meyer 2010)*



Appendix Figure 17.6: *Rat Tail line (Meyer 2010)*

While designing a drip irrigation system, it is important to consider the water needs of the plants as they mature. The systems should be designed so that the supply line capacity can accommodate all of the plants at their largest crown area, at maturity (requiring the most water). The irrigation system should accommodate plants as they grow, usually by adjusting the number and/or types of emitters.

The "rat tail" is a method appropriate for point-source emitters. A side line attached to the main drip line is wrapped around the drip line of the tree and slowly unwrapped and expanded as the tree grows, accommodating additional emitters with minimal effort (Appendix Figure 17.4).

Appendix Figures 17.7 and 17.8, below, from "Landscaping on the New Frontier" provide additional guidelines for designing an irrigation system (Meyer 2010):

- More information regarding drip irrigation design can be found in "Landscaping on the New Frontier", 2010 (see references).
- The Arizona Municipal Water Users Association publication "Landscape Watering by the Numbers: A Guide for the Arizona Desert" provides additional information pertaining to watering plants in Arizona and is available free as a pdf or hard copy (see references)

Emitter Needs for Watering Plants of Different Sizes with Drip Irrigation

The goal is to apply the approximate number of gallons needed to add the equivalent of 2″ of water over the entire crown area of the plant.

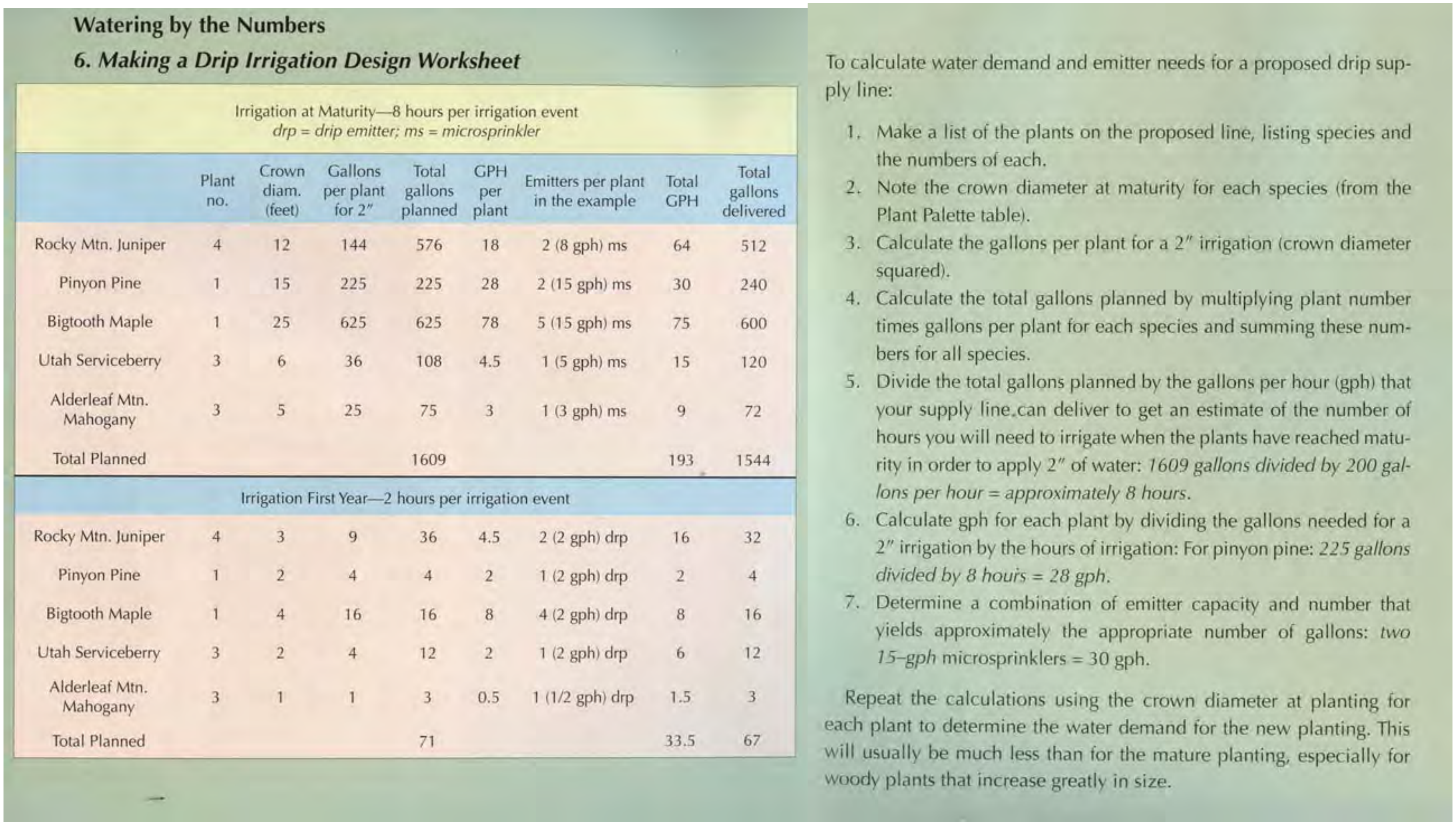
The total number of gallons needed is obtained by multiplying the crown area of the plant in square feet by 1.25, a conversion factor which represents the number of gallons needed to apply 2″ of water to one square foot.

Plant Crown Diameter (feet)	Crown Area (square feet)	Gallons for a 2″ irrigation	Example Drip Emitter Combinations for Applying ca. 2″ of Water during Irrigation Periods of Different Durations		
			2 hours	4 hours	8 hours
1	1	1	1-1 1/2gph	--**	--**
2	3	4	2-1gph	1-1gph	1-1/2gph
3	7	9	4-1gph	2-1gph	2-1/2gph
4	12	16	4-2gph	2-2gph	2-1gph
5	20	25	6-2gph	3-2gph	3-1gph
6	30	36	9-2gph	9-1gph	5-1gph
7	40	49	6-4gph	6-2gph	6-1gph
8	50	64	8-4gph	8-2gph	8-1gph
9	65	81	10-4gph	10-2gph	10-1gph
10	80	100	13-4gph	13-2gph	13-1gph
11	95	121	15-4gph	12-2gph	15-1gph
12	110	144	18-4gph	18-2gph	15-1gph
13	135	169	--*	11-4gph	18-1gph
14	155	192	--*	12-4gph	11-2gph
15	180	225	--*	14-4gph	14-2gph
16	200	256	--*	16-4gph	16-2gph
20	310	400	--*	--*	13-4gph
25	500	625	--*	--*	20-4gph

Rule of thumb: Gallons needed for a 2″ irrigation = crown diameter^2 (= crown diameter x itself).

* Better watered with microsprinklers.
** Irrigation period too long for small plants - smallest emitter overwaters.

Appendix Figure 17.7: *Emitter needs for plants of different sizes (Meyer 2010)*



Watering by the Numbers

6. Making a Drip Irrigation Design Worksheet

	Plant no.	Crown diam. (feet)	Gallons per plant for 2″	Total gallons planned	GPH per plant	Emitters per plant in the example	Total GPH	Total gallons delivered
Irrigation at Maturity—8 hours per irrigation event *drp = drip emitter; ms = microsprinkler*								
Rocky Mtn. Juniper	4	12	144	576	18	2 (8 gph) ms	64	512
Pinyon Pine	1	15	225	225	28	2 (15 gph) ms	30	240
Bigtooth Maple	1	25	625	625	78	5 (15 gph) ms	75	600
Utah Serviceberry	3	6	36	108	4.5	1 (5 gph) ms	15	120
Alderleaf Mtn. Mahogany	3	5	25	75	3	1 (3 gph) ms	9	72
Total Planned				1609			193	1544
Irrigation First Year—2 hours per irrigation event								
Rocky Mtn. Juniper	4	3	9	36	4.5	2 (2 gph) drp	16	32
Pinyon Pine	1	2	4	4	2	1 (2 gph) drp	2	4
Bigtooth Maple	1	4	16	16	8	4 (2 gph) drp	8	16
Utah Serviceberry	3	2	4	12	2	1 (2 gph) drp	6	12
Alderleaf Mtn. Mahogany	3	1	1	3	0.5	1 (1/2 gph) drp	1.5	3
Total Planned				71			33.5	67

To calculate water demand and emitter needs for a proposed drip supply line:

1. Make a list of the plants on the proposed line, listing species and the numbers of each.
2. Note the crown diameter at maturity for each species (from the Plant Palette table).
3. Calculate the gallons per plant for a 2″ irrigation (crown diameter squared).
4. Calculate the total gallons planned by multiplying plant number times gallons per plant for each species and summing these numbers for all species.
5. Divide the total gallons planned by the gallons per hour (gph) that your supply line can deliver to get an estimate of the number of hours you will need to irrigate when the plants have reached maturity in order to apply 2″ of water: *1609 gallons divided by 200 gallons per hour = approximately 8 hours.*
6. Calculate gph for each plant by dividing the gallons needed for a 2″ irrigation by the hours of irrigation: For pinyon pine: *225 gallons divided by 8 hours = 28 gph.*
7. Determine a combination of emitter capacity and number that yields approximately the appropriate number of gallons: *two 15–gph* microsprinklers = 30 gph.

Repeat the calculations using the crown diameter at planting for each plant to determine the water demand for the new planting. This will usually be much less than for the mature planting, especially for woody plants that increase greatly in size.

Appendix Figure 17.8: *Drip irrigation design worksheet (Meyer 2010)*

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Images

VZ Image 1.1	Colleen Corballis 2009
VZ Image 2.1	Sarah Nelson 2009
VZ Image 2.2	USFS, J. Miller http://dnr.state.il.us
VZ Image 2.3	Dow Agro Science 2010
VZ Image 2.4	USFS, J. Miller http://dnr.state.il.us
VZ Image 2.5	USFS, J. Miller http://dnr.state.il.us
VZ Image 2.6	Colleen Corballis 2009
VZ Image 2.7	Colleen Corballis 2009
VZ Image 3.1	Michael Timmons 2008
VZ Image 3.2	Michael Timmons 2008
VZ Image 5.1	Colleen Corballis 2009
VZ Image 5.2	Colleen Corballis 2009
VZ Image 5.3	Colleen Corballis 2009
VZ Image 6.1	Colleen Corballis 2009
VZ Image 6.2	http://commons.wikimedia.org/wiki/File:Kangaroo-rat.jpg
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