National Park Service
U.S. Department of the Interior

Canyon de Chelly National Monument
Arizona

Cooperative Watershed Restoration Project: Tamarisk and Russian Olive Management at Canyon de Chelly National Monument

Final Environmental Assessment

2005

Summary

Canyon de Chelly National Monument was established in 1931 to preserve a significant collection of prehistoric and historic cultural/archeological resources representing nearly 4000 years of occupations by Ancestral Pueblo Indians as well as historic and modern-day Navajo peoples. The floors of both Canyon de Chelly and Canyon del Muerto (both within the national monument) remain the homes, farms, and traditional grazing lands for approximately 50 Navajo families. The 1931 legislation establishing the monument assigned primary responsibility for the management of cultural resources, park administration and visitor services to the National Park Service. The Navajo Nation retains the actual control of the land and minerals within the monument and is primarily responsible for the surface and subsurface uses of the land. Members of the Navajo Nation that reside in the monument's canyons once relied upon their abilities to farm and graze the canyon floor as a means of subsistence.

Located near Chinle, Arizona, Canyon de Chelly National Monument is considered to be at the southernmost boundary of the Great Basin Desert and is generally included as part of the Upper Sonoran habitat zone . The monument's vegetation varies both from the canyon rims to the canyon floor and as the elevation climbs over 1500 feet from the lower canyons to the upper canyons. Vegetation changes from desert grasslands in the Chinle Wash area to stands of Piñon pine and Utah juniper on the canyon rims and on the uplands of the canyons.

Until recently, almost all natural resource issues within the national monument were left up to the management of the Navajo Nation. However, aggressive infestation by tamarisk (*Tamarix ramosissima, T. chinensis*, and their hybrids) and Russian olive (*Elaeaganus angustifolia*), in combination with intensive historic grazing and tour operations within the riparian corridors of the canyon floor, have created the need for an integrated and collaborative approach to managing all resources (natural and cultural) within the Canyons and their associated watersheds. Invasive plant infestations have seriously altered stream processes creating unnatural rates of channel incision and land erosion, and have consequently reduced land areas available for traditional farming. In addition, natural biological diversity has been significantly reduced along the riparian corridor, which is important for maintaining the natural ecology of the canyons as well as traditional/ethnological uses by the Navajo peoples. These changes have dramatically altered the appearance of this cultural landscape and seriously threaten valuable and irreplaceable archeological resources through excessive erosion and/or establishment of excessive woody fuels and increased fire hazards.

This Environmental Assessment delineates management options for tamarisk and Russian olive management in the entire Canyon del Muerto and Canyon de Chelly systems. This project will also address small pockets of these woody invasives in the upper side canyons and tributaries of each main system. In total, this represents over 40 miles of linear invasion. This is in accordance with the National Environmental Policy Act and the Council on Environmental Quality, as well as the Management Policies and Director's Orders of the National Park Service.

Alternatives

Five alternatives for tamarisk and Russian olive management are presented:

- a **no-action alternative,** no control actions for tamarisk or Russian olive;
- the **preferred alternative A**, test and implement, as appropriate, a variety of control treatments applicable for use in the park, including: stump cutting with direct herbicide application, low volume basal spray, heavy equipment with rotor mounted tree shredder, and whole tree removal with heavy equipment;
- an **additional alternative B (environmentally preferred)**, stump cutting and direct herbicide application only (including low volume basal spraying);
- an **additional alternative C,** mechanical removal with heavy equipment with rotor mounted tree shredder only; and
- an **additional alternative D**, whole tree removal with heavy equipment only.

In addition to the "no action" alternative, a preferred alternative and three additional single treatment alternatives have further been identified for potential management of tamarisk and Russian olive within the park. These include: (1) test and implement a variety of control treatments relevant for use at Canyon de Chelly National Monument (**alternative A - preferred**), (2) stump cutting and direct herbicide application only (including low volume basal spraying) (**alternative B**), (3) mechanical removal with heavy equipment with a rotor mounted tree shredder (**alternative C**), and (4) whole tree removal (**alternative D**). All identified alternatives have direct application for use at the Monument, but vary in their level of effectiveness based on site-specific habitat and environmental conditions and on the sensitivity of the area undergoing defined management actions. A brief overview of the positive and negative impacts of the various action alternatives is provided below.

The "**no-action" alternative** would allow for continued expansion of tamarisk and Russian olive infestations within the main riparian corridors of Canyon de Chelly and Canyon del Muerto, and in additional canyon areas within the park. This would further the degradation of the natural and cultural resources and landscapes, and promote the homogenization of vegetation throughout the canyon floor habitats of the monument. Areas currently not infested (including higher quality side canyons) would deteriorate as tamarisk and Russian olive continue to spread. The "no action" alternative risks future adverse impact to numerous archeological resources, additional loss of native biological diversity, and could result in a continued reduction of usable/traditional farmland by canyon residents.

Alternative A (**preferred action)** consists of the testing and the application of multiple techniques where best applied within the various tamarisk and Russian olive infested habitats of the park. This alternative would allow for the maximum recovery potential for currently infested and degraded lands and would combine all of the treatment options from the below single action alternatives. Treatment methodologies would include (1) cutting tamarisk and Russian olive trees and shrubs to a height of several inches above ground and immediately applying herbicide (Remedy or Garlon 3A depending on air temperatures) to the cut stumps; (2) use of targeted low volume basal application of herbicide to small diameter trees/shrubs, (3) mechanical removal of dense stands using heavy equipment with a rotor mounted tree shredder, and (4) whole tree removals (above and below ground). This alternative would

support a funded pilot study and provides the best opportunity to define removal techniques most applicable and effective, on a large scale and within the multiple conditions that exist at within the Monument. Most importantly, the results of this study will provide the best information for developing and guiding the long-term management of tamarisk and Russian olive at Canyon de Chelly National Monument and will provide the necessary information to direct and maximize efforts to restore the natural and cultural landscape within the park.

Alternative B would consist of cutting tamarisk and Russian olive trees and shrubs to a height of several inches above ground and immediately applying herbicide to the cut stump surface. This alternative would also implement the use of low volume basal spray to the bases of small diameter trees (<4 inches). This option is likely to have the highest "effectiveness rate" in creating tree mortality of any of the single treatment alternatives and would be most applicable to all habitats within the park. Alternative B has also been identified as the environmentally preferred alternative since it does not involve any ground disturbance and utilizes only a very targeted application of herbicide, minimizing any potential for overspray and/or impact to non-targeted species. However, the time and labor costs associated with this method can be prohibitive when dealing with extensive, dense stands of tamarisk and Russian olive. This alternative is applicable on smaller scales and in sensitive areas, but because of its labor intensiveness, it is not likely to result in the maximum control and recovery of tamarisk and Russian olive infested habitats within the park.

Alternative C heavy equipment removal with a rotor mounted tree shredder, involves use of a wheeled or tracked front loader, small skid-steer, trackhoe, or a bulldozer with a mounted shredder to mulch trees as they are cut. This treatment methodology cuts the tree near ground surface, leaving tree roots in place, and does not involve use of herbicide. This type of treatment can be cost effective, especially in removing larger size infestations and does allow for selective cutting of only targeted vegetation. Alternative C would be less effective than Alternative B in creating tree mortality and may result in re-sprouting from the un-removed root systems. Although this method provides a cost effective management option for certain sections of the park, the use of heavy equipment would also create various levels of surface ground disturbance and may not be a viable option for sites containing sensitive natural and/or cultural resources. Although this treatment method has application and benefit to certain sections of the park, it is much more restricted in the locations where it could be applied. As with Alternative B, use of Alternative C alone would improve localized sections of the park, but would fail to maximize the recovery potential within many areas of the park and would allow for continued spread of tamarisk and Russian olive from untreated areas.

Alternative D whole tree removal (above and below ground), would similarly involve the use of heavy equipment (a front loader with a clamshell bucket or hydraulic tree shear that grabs trees and rips the tree out by the roots and/or a backhoe that can pull trees out by the base) and does not use any herbicide applications. This method is especially cost effective in dealing with extensive, dense stands of tamarisk/Russian olive and would prevent any re-sprouting as a result of the removal of the entire root system. This treatment option will create surface and sub-surface ground disturbance as a result of roots being pulled from the soil. The absence of soil stabilizing roots can promote quicker and desirable geomorphic stream responses, but the resulting ground disturbance also has the potential for creating conditions favorable for the establishment of other undesired non-native species. Active native revegetation (grasses and herbs) would be required under Alternative D to avoid any

excessive or undesirable geomorphological effects, as well as, to minimize invasion by undesirable weed species. This option also presents a higher level of risk to unknown (below soil surface) archeological/cultural resources and could not be used in locations of known sensitive natural and/or cultural resources. As with both of the other single treatment alternatives, Alternative D has direct application and benefit to certain sections of the park, but when used alone would also fail to maximize recovery opportunities and would allow for continued spread of tamarisk and Russian olive from untreated areas.

Public Comment

If you wish to comment on this Environmental Assessment, you may mail comments to the name and address below. This Environmental Assessment will be on public review for 30 days starting April 3 and ending May 2, 2005. The document can be reviewed on the parks website as well as by contacting the park for a hard copy. Please note that names and addresses of people who comment become part of the public record. If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comment. We will make all submissions from organizations, businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses available for public inspection in their entirety.

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Table of Contents

1 Purpose and Need 9
1.1 Introduction 9
1.2 Purpose and Need 10
1.3 Public Scoping 12
1.4 Impact Topics Analyzed 13
1.4.1 Cultural Resources 13
1.4.2 Natural Resources 15
1.4.3 Visitor Use 18
1.4.4 Socioeconomic Considerations 19
1.4.5 Topics Dismissed from Further Analysis 19
2 Management Alternatives 20
2.1 Objectives of Tamarisk and Russian olive Management 20
2.2 Alternatives for Tamarisk and Russian Olive Management 22
2.2.1 No-action alternative 22
2.2.2 Alternative A (preferred): test and implement a variety of control treatments relevant for use at Canyon de Chelly 22
2.2.3 Alternative B (environmentally preferred alternative): Stump cutting and direct herbicide application 23
2.2.4 Alternative C: mechanical removal with heavy equipment with rotor mounted tree shredder 25
2.2.5 Alternative D: whole tree removal (above and below ground) 26
2.2.6 Mitigation measures for the action alternatives 26
2.2.7 Future management needs and recommendations 28
3 Affected Environment 30
3.1 Site Description 30
3.1.1 Location and Climate 30
3.1.2 Relevant Land Use History 30
3.2 Cultural Resources 32
3.2.1 Cultural Landscape and Archeological Resources 32
3.2.2 Historic Structures 35
3.2.3 Ethnographic Resources 35
3.3 Natural Resources 36
3.3.1 Climate 36
3.3.2 Geology 36
3.3.3 Soils 37
3.3.4 Stream/Canyon-Bottom Geomorphology 37
3.3.5 Water Resources 38
3.3.6 Vegetation 40
3.3.7 Wildlife 43
3.3.8 Species of Management Concern 45
3.3.9 Air Quality 50
3.3.10 Natural Sound 50
4 Environmental Consequences 50
4.1 NPS Guidance on Environmental Consequence Analysis 50
4.2 Consequences of Management Alternatives 77

4.2.1 Cultural Landscape……77
4.2.2 Archeological Resources……82
4.2.3 Ethnographic Resources……88
4.2.4 Historic Structures……94
4.2.5 Soils……100
4.2.6 Geomorphological Processes……105
4.2.7 Prime and Unique Farmlands……110
4.2.8 Water Resources……115
4.2.9 Air Quality……121
4.2.10 Vegetation……124
4.2.11 Wildlife……130
4.2.12 Threatened and Endangered Species……135
4.2.13 Natural Sound……142
4.2.14 Public Health and Safety……147
4.2.15 Visitor Use and Experience……152
4.2.16 Socioeconomic Conditions……157
5 Consultation and Coordination……162
5.1 Agencies, Tribes, Organizations, and Individuals Contacted……162
5.2 Preparers……162
5.3 List of Recipients……163
5.3.1 Federal Agencies……163
5.3.2 Indian Tribes……163
5.3.3 State and Local Agencies……163
5.3.4 Organizations……163
5.3.5 Individuals……163
6 References……164
7 Appendices……166

Tables, Figures, and Appendices

Table 1. Summary of Alternatives for Tamarisk and Russian olive Management at Canyon de Chelly National Monument. 29
Table 2. Federally[1] and Navajo Nation Natural Heritage Program (NHP) Listed[2] Threatened and Endangered Plant and Animal Species of Apache County, AZ. 47
Table 3. Definitions of Intensity Levels for Impact Topics Analyzed 53
Table 4. Comparative Summary of Environmental Impacts of Management Alternatives 61

Figure 1. Canyon de Chelly National Monument – Area Map. 10
Figure 2. Canyon de Chelly National Monument – Tamarisk/Russian Olive Management Project Location Map. 21

Appendix 1. US Fish and Wildlife Service Letter of Concurrence with NPS Determination of Impacts to Threatened and EndangeredSpecies……....167
Appendix 2. Garlon3 Herbicide Specimen Label…..……..…….……171
Appendix 3. Remedy® Herbicide SpecimenLabel…….……..175

1 Purpose and Need

1.1 Introduction

Canyon de Chelly National Monument was established in 1931 to preserve a significant collection of prehistoric and historic cultural/archeological resources representing nearly 4000 years of occupations by Ancestral Pueblo Indians as well as historic and modern-day Navajo peoples. The canyon-bottoms of both Canyon de Chelly and Canyon del Muerto (both within the national monument) remain the homes, farms, and traditional grazing lands for approximately 50 Navajo families. The 1931 legislation establishing the monument assigned primary responsibility for the management of cultural resources, park administration and visitor services to the National Park Service (NPS). Members of the Navajo Nation that reside in the monument's canyons and once relied upon their abilities to farm and graze the canyon floor as a means of subsistence.

Located in the northeastern corner of Arizona, near Chinle, (Figure 1), Canyon de Chelly National Monument occupies an area of approximately 84,000 acres. The monument provides spectacular scenery and an unparalleled example of an Ancestral Puebloan landscape reflecting the relationship between community and environment through time. In addition, the canyon exhibits the historic and present utilization of the landscape by the Navajo people. Specific park purposes as identified by the parks enabling legislation include:

- To preserve outstanding prehistoric Ancestral Puebloan archeological resources for their scientific, cultural, and scenic values.
- To preserve and protect features of historical and sacred significance to the Navajo and other Native American peoples.
- To provide for the protection and care of other scientific features and objects.
- To provide for the education, care, and accommodation of visitors to the monument.

NPS administers the Monument and the NPS and the Navajo Nation share resources and face mutual issues that frequently cross administrative boundaries. Canyon de Chelly National Monument does not currently have an approved General Management Plan (GMP), but a GMP planning process has been initiated. Previous planning documents for the monument are outdated and do not adequately address the many complex issues currently requiring management decisions, including invasive species issues. Until recently, almost all natural resource issues within the national monument were left up to the management of the Navajo Nation. However, aggressive infestation by non-native tamarisk (*Tamarix ramosissima, T. chinensis,* and their hybrids) and Russian olive (*Elaeaganus angustifolia*), in combination with intensive historic grazing within the riparian corridors of the canyon floor, have created the need for an integrated and collaborative approach to managing all resources (natural and cultural) within the canyons and their watersheds.

Invasive tamarisk and Russian olive infestations have seriously altered stream processes creating unnatural rates of channel incision and land erosion, and reduced land areas available for traditional farming. In addition, natural biological diversity has been significantly reduced within the main canyons, which is important for maintaining the natural ecology of the canyons as well as traditional/ethnological uses by the Navajo peoples. These changes have dramatically altered the appearance of this cultural landscape and seriously threaten the valuable and irreplaceable archeological resources through excessive erosion and/or establishment of excessive fuels and increased fire hazards. The NPS and the Navajo Nation currently seek to continue their working partnership by coordinating projects and long-range planning efforts to implement effective invasive species management actions control and landscape restoration (natural and cultural) of this special place.

Figure 1. Canyon de Chelly National Monument – Area Map.

1.2 Purpose and Need

Canyon de Chelly National Monument has a long history of previous and ongoing human-related activity and disturbances. More modern disturbances related to grazing, vehicle traffic, and direct planting of invasive species have created conditions that have altered the natural and cultural landscapes and associated resources in the park. The management and control of invasive non-native species has been identified as a high priority issue by the NPS and is specifically, under the Government Performance and Results Act of 1993, identified as an accountable goal for all national park units. Executive Order 13112 signed on February 3,

1999, further obligates all federal agencies to address the significant economic and biological threats posed by non-native species.

During a 2003 meeting of the NPS National Leadership Council (NLC) at Canyon de Chelly, and a follow-up meeting with the Board of Directors of the National Park Foundation in the fall of 2004, NPS Director Fran Mainella and several Regional Directors expressed serious concerns about the adverse effects of tamarisk and Russian olive on monument resources. In response to the resource issues and threats identified by the NLC, park administration, and monument residents, an interdisciplinary team consisting of individuals from the NPS Geologic Resources Division (GRD), Water Resources Division (WRD), Biological Resources Management Division (BRMD), Denver Service Center (DSC), Intermountain Support Office (IMSO), and various organizations from the Navajo Nation met in 2003 to identify resource issues and cooperative management opportunities within the monument. All parties identified riparian degradation triggered by tamarisk and Russian olive invasion and historic overgrazing as the largest and single most immediate threats to canyon resources as well as to long-term canyon ecology and continued subsistence use.

Large-scale removal of tamarisk and Russian olive on over 40 miles of riparian corridor in the narrow canyons associated with Canyon de Chelly and Canyon del Muerto, however, creates a risk for excessive, adverse, and unpredictable erosion. With assistance from the NPS Interdisciplinary team, the park has acquired the necessary funds to initiate a larger pilot study to determine which exotic woody plant removal and restoration approaches/techniques are most suitable for the main riparian corridors within the park. Additionally, the park has initiated a Cooperative Conservation Initiative (CCI) project in partnership with the Navajo Nation to initiate smaller-scale tamarisk and Russian olive removals within the a section of the Chinle Wash (from the park's visitor center to the confluence of Canyon de Chelly and Canyon del Muerto) as well as in the immediate area of the Visitor Center. Direct benefits that will be realized by the 2004 project activities, as well as by the development of a long-term Tamarisk and Russian olive Management Program at Canyon de Chelly include:

(1) a reduction in the loss of native habitat and forage for livestock and wildlife species resulting from existing tamarisk and Russian olive infestations;
(2) enhancement of native biodiversity and general ecosystem health;
(3) reduction in the negative changes to the physical, biological and chemical parameters of native soils created by extensive infestations of tamarisk and Russian olive;
(4) partial recovery of more natural stream geomorphologies and associated processes;
(5) enhancement of the visitor experience through improved aesthetics and interpretation of the natural and cultural landscapes within the park ;
(6) mitigation of both direct (accelerated erosion) and indirect (increased fire hazards) threats to archeological resources; and
(7) strengthen collaborative efforts between the NPS, canyon residents, and the Navajo Nation.

The scope of this Environmental Assessment is intended to cover an analysis of a range of management alternatives associated with both short-term management actions (pilot study) and long-term, full scale development and implementation of a Tamarisk and Russian olive Management Program at Canyon de Chelly National Monument.

1.3 Public Scoping

Scoping is a process to identify the resources that may be affected by a project proposal, and to explore possible alternative ways of achieving the proposal while minimizing adverse impacts. Canyon de Chelly National Monument conducted both internal scoping with appropriate NPS staff and external scoping with the public and interested/affected groups and agencies in association with GMP development. These scoping activities (internal and external) specifically included issues and discussions associated with the management of tamarisk and Russian olive within the park.

External scoping was initiated with the distribution of a scoping letter in association with the Monument's GMP planning process in 2003, including actions related to the management of tamarisk and Russian olive within the park. This letter was mailed to an extensive list of canyon residents, Navajo Nation Administrators and interested private parties. Several public meetings were also held between the Monument's administrative staff and local residents to communicate the intent of the planning processes. Additional internal and external "on-site" scoping was held in October 2003 between the Monument's administrative and cultural resource staff, an interdisciplinary NPS team of professionals representing water, geologic, biological, and ecological resource management, NPS park planning experts, and several external stakeholders. Internal and public scoping activities identified the following critical resource issues associated with existing tamarisk and Russian olive infestations within the park:

Lack of an integrated resource management approach for the watersheds – Currently, resource management activities are occurring at multiple levels - by individual canyon residents, by Monument concessionaires/tour guides, by various entities within the Navajo Nation (grazing, water, and/or soil conservation districts) - with little or no integration of efforts. Although all efforts have had the best intention, conflicting or uncoordinated management actions have, in several instances, further exacerbated resource impacts and/or degradation.

Threats to archeological and historic landscape including entire range of traditional cultural properties - Conditions created by historic and current grazing practices and the establishment of invasive, non-native invasive plants within the canyon riparian corridors (primarily tamarisk and Russian olive) have resulted in conditions of accelerated soil erosion that threaten several culturally significant locations in the park. Additionally, these infestations have contributed to hazardous levels of fuels build-up adjacent to archeological sites, increasing the threat of damage or loss of these resources as the result of wildland fire.

Ecosystem alterations created by land-use and non-native, invasive species – In addition to direct threats to cultural resources, land-use and uncontrolled invasive plant infestations have seriously impacted ecosystems associated with the Monument. Although grazing intensity is greatly reduced today as compared to historic levels, land use trends are shifting away from crops and orchards to cattle grazing. Canyon residents and tour guides additionally contribute to resource degradation as a result of uncontrolled vehicle and stock use within the canyons; there are no specific designated traffic routes.

Similar to overgrazing, this results in the loss of soil stabilizing vegetation, accelerates erosion, and favors the spread and establishment of non-native vegetation. The extensive infestations of high water uptake species, such as tamarisk, may also be reducing groundwater availability within the canyon systems.

Socio/political issues with canyon residents/Navajo Nation – Navajo community concerns associated with invasive, non-native plants include: (1) deterioration of the canyon floor, (2) loss of traditional farmsteads due to tamarisk and Russian olive invasions, (3) declining water resources for farming and human consumption, and, more broadly, (4) a deterioration of the Navajo sense of place and community (i.e. cultural memory). This even extends to aesthetic perceptions of how the canyon should look. Specifically, canyon residents have voiced their frustration and distress over the loss of the canyon's monumental scale (due to extensive tamarisk and Russian olive invasions) – as young people they remember being able to see from wall to wall – a magnificent vision of the landscape. At least one elderly resident has expressed her desire to see the canyon the way it was meant to be before she passes on.

1.4 Impact Topics Analyzed

The consideration of impacts on cultural and natural resources, and visitor use and experience, are required by certain Federal laws, regulations, orders, and planning documents. These include the National Historic Preservation Act, as amended in 1992 (16 USC 470 et seq.), the National Environmental Policy Act of 1969 (42 USC 4321 et seq.), and the NPS's Director's Order #28, "Cultural Resource Management Guideline" (1997), Management Policies 2001 (2000), and Director's Order #12, "Conservation Planning, Environmental Impact Analysis, and Decision Making" (2001). The following impact topics were identified by specialists in the NPS as issues and concerns related to the proposed management action. A brief rationale for the selection of each impact topic is given below, as well as the rationale for dismissing specific topics from further consideration.

1.4.1 Cultural Resources

Cultural Landscapes: The cultural landscapes associated with the Monument have been altered by numerous human related disturbances. The most significant alterations, however, have been the result of historic plantings and continued spread of invasive non-native species and impacts created from overgrazing. Selection of a "no action" alternative would continue deterioration of the cultural landscapes within the park. Implementation of an "action" alternative, and the associated reduction of tamarisk and Russian olive within the main riparian corridors of the canyons, would partially restore the appearance and function of these areas to one more historically and naturally representative, and would have long-term beneficial impacts. However, because either a "no action" or "action" alternative would cause alteration of the current cultural landscapes associated with these areas, cultural landscapes have been included as an impact topic.

Archeological Resources: Cultural and archaeological surveys have been completed for the Chinle Wash and for the Canyon del Muerto sections of the park. However, archeological

resource surveys and associated documentations remain incomplete for most of Canyon de Chelly. The proposed 2004 pilot study does include funding to perform detailed archeological work for any areas identified for tamarisk and Russian olive removal as part of the adaptive management study. Currently, excessive soil erosion and fire hazards created by the presence of uncontrolled populations of tamarisk and Russian olive (e.g. "no action") have placed several archeological sites (throughout both of the main canyon reaches) in jeopardy. Continuation of a "no-action" alternative could result in loss of irreplaceable archeological resources. Implementation of "action" alternatives that identify use of heavy equipment would result in direct impact to the ground surface and/or to sub-surface soil resources representing potential impacts to unknown archeological resources. Further potential exists as a result of the implementation of "action" alternatives for indirect impacts to archeological resources as a result of unintended herbicide overspray (discoloration) or in the felling of invasive trees (scraping/crushing). Although the short- and long-term management of tamarisk and Russian olive will have positive sustainable benefits and remove both imminent and longer-term threats to many archeological sites within the park, the potential for both direct and indirect impacts as a result "no action" or the removal of tamarisk and Russian olive necessitates that archeological resources be considered as an impact topic.

Ethnographic Resources: Per the NPS Director's Order 28 Cultural Resource Management, ethnographic resources are defined as any site, structure, object, landscape, or natural resource feature assigned traditional legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it. According to DO-28 and Executive Order 13007 on sacred sites, the NPS should try to preserve and protect ethnographic resources. Canyon De Chelly National Monument contains numerous individual ethnographic resources which are all interrelated and tied closely to the landscape and resources of the canyon. These resources include areas visited by holy people in Navajo legends, areas where traditional ceremonies take place, traditional agricultural areas, locations where natural herbs or other medicinal materials are collected by medicine men, and domestic areas which have been continually inhabited for several generations. Currently, these ethnographic resources are exceedingly endangered by the encroachment of exotic vegetation. Decreased accessibility has prevented the Navajo People from practicing these established life ways, and hence, knowledge of these areas and their resources are becoming lost, and would eventually disappear. Additional threats to ethnographic material stem from the erosion of the canyon floor, on which a majority of these resources are located, and from the increased risk of fire, due to excessive fuel build-up. These resources would only continue to degrade and become lost if a "no action" alternative were implemented. Implementation of "action" alternatives that identify use of heavy equipment would result in direct impact to the ground surface and/or to sub-surface soil resources representing potential impacts to unknown ethnographic resources. Further potential exists as a result of the implementation of "action" alternatives for indirect impacts to ethnographic resources as a result of unintended herbicide overspray (discoloration) or in the felling of invasive trees (scraping/crushing). Although the short- and long-term management of tamarisk and Russian olive will have positive sustainable benefits and remove both imminent and longer-term threats to many ethnographic resources within the park, the potential for both direct and indirect impacts as a result "no action" or the removal of tamarisk and Russian olive necessitates that ethnographic resources be considered as an impact topic.

Historic Structures: The term "historic structures" refers to both historic and prehistoric structures, which are defined as constructions that shelter any form of human habitation or activity. Canyon De Chelly National Monument contains numerous historic Navajo and Prehistoric structures which are threatened by the by the encroachment of exotic vegetation. White House Ruin, possibly the most visually identifiable historic structure in the canyon, is surrounded by hundreds of tamarisk and Russian olive trees. Cultural and archaeological surveys to identify and collect baseline documentation on these structures have been completed for the Chinle Wash and for the Canyon del Muerto sections of the park. However, archeological resource surveys and associated documentations remain incomplete for most of Canyon de Chelly. The locations of most major historic and prehistoric structures in Canyon De Chelly are known, however detailed documentation has only been completed for a handful of these structures. The proposed 2004 pilot study does include funding to perform detailed archeological documentation for any areas identified for tamarisk and Russian olive removal as part of the adaptive management study. Currently, excessive soil erosion and fire hazards created by the presence of uncontrolled populations of tamarisk and Russian olive (e.g. "no action") have placed several historic structures (throughout both of the main canyon reaches) in jeopardy. Threats to historic structures include the erosion of the canyon floor, on which a majority of these resources are located, and the increased risk of fire, due to excessive fuel build-up near the structures. Continuation of a "no-action" alternative could result in loss of irreplaceable historic structures. Implementation of "action" alternatives that identify use of heavy equipment would result in direct impact to the ground surface and/or to sub-surface soil resources representing potential impacts to unknown historic structures. Further potential exists as a result of the implementation of "action" alternatives for indirect impacts to historic structures as a result of unintended herbicide overspray (discoloration) or in the felling of invasive trees (scraping/crushing). Although the short- and long-term management of tamarisk and Russian olive will have positive sustainable benefits and remove both imminent and longer-term threats to many of the park's historic structures, the potential for both direct and indirect impacts as a result "no action" or the removal of tamarisk and Russian olive necessitates that historic structures be considered as an impact topic.

1.4.2 Natural Resources

Soils: According to the NPS Management Policies (Section 4.8.2.4, 2000), the NPS will strive "to understand and preserve the soil resources of parks and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources." Implementation of a "no-action" alternative allows for the perpetual spread of tamarisk and Russian olive within the park and for continuation of unnatural rates of soil erosion. Additionally, the presence of extensive tamarisk infestations would continue increases in soil salinity resulting in negative alterations to soil chemical and biological parameters. Proposed "action" alternatives would also represent short-term disturbance to soil surfaces or sub-surfaces as the result of use of heavy equipment with a minimal potential for short-term contamination of the soil from herbicide runoff following treatment. Also, there is the potential for small, short-term increases in soil erosion due to decreases in canopy coverage (exposing soils) immediately following invasive woody plant removals and as more natural stream geomorphological processes return. Therefore, soils will be considered as an impact topic.

Stream Channel/Canyon-Bottom Geomorphology: The NPS Management Policies (Section 4.8, 2000) indicate the protection of geologic and topographic features, and geologic processes, including geomorphologic process, in park units. Historical accounts indicate that the main stem channels in Canyon del Muerto and Canyon de Chelly began to incise during the late 1800's. A period of aggradation followed in the 1930's with accounts indicating wide expanses of sand in the canyons with solitary cottonwoods located along stream channels. In the 1970's, incision is believed to have recommenced, in part due to the expansion of tamarisk and Russian olive infestations throughout the middle sections of the canyon floor. Stable channels generally have the ability to carry water and sediment while maintaining their dimension, pattern, and profile. This is not the case with most of the channels within Canyon de Chelly and Canyon del Muerto. They are unstable and prone to rapid vertical and lateral channel adjustments. Since either the no-action or implementation of one of the "action" alternatives would result in detectable changes to channel geomorphologic conditions as compared to the current conditions, channel geomorphology will be considered as an impact topic.

Prime and Unique Farmland: All Federal agencies are charged to protect prime and unique farmlands, as directed by the Council on Environmental Quality and the Farmland Protection Policy Act (7 U.S.C. 4201 et seq.). As directed by this Act, Federal programs that contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses will be minimized. Agricultural use of lands within Canyon de Chelly National Monument has been carried on continually from ancient times to present day. Cultivation has decreased by almost half over the last few decades. One of the major reasons for this decline is the unnatural rates of erosion of land within the riparian corridors of the canyon floor, due to channel and streambank destabilization. Historic plantings of tamarisk and Russian olive (starting in the 1930's) were originnaly used to stabilize streambanks. Although these plantings tend to stabilize lateral erosion, they have created situations of increased downcutting in many sections of the canyon riparian corridors. The exlosive spread of these aggressive non-native species since the 1960's has seriously altered stream processes creating unnatural rates of channel incision and land erosion, and have reduced land areas available for traditional farming. The "no-action" alternative would allow the further spread of these invasive non-native species and continued deterioration of agricultural lands within the monument. The "action" alternatives would have varying degrees of beneficial effectiveness at reducing loss of agricultural lands and/or recoverying more natural channel/streambank erosional processes. Thus, prime and unique farmlands will be further addressed as an impact topic.

Water Resources: The NPS is directed to protect surface water, ground water, and water quality through both the NPS Management Policies (Section 4.6, 2000) and the Clean Water Act. There is the potential for minimal surface water and groundwater contamination due to runoff from "action" alternatives that identify herbicides use. Additionally, there is potential for impacts to surface water resources as a result of short-term increases in soil erosion (increased sediment loading of surface waters) caused use of heavy equipment and/or by a change in the vegetation structure in the treatment areas. However, longer-term benefits to water quality (less sediment runoff as removal sites become stabilized by native vegetation) and quantity (as excessively high water use plants such as tamarisk and Russian olive are removed). The "no-action" alternative would continue degradation of water and riparian

resources as a result of continued spread of tamarisk and Russian olive. Therefore, water resources will be considered as an impact topic.

Air Quality: Through its Management Policies, (Section 4.7.1, 2000), the NPS is charged to protect air quality in all park units, and to meet the air quality standards delineated in the Clean Air Act. Canyon de Chelly is currently classified as a Class II air quality area. The canyon areas within the park receive frequent large vehicle traffic as a result of concessions-guided tours and incidental movement by canyon residents. Implementation of "action" alternatives through either use of heavy equipment (increase vehicle emissions), chainsaws, or spray drift from herbicide applications represent a potential for limited, short-term negative impacts to air quality, thus, air quality will be discussed as an impact topic.

Vegetation: Section 4.4 of the NPS Management Policies 2001 (2000) defines the management of plants in park units, including the preservation and restoration of natural populations and habitats, restoration of native plant populations and ecosystems, and minimization of human impacts on vegetation. Continuation of the "no-action" alternative will result in continued spread of tamarisk and Russian olive infestations and considerable loss of native vegetation resources. The implementation of both short- and long-term "action" alternatives for the management of tamarisk and Russian olive, and associated restoration of native vegetation, will have long-term positive benefits to the vegetation communities (including agricultural lands) within the park. However, there may be short-term impacts to the vegetation community structure from the specific management actions taken to reduce density and abundance tamarisk and Russian olive. Therefore, impacts to vegetation will be considered in this analysis.

Wildlife: Section 4.4 of the NPS Management Policies (2000) also addresses the management, preservation, and restoration of animal populations, habitats, and behaviors. Similar to the impacts on vegetation in the two main and side canyon habitats, there may be impacts to some wildlife species depending on the management action(s) implemented. The "no-action" alternative would result in further invasion by tamarisk and Russian olive and for the continued degradation and loss of wildlife habitat. Implementation of the "action" alternatives may cause limited short-term disturbance to wildlife as a result of increased noise and alterations to vegetation community structure as tamarisk is removed. However, in the long run, removal of invasive plants and the restoration of native vegetation (predominantly native cottonwood, willow, grasses, and forbs) will allow for a more natural and diverse wildlife community than presently exists. The effects of herbicide treatments as proposed by the identified action alternatives are anticipated to have little or no impact on wildlife, but could have potential for short-term minor impacts on some wildlife species, should they come in contact the herbicide immediately after application. Wildlife will, thus, be considered as an impact topic in this analysis.

Threatened and Endangered Species: NPS Management Policies (Section 4.4.2.3, 2000) identifies conservative management when dealing with of species of special concern. The U.S. Fish and Wildlife Service (FWS) and the Navajo Nation Natural Heritage Program (NHP) have identified 3 species of concern that could be impacted as a result of proposed tamarisk and Russian olive control activities. These species include the Southwest willow flycatcher (*Empidonax traillii extimus* – listed as endangered by the FWS and the Navajo Nation NHP), the Mexican spotted owl (*Strix occidentalis lucida* – listed as federally

threatened by the FWS and as endangered by the Navajo Nation NHP), and the Golden eagle (*Aquila chrysaetos* – listed as endangered by the Navajo Nation NHP only). Additionally, potential exists for residential or transitory use of riparian/wooded habitats by the yellow-billed cuckoo (*Coccyzus americanus* – listed as a candidate species by the FWS, an endangered species by the Navajo Nation NHP, and as a State of Arizona species of concern). Peregrine falcons, although federally delisted, have been identified as a Species of Management Concern (SOMC) by the park. Funding has been received to conduct habitat assessments and formal surveys where needed based on a determination of suitable habitat for these species and additional funding is being sought to collect comprehensive data. All assessment/survey work will be completed before any major tamarisk and Russian olive management actions are taken. Informal consultations have been initiated with both the FWS and the Navajo Nation NHP. Should habitat for any of the above species of concern be identified in association with a specific tamarisk and Russian olive infestation area, then that area would be eliminated from any further management activities or appropriate conservation measures will be integrated into the project to ensure species protection. Due to the NPS direction to consider species of special concern when prescribing management actions, these identified species will be considered as an impact topic.

Natural Sound: Section 4.9 of the NPS Management Policies (2000) states that the NPS "will preserve, to the greatest extent possible, the natural soundscape… [which] is the aggregate of all the natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds." Currently there are existing impacts to natural sound as a result of vehicle use/activities by concessionaires and by canyon residents. The proposed "action" alternatives requiring the use chainsaws and/or heavy equipment in association with the management of tamarisk and Russian olive will create additional short-term increases in noise impacts to natural sound. As a result, natural sound will be considered as an impact topic.

1.4.3 Visitor Use

Public Health and Safety: Section 8.2.5 of the NPS Management Policies (2000) states that "the Service and its concessionaires, contractors, and cooperators will seek to provide a safe and healthful environment for visitors and employees." Currently concessionaires lead guided tours into the canyon with the entry to all tours being through the Chinle Wash and then into the main riparian corridors of Canyon de Chelly and Canyon del Muerto. The "action" alternatives associated with management of tamarisk and Russian olive include activities that rely on short-term chemical and/or mechanical treatment of vegetation. Although concessionaires and canyon residents would be kept informed on areas and dates for removal activities, public health and safety will be considered as an impact topic.

Visitor Use and Experience: Section 8.2 and Section 7.1 of the NPS Management Policies (2000) define the Service's direction for and commitment to providing enjoyment of park resources for all visitors, and to provide education and interpretation of park resources and the values they represent. In the long-term, implementation of "action" alternatives would enhance visitor experience as a result of the positive impacts of creating a more historically representative cultural and natural landscapes. Interpretive information that explains the importance of the management to cultural and natural resources at the park will be provided

to both park concessionaires and park visitors to assist in minimizing impacts to visitor experience. Although all attempts will be made to avoid closing sections of the park during implementation of identified "action" alternatives, there is some potential that park concessionaires and/or visitors may be temporarily excluded from an area for safety reasons while removals are being conducted. Therefore, visitor use and experience will be considered as an impact topic.

1.4.4 Socioeconomic Considerations

Socioeconomic issues: The Navajo community has expressed direct concerns related to invasive tamarisk and Russian olive related deterioration of the canyon floor. Not only have the establishment of dense infestations of these non-native species resulted in the direct alteration natural habitats and loss of traditional farmlands they have altered aesthetic perceptions (i.e. cultural memory) of how the canyon should look. Canyon residents have voiced their frustration and distress over the loss of the canyon's monumental scale – as young people they remember being able to see from wall to wall – a magnificent vision of the landscape. At least one elderly resident has expressed her desire to see the canyon the way it was meant to be before she passes on. Today extensive non-native, and to a lesser extent even native, woody vegetation have overgrown the canyon floor removing the open landscape associated with the cultural memory of the park. A "no action" alternative would fail to address these concerns and would continue to allow additional spread of non-native woody vegetation. The proposed "action" alternatives would have positive benefits and will begin to address these concerns, however, depending on the alternative selected, these benefits could be either very localized or applied on a larger scale. Both the "no action" and "action" alternatives have potential to alter existing erosion levels and, thus, socio-economic issues will be considered as an impact topic.

1.4.5 Topics Dismissed from Further Analysis

Natural Resources

Wetlands: The NPS is charged to protect wetlands and wetland resources through both its Management Policies (Section 4.6.5, 2000) and the Clean Water Act. Although some of the acreage within the main and side canyon habitats include areas of wetland, the proposed tamarisk and Russian olive management areas do not include any areas of wetland habitat. Therefore, wetlands have been dismissed as an impact topic.

Cultural Resources

Museum Collections: According to Director's Order 24 Museum Collections, the NPS requires the consideration of impacts on museum collections (historic artifacts, natural specimens, and archival and manuscript material), and provides further policy guidance, standards, and requirements for preserving, protecting, documenting, and providing access to, and use of, NPS museum collections. This project does not affect the museum collections at Canyon de Chelly. Therefore, the topic of museum collections has been dismissed from

further consideration.

Visitor Use

Park Operations: This project will only have negligible effects on the overall park operations at Canyon de Chelly. Park visitors are only allowed in the canyon areas through park concessions and/or guided activities. A hiking trail that runs from the White House Overlook down to the White House Ruin in Canyon de Chelly is the only public, non-guided access route which leads into the canyon. Park visitors and concessionaires may be restricted from accessing limited areas associated with tamarisk and Russian olive management activities, especially during times of herbicide or heavy equipment use. However, any disruptions to park visitors, concessions operators, and park staff would be relatively negligible, of short duration, and primarily limited to sporadic noise from chainsaws and trucks during tamarisk and Russian olive removal operations. Therefore, this topic was dismissed as an impact topic for analysis.

Socioeconomic Considerations

Environmental Justice: Presidential Executive Order 12898, "General Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires all federal agencies to incorporate environmental justice into their missions by identifying and addressing the disproportionately high and/or adverse human health of environmental effects of their programs and policies on minorities and low income populations and communities. None of the management alternatives would have disproportionate health or environmental effects on minorities or low-income populations and communities. Therefore, environmental justice has been dismissed as an impact topic.

2 Management Alternatives

2.1 Objectives of Tamarisk and Russian olive Management

Historical records indicate that the upper Chinle Wash was a predominantly un-vegetated braided sandy channel with vegetation scattered only in association with channel margins and mid-channel bars. The dominant species associated with the vegetated sections of the Wash include Fremont cottonwood (*Populus deltoides* ssp. *Wislizenii*) and several native willow species (primarily *Salix exigua*). These native species remain fairly dominant within the Chinle Wash, but have become infested with non-native tamarisk and Russian olive. Similarly, the canyon-bottom habitats within Canyon de Chelly and Canyon del Muerto historically resemble a condition of scattered cottonwood and native willows with open vistas from canyon wall to canyon wall. Tamarisk was introduced via intentional plantings on the canyon floor in the 1930's (SCA planted roughly 31,737 units) along with extensive plantings of cottonwood (118,154 units), willow (59,384 units), plum (400 units) and grape (75 units). Russian Olive was introduced in 1942 in the White House locale and then transported to Spider Rock that same year (personal communication, Lena Spencer and Sally Sam 2003). During this same time period, sections of some of the stream reaches within the canyons were purposefully channelized. It is not entirely clear if these events are directly related, but it is

more than likely that tamarisk and Russian olive were planted to stabilize the banks of the newly straightened and incised channels in order to help maintain the new configurations. Since the 1930's tamarisk and Russian olive have continued to spread both up and downstream from their original plantings within both of the main canyon riparian corridors.

The goal of the proposed management actions are to reduce tamarisk and Russian olive infestations in the canyon-bottom corridors the Monument (Figure 2). The overriding objectives of the tamarisk and Russian olive removals are to restore the cultural and natural landscape(s), as best as possible, to the canyon-bottom habitats of the park.

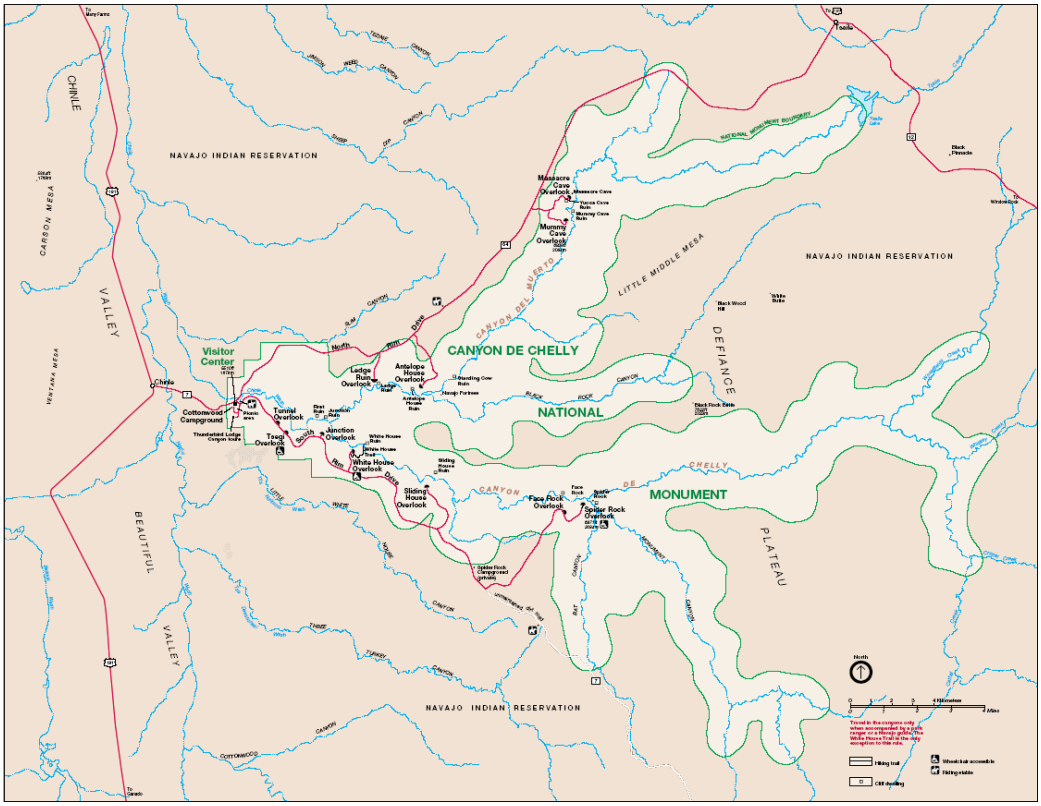

Figure 2. Canyon de Chelly National Monument

Tamarisk/Russian Olive Management Project Location Map.

Natural recovery processes to stream geomorphology would be allowed to occur. Where stands of native vegetation have become lost or very limited as a result of invasive woody plant establishments, restoration actions will be implemented to reintroduce poles of native cottonwoods and willows as well as propagules of native grass and forb species. After completion of the tamarisk and Russian olive reductions and native vegetation restoration efforts, a more natural stream channel-vegetation complex will remain. Future maintenance actions in order to prevent reinvasion of tamarisk/Russian olive will be minimal and are likely to include annual surveys for new tamarisk and Russian olive sprouts, most of can be hand-pulled, with minimal use of additional herbicide applications (if allowed).

2.2 Alternatives for Tamarisk and Russian Olive Management

2.2.1 No-action alternative

If a no-action alternative were implemented, no tamarisk or Russian olive management would occur in the within the riparian corridors of the Monument (Table 1). Due to the aggressive and invasive nature of these non-native woody species, populations would continue to expand unchecked, resulting in the further degradation of the Monument's ecosystem. No natural controls exist for tamarisk and Russian olive. Biological control agents are currently being studied for use in reducing tamarisk infestations, however, these agents have not yet been approved for use beyond designated experimental sites. Due to the human influences such as cattle and horse grazing and vehicle use, most of the stream/riparian corridors will remain susceptible to invasive weed expansion. Tamarisk and Russian olive growth forms include small-stature shrubs and large trees, and their rooting structure permits tapping of shallow as well as deep- water sources, and their reproduction is self-perpetuating. Thus, based on observances of current rate of spread, these species will likely dominate most of the canyon floor and continue to expand into side canyon drainages as well as downstream into the San Juan River.

The no-action alternative would result in the continued degradation of the cultural, historical, and natural resource values Chinle Wash, Canyon de Chelly, and Canyon del Muerto. The physical and biotic environments associated with the wash and the canyon riparian channels would be distinctly altered, as a result of this woody non-native vegetation expansion. The conversion of a more diverse vegetation community (cottonwood, willow, native grasses and herbs) to a less diverse one would additionally reduce the faunal diversity for in the park. Allowing continued tamarisk and Russian olive establishment throughout the park contradicts guidance laid out in the parks enabling legislation by facilitating further degradation of the cultural, historical, and natural resources the park was created to preserve. The modification of the physical and biotic environments through increased densities of tamarisk and Russian olive would also compromise the viewshed that is a critical part of the cultural landscapes and the interpretation of the events that took place there. Additionally, invasive woody plant expansion increases the potential for unplanned fire events that threaten archaeological resources associated with the wash. Thus, the no-action alternative would not merely be a perpetuation of the extant scattered tamarisk and Russian olive infestations, but would undoubtedly lead to further decline of all resources within the park and promote the expansion of these invasive weeds beyond the parks boundary and into the San Juan River.

2.2.2 Alternative A (preferred): test and implement a variety of control treatments relevant for use at Canyon de Chelly

Alternative A (preferred action) consists of the testing and the application of multiple techniques where best applied within the various tamarisk and Russian olive infested areas of the park. In October 2003, an NPS interdisciplinary team determined that the canyon-bottom riparian zones are very close to reaching a threshold that, if crossed, could severely limit any future restoration of the canyon floor and riparian habitats. Thus, more immediate mitigation and restoration actions associated with tamarisk and Russian olive control and re-

establishment of native vegetation may be necessary. Large-scale removal of tamarisk and Russian olive in the riparian corridor and these narrow canyons, however, creates a risk for excessive, adverse, and unpredictable erosion unless an additional study is performed to determine which removal/control techniques are most effective and applicable to Canyon de Chelly National Monument.

The management of tamarisk and Russian olive within the southwestern United States typically involves the application of herbicides (stump cut or basal application), often followed by the removal of above ground woody material by shredding or by burning. Although, these techniques have proven beneficial, they also have some limitations. Killing tamarisk and Russian olive in this way does not remove the plant's woody root system from the soil. Even though the roots are dead, they continue to stabilize floodplain sediments, making them resistant to erosion for many years and reducing the probability of restoring natural stream channel geomorphology. Thus, a pilot study has been designed for Canyon de Chelly which involves developing an understanding of the effectiveness a variety of techniques related to herbicide treatments, partial (above ground) mechanical removal and/or whole tree (above and below ground) removal to kill tamarisk and Russian olive and in restoring more natural and sustainable riparian conditions to the park

This alternative would allow for the maximum recovery potential for currently infested and degraded lands and would combine all of the treatment options from the below single action alternatives. Treatment methodologies would include (1) cutting tamarisk and Russian olive trees and shrubs to a height of several inches above ground and immediately applying herbicide (Remedy or Garlon 3A depending on air temperatures) to the cut stumps; (2) use of targeted low volume basal application of herbicide to small diameter non-native trees/shrubs, (3) mechanical removal of dense stands using heavy equipment with a rotor mounted tree shredder, and (4) whole tree removals (including root systems). This alternative would support a funded pilot study and provides the best opportunity to define removal techniques most applicable and effective, on a large scale and within the multiple conditions that exist at Canyon de Chelly National Monument. Most importantly, the results of this study will provide the best information for developing and guiding the long-term management of tamarisk and Russian olive at Canyon de Chelly and will provide the necessary information to direct and maximize efforts to restore the natural and cultural landscape within the park.

2.2.3 Alternative B (environmentally preferred alternative): Stump cutting and direct herbicide application

The environmentally preferred alternative is determined by applying the criteria suggested in the National Environmental Policy Act of 1969 (NEPA), which is guided by the Council on Environmental Quality (CEQ). The CEQ provides direction that "[t]he environmentally preferable alternative is the alternative that will promote the national environmental policy as expressed in NEPA's Section 101..." to

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

- assure for all generations safe, healthful, productive, and esthetically and culturally pleasing surroundings;
- attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences;
- preserve important historic, cultural and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;
- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities; and
- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

The environmentally preferred alternative for tamarisk and Russian olive management in the at Canyon de Chelly National Monument is cutting the non-native trees (> 4-inches diameter) and applying herbicide (either Remedy or Garlon 3A depending on air temperatures at the time of application) directly to the cut stumps (Alternative 1) (Table 1). Additionally, the environmentally preferred alternative would use low volume basal applications of these herbicides for smaller diameter trees and sprouts (< 4-inches diameter) of tamarisk and Russian olive. Cut stump treatment and low volume basal spray methods have been used widely throughout the southwest, and have met with widespread success due to their ease of implementation and high degree of success in managing tamarisk and Russian olive. See Appendix 1 for the completed Environmental Screening Form for this alternative.

Specifically, the cut stump method will use a 25% Remedy or Garlon 3A (when air temperatures are above 85 ^{o}F) solution (active ingredient triclopyr for both herbicides) mixed with a surfactant. Trees are cut at the base with chainsaws or hand saws and herbicide is directly applied to the cut stump within 15 minutes. This method is 75-95% effective on tamarisk, 50-75% effective on Russian olive. The cut stump method is more labor intensive than a general foliar application but is typically required for woody stems greater than 4 inches in diameter or in areas of dense larger stems. Because the herbicide is directly applied to the cut stump, herbicide use is minimized and little risk exists to surrounding non-targeted vegetation. Slash created by the cutting of larger tamarisk and Russian olive will be made available to canyon residents for use as fire wood. Some slash will be maintained to be dispersed in bare ground areas to prevent erosion and/or to promote favorable site conditions for native plant establishment. This method leaves the plant roots of cut trees in the soil adding to soil stabilization. Use of chainsaws will result in short-term noise impacts.

The low volume basal spray method will use 20% Remedy Herbicide or Garlon 3A (active ingredient triclopyr for both herbicides) mixed with JLB Improved Oil Plus (vegetable based penetrant). Herbicide is applied by handcrews to the base stems of each tree from 12 inches to 36 inches in height depending on tree diameter. A United States Geological Survey (USGS) study by Doug Gladwin and Curt Deuser produced 88% overall mortality of all sized classes of tamarisk (2000, unpublished). The National Park Services' Lake Mead EPMT consistently achieves 95-100% mortality on tamarisk less than 6 inches in diameter using the low volume basal spray method. This methodology is low impact and does not harm surrounding vegetation. This technique is effective any time of year and leaves treated plants to die in-place. Standing snags provide wildlife habitat as well as having the added benefit of

creating safe micro-sites for native plant transplants and/or natural recruitment. Standing snags usually fall within 2-3 years with plant roots remaining in the soil to assist with soil stabilization.

The main benefits to this alternative are that the treatment can be targeted directly at the tamarisk and Russian olive plants, with little risk to non-targeted vegetation, and with no ground-disturbing activities. However, since this alternative relies entirely on hand-labor, it is very cost prohibitive to employ on a large-scale. Extensive time periods (up to 10 years and assuming funding remains available throughout this timeframe) would likely be required to remove large-scale beneficial levels of tamarisk and Russian olive within the canyon-bottom habitats using this treatment option alone.

2.2.4 Alternative C: mechanical removal with heavy equipment with rotor mounted tree shredder

Alternative C would use heavy equipment (a wheeled or tracked front loader, small skid-steer, trackhoe, or a bulldozer) to remove tamarisk and Russian olive from "non-sensitive" areas within the canyon riparian corridors. A mounted shredder would also be utilized to mulch trees as they are cut. "Non-sensitive" is defined for the purposes of this environmental assessment as those areas that are unlikely to contain or adversely impact archeological resources, private residences, and/or unique or rare wildlife or plant habitat.

This treatment methodology would cut non-native trees near the ground surface, leaving root systems in place, and would not involve use of herbicide. Removed woody materials would be shredded in place to add mulch to the soil surface and to minimize soil erosion. The type of shredder to be used would vary depending on the topography of the area to be treated. On broad floodplain areas a front mounted shredder would be used to increase shredding efficiency. For cut bank areas, a shredder mounted on an articulating arm would be used to optimize equipment and personnel safety. This type of removal treatment allows for selective cutting of only targeted vegetation and can be cost effective especially in removing larger size infestations.

Since Alternative C does not use herbicides, this treatment option would be less effective than Alternative B in creating tree mortality and may result in re-sprouting from the un-removed root systems. Although this method provides a cost effective management option for certain sections of the park, the use of heavy equipment would also create various levels of surface ground disturbance and would not be a viable option for many areas within the canyon-bottom habitats, especially sites containing sensitive natural and/or cultural resources. Thus, this treatment option would be much more restrictive as to the locations where it could be applied. Treatment actions under Alternative C alone would improve localized sections of the park, but would fail to maximize the recovery potential within many areas of the canyon floor and, as a result, would allow for continued spread of tamarisk and Russian olive from untreated areas.

2.2.5 Alternative D: whole tree removal (above and below ground)

Alternative D, whole tree removal, would similarly involve the use of heavy equipment (a front loader with a clamshell bucket or hydraulic tree shear that grabs trees and rips the tree out by the roots and/or a backhoe that can pull trees out by the base) and does not use any herbicide applications. This method is especially cost effective in dealing with extensive, dense stands of tamarisk/Russian olive and would prevent any re-sprouting as a result of the removal of the entire root system. Preliminary results from a study investigating the effects of whole tree removal at Dinosaur National Monument indicate that physically removing tamarisk plants, including their roots, has a significant positive benefit for rejuvenating floodplain geomorphic processes (Cooper et al. 2003).

This treatment option will create surface and sub-surface ground disturbance as a result of roots being pulled from the soil. Although the removal of root systems has distinct benefits to expediting recovery of geomorphological processes and it eliminating resprouting events, the resulting ground disturbance impacts has the potential for creating conditions favorable for the establishment of either the same or other undesired non-native species. Active native revegetation would be critical to meeting management objectives under Alternative D. This option also presents a higher level of risk to unknown (below soil surface) cultural resources and could not be used in locations of known sensitive natural and/or cultural resources. Alternative D has direct application and benefit to certain sections of the canyon floor, but would be restrictive in its application on a wide-scale basis. When used alone, this treatment option would only benefit limited locations and would fail to maximize recovery opportunities on a large-scale basis. The spread of tamarisk and Russian olive would continue from those areas that remained untreated.

2.2.6 Mitigation measures for the action alternatives

Since the action alternatives (including the preferred alternative) include the potential use of heavy equipment, use of chemical herbicides and/or clearing of non-native trees and brush, mitigation measures are necessary to ensure the health of canyon residents, park staff, contractors, and visitors. These mitigation measures will also protect the cultural and natural resources in the park.

- *Visitor and public health and safety:* Visitor and public health and safety can be ensured by limiting concessionaire and visitor access to treatments sites during periods of active removal operations. Park staff would keep all canyon residents, visitors, concessionaires, and tour guides informed of daily work schedules and treatment locations. Additionally, canyon residents, park concessionaires and visitors would be provided with information that identified the impacts of non-native tamarisk and Russian olive infestations and the benefits of managing these species within the upper within Canyon de Chelly National Monument as a whole.

- *Cultural landscape/archeological resources*: To minimize any potential impact to known park cultural or archeological resource(s), work performed in association with a known cultural or archeological resource site will be strictly supervised by the parks' cultural resource staff. If new or unexpected cultural resources are identified within a treatment area, all work will be halted immediately until appropriate investigation/documentation or site stabilization can be completed. Tree felling, removals, use of heavy equipment, and herbicide applications will only be accomplished with use of trained personnel. Work zones will be strictly designated when working near or adjacent to known cultural/historic/or archeological resources.

- *Water resources*: To minimize any potential for herbicide "wash-off" into surface and/or ground water, no herbicide application would be made within 24 hours of an expected rain event. Similarly no herbicide applications would occur during any period in which there is water flow within the wash or channels of Canyon de Chelly or Canyon del Muerto.

- *Air resources*: To minimize potential for air resource impacts as a result of undesired herbicide overspray and/or volatilization, herbicides would only be applied under conditions of little to no wind and under the appropriate air temperature regimes. Herbicide applications would strictly adhere to application conditions as specified on the Manufacturers Specimen Label (MSL) for the identified herbicides. The MSL's for Remedy and Garlon 3A are presented in the appendix.

- *Soils*: Use of a cut stump treatment method with direct application of herbicide minimizes any potential for herbicide contamination of soils. Herbicide applications will be only be applied by trained personnel and will not be used within 24 hours of an expected rain event, again to minimize any potential for herbicide contamination of soil. Work zones for the use of heavy equipment will be specifically defined in order to limit impacts to soil resources.

- *Vegetation*: To minimize impacts to non-targeted (native) vegetation, all herbicide applications would be applied by appropriately trained personnel and under appropriate environmental conditions as specified on the MSL. All herbicide application equipment (hand and backpack sprayers) would be checked daily to ensure "proper functioning condition" prior to use. Heavy equipment use will be limited to designated work zones to minimize impacts to non-targeted vegetation resources.

- *Wildlife/Species of Concern*: Treatment sites would be walked through prior to treatment initiation to assist in minimizing wildlife presence during treatment activities. All herbicide use would be limited to the minimal application needed to obtain weed management objectives and applied only under the appropriate environmental conditions. No tamarisk or Russian olive removals will be performed in locations identified as habitat for threatened or

endangered species. No removal activities will occur in or near sensitive species habitat during breeding or nesting seasons. At all other times, noise levels would be kept to the minimum level necessary to accomplish weed management actions. Conservation measures will be consulted on with US Fish and Wildlife Service as well as the Navajo Nation.

2.2.7 Future management needs and recommendations

Although the Chinle Wash remains much less infested with tamarisk and Russian olive than the central sections of the main canyon riparian corridors, it will be important to establish routine monitoring and a "follow-up" treatment program (once per year) for all areas associated with Russian olive and tamarisk control actions. Since waters flowing through the more heavily infested Canyon de Chelly and Canyon del Muerto eventually drain through the Chinle Wash, the potential for re-invasion of non-native woody vegetation into downstream habitats is high. Priority should be given to control actions that will eliminate minor infestations and prevent further spread of tamarisk and Russian olive beyond the current infestation limits in both up-stream (upper reaches of Canyon de Chelly and Canyon del Muerto) and downstream (within the Chinle Wash) habitats. Special priority should also be given to monitoring side canyon habitats. Most side canyon areas are currently uninfested or contain a minimal number of tamarisk and Russian olive plants (<25 plants). Immediate control actions are warranted in these areas to ensure that these small infestations are eliminated.

Annual visual "walk-through" surveys, augmented by the establishment of several permanent photostations would provide sufficient detection ability for any re-establishment or new invasion of tamarisk and Russian olive. Any new tamarisk and Russian olive seedlings detected as a result of annual surveys should be immediately hand-pulled (or treated with herbicide, if allowed) to prevent spread. Use of permanent photostations would additionally allow for qualitative assessments of native plant recovery and changes over time within tamarisk and Russian olive treatment areas. Quantitative monitoring protocols may also be developed if specific management questions arise requiring a more detailed understanding of "cause and effect" relationships associated with tamarisk and Russian olive removals and native vegetation and/or natural stream geomorphology recovery processes.

Table 1. Summary of Alternatives for Tamarisk and Russian olive Management at Canyon de Chelly National Monument.

Management Alternative	No Action	Alternative A (preferred): test and implement a variety of control treatments	Alternative B (environmentally preferred): Stump cutting with direct herbicide application	Alternative C Above ground mechanical removal with heavy equipment and rotor mounted tree shredder	Alternative D Whole tree removal (above & below ground) Mechanical removal with heavy equipment
Summary of Potential Action and its Effects	No tamarisk or Russian olive management would occur. These non-native species would continue to increase and spread throughout the Chinle Wash and canyon riparian corridors. Over time, the vegetated portions of the canyon floor (and side canyons) would become completely dominated by tamarisk and Russian olive. The accessibility of cultural resources associated with the park would decline, and the viewshed would continue to degrade. Homogeneity of the vegetation to a non-native tamarisk and Russian olive dominated community would reduce wildlife habitat and overall biological diversity. The salt-laden leaves of tamarisk would continue to contaminate soils. Increases in tamarisk, which is highly water consumptive, would reduce available groundwater. Threats to archeological resources and traditional use areas would increase. Visitor enjoyment would decline as riparian/canyon habitats become less representative of their cultural and natural resource values.	This alternative would test a full range of treatment options for tamarisk/Russian olive control and allow for the greatest application of large-scale treatment/removal of non-native woody species throughout all of the canyon riparian habitats. Alternative A would use a combination of all treatment options (alternatives B-D) identified under this environmental assessment. Short-term, minor negative impacts to wildlife would occur as a result of increases in noise during removal/treatment operations. Potential for minor negative impacts to unknown cultural resources could also occur as a result of heavy equipment use and "below-ground" and "at ground surface" disturbances. Minor to moderate, short-term negative impacts would occur related to increases in streambank erosion as the stream channels re-establish a more natural and stable condition. However, this alternative provides the greatest potential for moderate to major, long-term, positive benefits and provides the best opportunity for long-term sustainability of both the cultural (including traditional farming) and natural resources associated with the canyon floor.	Tamarisk and Russian olive trees and shrubs would be cut to stump height and immediately treated with Remedy or Garlon 3A herbicide. Most cut plant material would be removed from treatment areas and/or used as firewood by local canyon residents. Activities are labor intensive, which may limit full application of removal/control in all of the canyon-bottom habitats. Wildlife would experience short-term minor negative impacts, as a result of increased noise during tree removals. However, long-term beneficial impacts would be obtained in treatment areas as the natural vegetation community (cottonwood and willow) in the canyon corridors are restored to a more natural condition, maximizing wildlife habitat and overall biological diversity. Soil salinity created by tamarisk would be reduced in treatment areas. Aggressive water consumption by tamarisk would be reduced. The cultural landscape and viewshed of the canyon riparian corridors would be greatly enhanced and provide benefits to cultural resources and increased visitor understanding and enjoyment.	This alternative would cut tamarisk and Russian Olive trees near the ground surface, leaving root systems in place, using a wheeled or tracked front loader, small skid-steer, trackhoe, or a bulldozer. A mounted shredder would also be utilized to mulch trees as they are cut. Alternative C would not involve the use of any herbicide application. This alternative would be limited to use only in areas identified as "non-sensitive" due to the level of ground surface disturbance that can be created by heavy equipment. Alternative C is a cost-effective methodology for removing dense stands of tamarisk/Russian olive, but resprouting from remaining root systems would require additional follow-up treatments. Intact root systems would continue to provide stream bank stabilization, but could increase the time needed for re-establishing natural stream geomorphological processes. Alternative C would allow for the continued spread of tamarisk/Russian olive from untreated areas.	Alternative D would use heavy equipment in the removal of whole trees, including root systems, of tamarisk/Russian olive. This removal methodology is very cost effective when dealing with extensive and dense areas of infestation. Similar to Alternative C, whole tree removal would not involve the use of herbicides and would be restricted in its application to areas with "non-sensitive" natural/cultural resources. Alternative D would not require additional follow-up treatments since the removal of root systems eliminates the potential for resprouting. Although the removal of root systems has distinct benefits to expediting recovery of stream geomorphological processes, the resulting ground disturbance has the potential to adversely impact unknown (below ground) cultural resources and for creating conditions favorable for the establishment of either the same or other undesired non-native species. Tamarisk and Russian olive would continue to spread from untreated areas.

3 Affected Environment

3.1 Site Description

3.1.1 Location and Climate

Canyon de Chelly National Monument is located on a high plateau on the Navajo Nation Reservation in northeastern Arizona, near the Four Corners. The monument is about 3 miles from the town of Chinle, on the northwest slope of the Defiance Plateau. Three red-walled canyons make up the monument – Canyon del Muerto, Monument Canyon, and Canyon de Chelly – which encompass 83,340 acres or 130 square miles. The steep sandstone walls of these canyons have been sculpted by wind and water into a wide variety of dramatic formations. The canyons range in depth from 30 feet deep at the mouth to over 1,000 feet deep just 15 miles away. At an elevation of 5,000 to 6,000 feet, the area is characterized by an arid climate, with extremes of temperature – temperatures can range from 105°F in summer to -30°F in winter. The average rainfall is about 9.6 inches.

3.1.2 Relevant Land Use History

Because Canyon de Chelly National Monument has been inhabited by people for thousands of years, native vegetation and most of the canyons' vegetative communities have been substantially altered over time. Native vegetation in the lower and middle canyons, in particular, has been modified by the activities of people, which includes grazing, farming, wood cutting, plant gathering, clearing, alteration of natural fire regimes, and the introduction of non-native plants. McDonald identified a long list of plants that were used by residents of Antelope House (NPS 1976). As a result of the long history of human occupation, "pristine" vegetation in the monument is rare, although Morris noted it does occur on the top of Wide Rock Butte, near Spider Rock (NPS 1986).

Farming has had a large impact on plant communities in Canyon de Chelly and Canyon del Muerto. Ancestral Puebloan populations and Hopi grew corn, beans, squash, melons, gourds, and cotton (Remley 1993). The Hopi also planted peach trees, which were introduced by the Spanish, in the monument. Historically, the Navajo have planted crops of corn, melons, squash, and beans, with the addition of alfalfa in the 20th century. Cultivated fields were located along the canyon floor, including alcoves, on embankments on the sides of the streams, and on natural terraces. Orchards were also planted. Although farming is not as prevalent as it once was in the past, this activity still occurs in parts of the lower canyons and continues to affect the types, location and distribution of native plants in these areas.

Livestock grazing has also had a major impact on plant communities. Extensive grazing of large numbers of sheep, cattle, goats, and horses has occurred in the canyons in the past. Livestock grazing still occurs in the canyons, but like farming, this activity is no longer as intensive as it once was. Long-term heavy grazing and other factors have

resulted in a substantial decrease in understory grasses and forbs, and a substantial increase in density of trees and shrubs in Canyon del Muerto and Black Rock Canyon. The savanna woodlands are also encroaching into the grassland communities, primarily due to overgrazing, although fire suppression and other factors have also assisted in the spread of exotics. Many grasslands show signs of range deterioration, with native grass species having been replaced with non-native, less desirable grasses and weeds (NRCS 2000). Much of the canyon floor has traditionally been grazed, and continues to be grazed today. The NRCS concluded in its watershed plan that the riparian zones in the bottom of Canyon del Muerto were in poor condition, primarily due to intensive grazing. NRCS observed that forage production was low, even along the moist stream banks. This is also likely true for Canyon de Chelly. In the past, commercial logging has occurred on the rims of Canyon de Chelly and Monument Canyon (NPS 1986b). Approximately 9,880 acres along the rims of the upper canyons are within the Navajo Commercial Forest. Some commercial harvesting has occurred in all of the compartments that overlap the monument boundary (NPS, BIA, Navajo Nation 1990).

The riparian plant communities have been some of the most heavily altered communities in the monument. Historic photographs in the late 1800's and early 1900's show sparse vegetation, and a few scattered cottonwoods growing in the lower and middle reaches of the canyons (Dennis 1975, Andrews 1990, NRCS 2000; however, Andrews (1990) notes that there could have been dense vegetation growing earlier). In the 1930's major erosion control efforts were undertaken in the canyons to protect stream banks and adjacent cultural resources and farms. Thousands of willow, Russian olive, tamarisk, cottonwood, and luka reed (*Phragmetes communis*) seedlings were planted from the 1930's through the late 1960's (Andrews 1990, Dolan 1993, NRCS 2000). Cooper and Wohl (2003) suspect, based upon historic accounts, that certain stream reaches were channelized to open more area in the canyon-bottom habitats for farming or other uses, and that these straightened and incised channels were then stabilized through the planting of Russian olives and tamarisk. The National Park Service also frequently planted tamarisk, willows, and cottonwoods to divert stream flows away from threatened archaeological sites, such as at White House Ruin, Antelope House and Tse-ta-a' (Remley 1993).

Since the 1960's this vegetation has dramatically spread throughout the canyons' riparian areas. In particular, there has been a massive spread of Russian olive and tamarisk from the sites where they were originally planted along at least 15 to 20 miles of the canyon floor (Cooper and Wohl 2003). Today the stream banks, in places, are choked with a varying combination of tamarisk, Russian olive, willow, and luka reeds. Just above the confluence with Canyon del Muerto, the Canyon de Chelly channel is lined with Russian olive and tamarisk. Cooper and Wohl observed that Russian olive and tamarisk, interspersed with some older cottonwoods, continues to dominate the middle reach of Canyon de Chelly's channel. Understory vegetation is not present within the denser thickets of tamarisk and Russian olive, while in less dense stands, cheatgrass (*Bromus tectorum*) and rip-gut brome (*Bromus diandrus*) dominate. Tamarisk and Russian olive are continuing to move up canyon into the upper reaches of Canyon de Chelly and into side channels, although they are currently less dense and more intermixed with native woody and herbaceous riparian vegetation.

Hunting continues to occur in the monument under the management of Navajo Fish and Wildlife. The primary species that are hunted, mainly along the monument boundary above the rim, are Merriam's turkey, mule deer, black bear, and Rocky Mountain elk. (Some deer may be hunted in the canyons by a few individuals although there is no official documentation of this. J. Cole, Navajo Fish and Wildlife, pers. com., 5/23/03). All hunts are limited and on a permit basis, with annually adjusted permit numbers based upon survey and harvest reports.

3.2 Cultural Resources

3.2.1 Cultural Landscape and Archeological Resources

The proposed project area includes the Chinle Wash (from the park boundary and visitor center to the confluence of Canyon de Chelly and Canyon del Muerto), and the canyon floors of Canyon de Chelly and Canyon del Muerto (Figure 2 – Project Area). Historically, culturally, and spiritually, Canyon De Chelly is an extremely significant area to several native groups, including the Navajo people who inhabit the area today. Though not mentioned in the monument's enabling legislation, the canyon complex served as a stronghold for the Navajo in their wars against the Spanish, Mexicans, and Anglo-Americans. In 1864, it was within the modern-day national monument, that Kit Carson, along with U.S. Army forces, concluded the campaign against the Navajo, which resulted in their temporary exile (the "Navajo Long Walk") to Bosque Redondo, New Mexico. After their four-year internment at Bosque Redondo, the Navajo signed the "Treaty of 1868" which established the Navajo Reservation, with Canyon De Chelly at its geographic center. This treaty enabled a return to their former homeland. Canyon De Chelly was intentionally located at the very heart of the Navajo Nation since the canyon figures prominently in many traditional accounts and origin stories. Navajo families from the Canyon De Chelly area made a concerted effort to return to this important place after their hardship.

The canyons are rich in archeological and historic sites and provide homes, farming, and grazing lands for the Navajo people today. Visitors come to view archeological sites such as White House Ruin and Mummy Cave Ruins, and experience the ongoing Navajo culture. The monument contains more than 750 officially recorded archeological sites (most dating from A.D. 350 to 1300) and over 2000 other culturally significant sites, including areas which are traditionally important to the Navajo. Several cultures are represented at Canyon De Chelly throughout its long history of human occupation- the Ancestral Puebloan Indians (A.D. 350-1300), the Hopi Indians (A.D. 1300 to 1700), and historic and modern Navajo peoples (A.D. 1700 to present).

Evidence for human occupation at Canyon De Chelly begins approximately four thousand years ago with the Archaic period, a time of a nomadic hunter-gatherer lifestyle which gradually gave way to a more sedentary existence as domesticates, such as corn and beans, were introduced from Mesoamerica towards the end of the period (around

1,500 B.C.). At this time, most habitation was on the canyon rim around the confluences of side canyons with the main canyon, with growing utilization of the canyon floor as agriculture took hold. As people became more dependent upon cultivation as a means of subsistence and populations grew, a shift in social organization, material culture, and architectural forms took place. People began to live in small seasonal pithouse hamlets or villages within the canyon, which increasingly became larger year-round villages. This gradual shift occurred approximately 1,500 B.C., and is the beginning of the Basketmaker Period. This period is divided into two stages; the Basketmaker II (1,500 B.C.-A.D. 450) and Basketmaker III-Puebloan Transition (A.D. 450-850) stages. There is substantial evidence of the Basketmaker occupation of Canyon De Chelly, as evidence of their occupation can be found scattered throughout the canyon system. Their habitation sites can be found in both high alcoves and on the canyon floor, and consist of vertical slab, semi to fully subterranean storage and habitation structures with food production and social spaces. Trails led from the floor of the canyon to the rim, and were used to continue hunting and gathering, although not on the same, wide scale of the Archaic period. The canyon floor would have been extensively utilized for agriculture, and there is some evidence that the canyon rim was also used for this purpose. Since Basketmaker architecture was partial to sometimes fully subterranean, the remnants of structures and other features are often obscured by later period (Puebloan) architecture or naturally accumulated soils or other natural materials. Oftentimes, the uppermost portions of upright slabs from structures and storage cists can be seen at the modern ground surface, which is the only indication of a Basketmaker occupation in the area. At other times, this resource can be completely buried, with the only evidence of a site being slight, almost unnoticeable depressions in the modern ground surface. Human burials often occur in the storage structures at this time. Tightly woven baskets, from which the culture got its name, were used for storage, transport of material, and cooking. The population grew, and towards the end of the Basketmaker period, ceramic technology was developed, and new architectural forms emerged.

The Puebloan Period (Pueblo I-III, A.D. 850-1350 Pueblo IV, A.D. 1350-1600) saw continued use of alcoves for habitation, however, large open sites on alluvial terraces became commonplace. These sites were chosen for their proximity to large, farmable tracts of canyon floor, water, and the ability to see greater distances in the canyon (which suggests a more complex social organization between villages). In the Pueblo I Period, houses were constructed above ground, and were of jacal (wattle-and daub) construction. Activity areas for food processing and material goods production existed. Evidence for Pueblo I settlements at Canyon De Chelly is minimal, however a majority of these sites could be obscured by accumulated soils or later Puebloan constructions which are still visible today. The Pueblo II Period saw another population increase and another architectural development with the advent of wet-laid, rectangular, masonry structures. Large, multi-storied units can be found on the floor of the canyon (Antelope House Ruin) or in an alcove (Mummy Cave Ruins). These structures can also be located in small or large lower alcoves which utilize the canyon floor to create multi-storied pueblo units (White House Ruin). Social, storage, work, and religious spaces were thoughtfully incorporated into the settlement areas. The entire canyon was utilized by the Puebloan people. Settlements occur nearly every half mile and cultivated areas around the pueblos

must have been wide-ranging. Nearly inaccessible ledges provided refuge in times of strife. Those same ledges sometimes contain kiva complexes with storage units. As the Pueblo III period came to a close, fewer and fewer settlements remained inhabited, as a shift in culture took place, and Canyon De Chelly became a corridor between pueblos to the east and west of the canyon. The Pueblo IV Period (Hopi) saw sporadic visits and farming on the floor of the canyon, but not large-scale habitation as previously seen. Several sites on the canyon floor show scatters of ceramics undoubtedly Hopi in origin, but not enough information is available at this time to determine the full extent of use by the Hopi.

Navajo occupation of the canyon began approximately in the 1700s. The canyon floor was used for habitation and subsistence, while high alcoves and previous Puebloan sites were re-used for sheep and goat herding, grain storage, and habitation. A continuity of ancient life ways may be observed at the park in the modern Navajo peoples who inhabit the park today. Although Canyon De Chelly National Monument was established to preserve the significant collection of prehistoric and historic cultural resources, the intangible intricate interrelationships between the cultural resources and natural landscapes of the park cannot be separated. The Ancestral Puebloans who lived in the canyons prior to the Navajo occupation farmed the fertile canyon floor. Present day seasonal Navajo homes and farms are still scattered along the canyon floor, with more permanent homes on the rims above the seasonal canyon homes. Today, approximately 50 Navajo families reside in the monument's canyons on a seasonal basis. The Navajo continue to carry on traditional agricultural activities during the warm weather months, and raise crops of corn, squash, alfalfa, and various fruits. Canyon floor acreage under modern-day cultivation varies from year to year, but ranges between 150-200 acres. Although not as extensive as in the past, grazing of sheep, cattle, and horses also occurs within the canyon. The landscape of Canyon De Chelly and its cultural resources have become tremendously intertwined over the last 4,000 years of human occupation; therefore the landscape of the canyon system, as a whole, must be considered to be a "Cultural Landscape". The cultural resources of the monument, including the modern-day observable life ways of the Navajo, are closely connected with the landscape and hence form the most significant aspect of Canyon De Chelly National Monument.

Invasive plant infestations have seriously altered stream processes creating unnatural rates of channel incision and land erosion, which has reduced land areas available for Navajo traditional land uses such as farming. In addition, natural biological diversity has been significantly reduced within the main canyons. This biodiversity is important for maintaining the natural ecology of the canyons and supporting traditional and ethnological use of resources by Navajo peoples. These changes have dramatically altered the appearance of the cultural landscape and seriously threaten valuable and irreplaceable archeological resources through excessive erosion and/or establishment of excessive fuels and increased fire hazards.

NPS Management Policies 2001 (2000) state that "the treatment of a cultural landscape will preserve significant physical attributes, biotic systems, and uses when those uses contribute to historical significance." Three types of treatment for cultural landscapes are

delineated by the Management Policies, including preservation, rehabilitation, and restoration. In the case of Palo Alto, restoration is the most appropriate treatment option because it is essential to understanding the park's cultural and historic significance, and enough data exists to accurately restore the landscape (NPS 2000).

3.2.2 Historic Structures

Canyon De Chelly National Monument contains numerous historic Navajo and prehistoric structures which are threatened by the by the encroachment of exotic vegetation. The age, shape, size, and function of these structures varies widely. The canyon is most famous for its large Ancestral Puebloan habitation sites such as Mummy Cave, Antelope House, and White House, however much earlier precursors to these structures still exist, but are not as well known to the general public. These subterranean habitation structures, often lined with upright stone slabs of various sizes, are called pithouses. These pithouses can be located in canyon alcoves, on canyon rims, and directly on the canyon floor. Storage structures and cists are also common, and are located around the pithouses, or in high protective alcoves. Oftentimes on the canyon floor, the only indication of the presence of a pithouse is a slight depression in the soil, so it is possible that many pithouse villages remain undetected in Canyon De Chelly. In other instances, later Puebloan peoples settled in the very same areas as the earlier pithouse villages, and therefore much of the earlier architecture is obscured by later additions.

This later, classic Puebloan architecture is the primary reason that visitors flock to Canyon De Chelly National Monument. Impressive masonry structures which are still standing, such as White House and Antelope House ruins, are located directly on the canyon floor, and have been threatened with the threat of uncontrolled erosion and fire for some time. Previous erosion control efforts have been instituted at these major structural sites, and have been successful to varying degrees; however numerous other lesser known structures, such as Ute Raid Pueblo, have already been affected by destructive erosion events and are continually threatened today.

Later structures of Hopi and Navajo origins can be found throughout the canyon. These include masonry room blocks and storage structures of Hopi origin, similar to the Ancestral Puebloan structures, and traditional Navajo homes of masonry and/or log construction, called hogans, ceremonial structures (often of wood) such as sweatlodges, and masonry storage structures, called granaries. In addition, these later time periods saw quite a bit of adaptive reuse of previous Puebloan structures for grain storage and livestock pens. The Navajo today, continue to live seasonally in hogans, some of which are several generations old, which are located directly on the canyon floor. Many of these structures are also threatened by increased rates of erosion and hazardous fuel build up.

3.2.3 Ethnographic Resources

Canyon De Chelly National Monument contains numerous individual ethnographic resources which are all interrelated and tied closely to the landscape and resources of the

canyon. These resources include areas visited by holy people in Navajo legends, areas where traditional ceremonies take place, traditional agricultural areas, locations where natural herbs or other medicinal materials are collected by medicine men, and domestic areas which have been continually inhabited for several generations. Currently, these ethnographic resources are exceedingly endangered by the encroachment of exotic vegetation. Additional threats to ethnographic material stem from the erosion of the canyon floor, on which a majority of these resources are located, and from the increased risk of fire due to excessive fuel build-up. Decreased accessibility has prevented the Navajo People from practicing these established life ways, and hence, knowledge of these areas and their resources are becoming lost, and would eventually disappear. The loss of this ethnographic information would be extremely detrimental to the Navajo, as Canyon De Chelly is considered to be one of the most important religious centers of the Navajo Culture. The area figures prominently in many of their origin stories and ceremonies. The loss of the continually occupied landscape of the canyon would moreover eliminate an experience that most visitors find to be one of the most endearing qualities of their canyon experience.

3.3 Natural Resources

3.3.1 Climate

The climate of the monument area can be generally characterized as steepe or, cool, inland desert (Harlan and Dennis 1976). The mean annual temperature varies from 67.9^{o}F down to 60.0^{o}F at the higher elevations. The highest mean daily maximum, recorded from the monuments entrance (lowest elevation for the park ~ 5538 ft.) is 91.1^{o}F in July, and the mean lowest daily minimum is 15.2^{o}F in January. Precipitation is relatively low, averaging 9.6 inches per year at the lower western boundary of the park and ranging to as high as 12 inches per year toward the higher elevations of the upper canyon reaches. Precipitation is received as both snow or as rainfall. Summer is the wettest time, when thunderstorms may develop several times per week. June is typically the driest period with a mean annual rainfall of 0.28 inches, with August being the wettest month, averaging 1.7 inches of rainfall (Canyon de Chelly Statement for Management 1987).

3.3.2 Geology

The monument lies on the western slope of the Lukachukai and Chuska mountains. This region is characterized by steep-walled, meandering canyons up to 1000 feet deep, which were cut by streams as through the surrounding Defiance Plateau. Elevations range from 5500 feet at the mouth of Chinle Wash to approximately 7500 feet above mean sea level (msl) in the upper canyon reaches.

The canyons cut through three geological formations. The uppermost and youngest is the Shinarump conglomerate, a course grey sandstone and conglomerate deposited during the Triassic period. The De Chelly sandstone, a massive cross-bedded red-brown sandstone deposited during the Permian period, lies beneath the Shinarump conglomerate. The De

Chelly sandstone contains the regional groundwater reservoir. Prehistoric stream erosion of the De chilly sandstone has formed the high overhanging rock shelters that contain most of the prehistoric ruins. The lowest and oldest geological formation is the Supai sandstone, composed of dark red Permian sandstones and shales. The canyon floor is made of valley fill or alluvium ranging from 20-50 feet in depth. Within the boundaries of the national monument the canyon floor is narrow and confined, but fan out rapidly after leaving the monument (Canyon de Chelly Statement for Management 1987).

3.3.3 Soils

The soils located on the canyon's rim are level, shallow (10 to 20 inches) to sedimentary bedrock, coarse textured, have low water holding capacities, and were formed in eolian and residual materials. In the canyon floodplain and on stream terraces, the soils are nearly level to gently sloping and very deep (greater than 60 inches). They are composed of stratified sands and fine and medium gravel overlying sandy clay, gravelly clay or silty clays. Water holding capacities are medium to high.

Soils above and near Canyon del Muerto are sloping, shallow and very shallow (4 to 20 inches to sedimentary bedrock), are coarse textured, have low water holding capacities, and formed in eolian and residual materials. In the canyon, soils are generally nearly level to gently sloping stratified sands with layers of fine and medium gravel over sandy clay, gravelly clay or silty clays, forming in mixed alluvium. Water holding capacities are medium to high. Sloping areas along the canyon walls are deep and very deep (40 to greater than 60 inches) sands or sandy loams. Water holding capacities are medium to high. These soils developed predominantly in eolian material. At this time, an updated soil survey conducted through the NPS Soils Program has been initiated.

3.3.4 Stream/Canyon-Bottom Geomorphology

Erosion has been a major problem in the monument along the canyon floor. Rapid heavy flows of water from the canyon rims and from areas upstream of the monument, continual shifting of the water courses within the canyons, and severe bank cutting and downcutting of the stream beds all contribute to erosion of the lands in the canyon. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims, including logging, grazing, and agricultural practices have significantly affected erosion in the monument (NPS 1986b). Hundreds of dirt tracks in the monument also contribute to erosion (NPS, BIA and Navajo Nation 1990).

Erosion has resulted in the loss of soil and in agricultural fields no longer being able to be irrigated and farmed. For instance, the stream in Canyon del Muerto is entrenched between the mouth and Mummy Cave and fields in some locations are 25-30 feet above the stream bed (NRCS 2000). Numerous small cultural resource sites and burials also have been damaged by erosion (NPS 1989).

Channel erosion has been caused by past and present grazing of horses, sheep, goats and cattle, the invasion of non-native plant species such as salt cedar and Russian olive (which have shaded out understory plants that bind the soil and help to stabilize stream

banks), roads in the canyons, and the construction of the Tsaile and Wheatfield Dams upstream of the monument (which altered peak flows in the canyons, enabled vegetation to confine channels, and may have increased the erosive potential of the flow (NRCS 2000). Water releases from the dams also have been reported by local residents to cause erosion in the monument in the past. Stream bank erosion control efforts began in the 1930s and have been successful in some places, such as at White House Ruins and Antelope House Ruins where water control gabions were installed. However, erosion along the stream beds continues to threaten agricultural fields, burials, and archaeological sites along the floors of Canyon de Chelly, Canyon del Muerto, and their tributary canyons.

3.3.5 Water Resources

Surface Water

There are two primary drainages in Canyon de Chelly National Monument: Canyon de Chelly and Canyon del Muerto. These two drainages confluence about three river miles upstream of the Monument's Visitor Center forming Chinle Wash, which eventually flows into the San Juan River. The contributing watershed area to Canyon del Muerto is about 200 square miles, while Canyon de Chelly receives runoff from an excess of 400 square miles. Both of the canyons support intermittent flow in the lower reaches, generally in response to spring snowmelt and summer thunderstorms. The upper reaches of both drainages support perennial flow.

Two streams, Tsaile and Wheatfields Creeks, flow through Canyon de Chelly. Quantitative records of stream flows in the canyons are lacking. Peak flows occur during the spring and late summer. Summer thunderstorms typically account for about 40% of the rainfall. Flows in the spring are fed by snowmelt runoff from the watershed above the canyons and from groundwater inflow in the upper canyons, while late summer flows are the result of thunderstorms. High peak flows are the result of intense rainfalls, shallow soils, extensive rock outcrops, and short distances to the mainstem channels. Although the streams flow year round in the upper canyons, they are intermittent in the lower reaches. For the last several years the region has been experiencing a severe drought and the streams have stopped flowing in the lower parts of the canyons in the summer – Canyon de Chelly is usually dry during the dry season below the junction with Canyon del Muerto. The lack of water in the summer due to the drought has resulted in little if any stream water being available for irrigation of the canyons agricultural fields.

Recently the USGS has assumed operation of the gage located on Chinle Wash just downstream of the bridge adjacent to the Visitor Center. This gage, number 09379025, has recorded mean daily flows and annual peaks from November 1999 to September 2002. From this three year record, it appears that winter baseflows begin around the end of the calendar year and continue until springtime, April to May. The rest of the year, there is no measurable flow in Chinle Wash with the exception of short duration (2-8 days) thunderstorm driven flows. Mean daily flows during the baseflow period vary from about 5 to 30 cubic feet per second (cfs), with some daily values approaching 100 cfs. Intermittent mean daily flows derived from thunderstorms are usually less than a few cfs

but may approach 100 cfs. Annual peak flows vary from 164 cubic feet per second (cfs) in April 2000 to 1000 cfs in August 2001. The third recorded annual peak flow, 967 cfs, occurred in August 2002. Due to the short record (3 years) and high variability (164 cfs-1000 cfs) no reliable flood frequency curve can be calculated.

Two large earthen water storage dams above the monument significantly affect flows in the canyons. Tsaile Dam above Canyon del Muerto was built in 1963, and has a storage capacity of 3,100 acre-feet. Wheatfields Dam, above Canyon de Chelly, was built in 1993 and has a storage capacity of 5,700 acre-feet. Both dams have reduced base flows and peak flows during the spring (NRCS 2000). The dams also have changed spring flow patterns from short-lived, intense runoff into extended periods of runoff that can hinder access into the canyons. In some years it is early or mid-June before families can enter Canyon del Muerto to plant their fields because of the prolonged flow (NRCS 2000). In addition, the dams and the downcutting of the streams have resulted in very few agricultural fields now being able to be sheet flooded by naturally occurring overflow from the streams.

Groundwater

Readily available groundwater in the two canyons is restricted to shallow water-table aquifers that occur in the valley fill alluvium. High-stage stream flows and flow from the side canyons, pour-offs and springs all recharge the alluvial deposits that fill the canyons to varying depths. Throughout the growing season the alluvial aquifer supports the riparian vegetation and during low flow periods, this relatively young groundwater provides baseflow to the main channels. The occurrence of measurable baseflow during the winter season is indicative of reduced transpiration. Channel incisions may serve to lower water levels in the adjoining alluvial aquifer and any wells finished in the alluvium.

The park owns two relatively deep water supply wells (about 600 feet below land surface) located near Thunderbird Lodge. Review of the existing well logs suggests that both of these wells derive water from the alluvial aquifer associated with Chinle Wash. While this aquifer is continuous with the alluvial aquifer in the upper canyons, drawdown in the supply wells likely has little effect on alluvial groundwater levels in the two canyons. The distance from the supply wells to the upper canyons and the presence of bedrock canyon walls which serve as hydrologic boundaries, coupled with the relative permeability of the alluvium, would restrict drawdown effects to the locality of the supply wells.

Water Quality

There is very little water quality data for the streams in the monument. The streams' water quality tends to reflect the geology of the area. The dams above the monument probably reduce the sediment loads that would otherwise be present in the streams. On the other hand, summer flows that result from thunderstorms probably produce high sediment loads in the canyons. There are no known major water quality problems in the monument. However, surface water appears to have been affected by human activities. Potential sources of contaminants include ranching and agricultural activities (both in and outside the monument), stormwater runoff, residential development and road construction

along the canyon rims, recreational use, timber harvesting and mining activities, and atmospheric deposition (NPS 1999).

3.3.6 Vegetation

Overview

Canyon de Chelly National Monument is considered to be part of the southern Great Basin Desert (Brown 1994) and is also considered part of the Upper Sonoran life zone (Cook 1994). The monument's vegetation varies both from the canyon rim to the canyon floor and as the elevation climbs over 1500 feet from the lower canyons to the upper canyons (NPS 1987). Vegetation changes from desert scrub and grasslands in the Chinle Wash area to stands of evergreen trees at the upper ends of the monument, where the canyons join the Defiance Plateau. Douglas fir and aspen trees also are found on north-facing slopes within the canyons at elevations as low as 6000 feet. Dense stands of big sagebrush are found at the monument's upper elevations. Short grasses, rabbitbrush, sagebrush, yucca, low-growing prickly pear, cholla cactus, Russian olive, juniper, and piñon are found on rim tops and mesas. Canyon-bottom habitats support cottonwoods, willow, tamarisk, Russian olive, oak, box elder, wild grape, cactus, yucca, and annual and perennial flowers such as evening primrose and asters (NPS 1987).

The Monument's vegetation has not had been extensively studied or mapped until recently. In the 1970s the monument's vegetation and plant communities were studied by a couple researchers (Halse 1973, Dennis 1975, Harland and Dennis 1976). A few other vegetative/ecological studies have subsequently been done on specific areas in the monument (Schmutz et al 1976; Cook 1994). In 2003 an inventory of the monument's flora was completed by Rink and a draft report is in progress (Rink 2003).

Canyon de Chelly supports a variety of plant species, due largely to changes in environmental factors (e.g., topographic features, elevation, water, soil, temperature). A total of 764 vascular plant species and 12 subspecies have been documented thus far in the monument (Park Natural Resource Files. Rink's inventory noted 246 previously unrecorded species and eight subspecies. He observed that the monument harbors "significant rare plant resources," such as new discoveries of plants at the edge of their range (Chihuahuan sedge (*Carex chihuahuensis),* Navajo sedge (*C. specuicola*) , and sheathed deathcamus (*Zigadenus vaginatus*)). The draft report also notes that "significant plant diversity" remains to be discovered in the park.

Seven major vegetative communities have been identified in the monument: canyon-bottom communities; talus communities; springs, seeps, and other wet places; piñon-juniper continuum; lower shrub grassland communities; sagebrushland community; and canyon rim, cliffs and ledge communities (Dennis 1975; Harland and Dennis 1976; Morris 1986). These communities form a complex mosaic and often grade into each other. Thus, the boundaries of these communities are not always necessarily distinct, particularly in the heads of the canyons where several communities (wet places, canyon-bottoms, talus and canyon rims) form a continuum. There is a considerable variation in species abundance and diversity in the seven communities. The communities found primarily in the canyons (canyon-bottom, talus slope, springs, seeps and other wet places,

and canyon rims cliffs and ledges) tend to be more diverse in composition than the communities found primarily on the plateau (piñon-juniper continuum, sagebrushland, and low shrub-grassland) (McDonald 1976). The following descriptions are based largely on the work of Dennis (1975), and Harland and Dennis (1976). (All of the plant community cover type percentages listed below from Harland and Dennis are about 30 years old). Although the percentages give a general idea of the relative size of the plant communities, the numbers likely have subsequently changed, perhaps significantly in places. The National Park Service will be developing a vegetation map based on aerial photography, which will update these figures in late 2004.

Canyon-Bottom Communities

The canyon-bottom communities cover about 24% of the monument (~25,000 acres) and can be divided into a lower region below 6000 feet (the very sandy lower ends of the canyons), characterized by a wide streambed and almost no vegetation, and an upper region that was more densely vegetated. Dennis (1975) noted that the canyon-bottom communities supported the most diverse collection of plants of all the communities occurring in the monument. However, the communities in the lower ends of the canyons, particularly the riparian vegetation, have largely been altered over time by people, primarily by the introduction of plants and animals. (The canyon floor is also the best land for agriculture.) Stands of trees and shrubs border the stream channels. The dominant trees of the lower canyons are Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamrix ramosissima*), cottonwood (*Populus deltoides*), and various willow species (*Salix* spp.). This riparian vegetation has become very dense in the past 30 years or so (Rink 2003). The sandy terraces that are not in cultivation often support large stands of reeds (*Phragmites communis*). Plants such as four-wing saltbrush (*Atriplex canescens*), pale wolfberry (*Lycium pallidum*), prickly pear cactus (*Opuntia phaeacantha*), and narrow leaf yucca (*Yucca angustissima*) occur on drier sites. Scattered western hackberry (*Celtis reticulata*), box elder *(Acer negundo*), and Utah juniper (*Juniperus osteosperma*) also grow on the canyon floor.

The upper bottoms of Canyon del Muerto and Canyon de Chelly are cooler and have a greater water supply, and thus support a diversity of plants and much denser plant growth. Several different trees and shrubs grow along the streams in the upper canyons, including box elder, alder (*Alnus* spp.), birch (*Betula occidentalis*), Gambel oak (*Quercus gambelli*), Rocky Mountain juniper (*Juniperus scopulorum*), Douglas fir (*Pseudotsuga menziesii*), and dogwood (*Cornus sericea*). Many herbs are also common here. Two species not known to occur anywhere else in the monument, blue spruce (*Picea pungens*) and common cattail (*Typha latifolia*) occur in upper Canyon del Muerto (Harland and Dennis 1976).

Riparian Communities (Including Wetlands, Springs, and Seeps)

Springs, seeps, and other wet places (riparian/streamside vegetation, wetlands) are scattered through the monument and cover only a small proportion of the area (about 0.5% of the monument). These communities intermesh and overlap with canyon-bottom communities and talus communities in the moist upper canyons, making their boundaries hard to distinguish. The wet communities support a number of plants that do not occur

elsewhere in the monument. A springs inventory in the monument has not been completed, however, seeps are common along cracks in the sandstone walls of both Canyon de Chelly and Canyon del Muerto. These seeps support hanging gardens, which are an important resource. Plants that are commonly found in the hanging gardens include maidenhair fern (*Adiantum capillus-veneris*; most common in the lower canyons), columbine (*Aquilegia micrantha*), monkey-flower (*Mimulus eastwoodiae*), goldenrod (*Solidago sparsiflora*), and grasses. Hanging gardens support rare plants, such as MacDougal's aletes (*Aletes* macdougalii), death camas, and Navajo sedge.

Along the streamsides of both the upper and lower canyons species such as sedges (*Carex* spp.), rushes (*Juncus* spp.), common spikerush (*Eleocharis macrostachya*), bulrushes (*Scirpus* sp.), and horsetail (*Equisetum laevigatum*) grow. Box elder also is ubiquitous in moist areas. Other species found in very moist areas in the upper canyons include Arizona alder, water birch, dogwood, water hemlock (*Cicuta douglasii*), buttercup (*Ranunculus cymbalaria*), cutleaf coneflower (*Rudbeckia laciniata*), and cattail.

Talus Communities

The talus communities occur along the sheer cliffs of the lower canyon. They are estimated to cover about 1% of the monument. Dennis (1975) observed that these communities have small tree-large shrub populations, which contrasts with the large tree-low shrub-grass populations of the canyon-bottom communities. Talus communities on north and east-facing slopes support plants with higher moisture requirements, including Douglas fir and Utah serviceberry (*Amelanchier utahensis*). The drier south and west facing talus slopes support a modified piñon-juniper flora, with a predominance of Utah juniper (*Juniperus osteosperma*) at the lower elevations and increasing numbers of piñon pine (*Pinus edulis*) at higher elevations. Other species that occur in the talus communities include Indian rice grass (*Oryzopsis hymenoides*), Mormon tea (*Ephedra viridis*), Fendlerbush (*Fendlera rupicola*), walnut (*Juglans major*), beargrass (*Nolina microcarpa*), littleleaf mock orange (*Philadelphus microphyllus*), shrub oak (*Quercus turbinella*), Gambel oak, and box elder.

Canyon Rim/Ledge Communities

The canyon rims, cliffs and ledges communities also contain a diverse group of plants due to changes in elevation and exposure. These communities are estimated to cover about 3% of the monument. The vegetation in these communities is found from 5600 feet to 7600 feet in elevation, and usually does not extend more than 650 feet from the canyon walls. At lower elevations (about 6200 feet) with south to west exposures, perennial plants commonly found include sagebrush (*Artemisia bigelovii*), little leaf mountain mahogany (*Cercocarpus intricatus*), Utah juniper (*Juniperus osteosperma*), scrub oak (*Quercus turbinella*), narrow leaf yucca (*Yucca angustissima*), banana yucca (*Y. baccata*), and several grass species in scattered clumps. At higher elevations (above 6600 feet), with north to east exposures, common plants include box elder, Utah serviceberry (*Amelanchier utahensis*), alder leaf mountain mahogany (*Cerocarpus montanus*), Fendler bush (*Fendlera rupicola*), New Mexico muhly grass (*Muhlenbergia pauciflora*), mock orange, mutton grass (*Poa fendleriana*), Douglas fir, Gambel oak, selaginella (*Selaginella mutica*), and meadow rue (*Thalictrum fendleri*). Plants that are

commonly found on ledges of any exposure are rabbitbrush (*Chrysothammus* sp.), clemantis (*Clematis ligusticifolia*), Mormon tea (*Ephedra viridis*), piñon pine, and squawbush (*Rhus trilobata*).

Piñon-Juniper Communities

The largest vegetative community in the monument, covering an estimated 57% of the area, is the piñon-juniper continuum. This community occurs approximately between 6200 -6600 feet and occurs only on the plateau above the canyons. Although it covers a large area, this community supports a relatively small number of the plants known in the monument. Dennis (1975) divided this group into sparse, medium and dense communities, with vegetation changing due to increasing elevation, increasing precipitation, and cooler temperatures. However, the boundaries between these communities are not that distinct. The "sparse" community occurs at low elevations and is transitional between the low shrub-grassland communities and the denser piñon-juniper communities. The tree cover in this group is only 10%, with Utah juniper being dominant. The understory includes rabbitbrush, snakeweed (*Gutierrezia sarothrae*), and grasses such as blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*). In the "medium" piñon-juniper group, the tree cover increases to 30% and there is a relative increase in piñon pine over juniper. Big sagebrush (*Artemisia tridentate*) becomes more common in the understory. In the "dense" piñon-juniper areas the tree cover increases to 60%, with piñon pine continuing to increase relative to juniper and big sagebrush becoming still more common in the understory.

Low Shrub-Grassland Communities

Low shrub-grassland communities occur along the western edge of the monument, on the plateau above the canyon, generally at or below 6200 feet. These communities dominate the rims, the upper terraces, and the slopes of the lower canyons, and cover about 5% of the monument. In the past these communities likely had more of the highly palatable grasses and less of the unpalatable shrubs. But livestock grazing has extensively altered the plant community. One grass species, galleta, is the dominant plant, with the low shrubs rabbitbrush and snakeweed also being relatively common. Other common species include Mormon tea and prickly pear and cholla cactus (*Opuntia* ssp.).

Sagebrush Communities

The sagebrushland community covers about 9% of the land. It occurs primarily above 6200 feet on the broad flat areas along drainages, interjoining with the piñon-juniper that caps the hills and rocky areas. Sagebrush is a relatively homogenous group, with big sagebrush accounting for over 90% of the total vegetative cover. Juniper and piñon occur sparsely along the borders of the community. Other species that are scattered through this community include segolily (*Calochortus nuttalli*), larkspur (*Delphinium scaposum*), foxtail barley (*Hordeum jubatum*), and needle and thread grass (*Stipa comata*). Rink (2003) observed that piñon pine and juniper are invading many areas of this community.

3.3.7 Wildlife

Based on the diversity of habitats found in Canyon de Chelly National Monument (including vegetative and elevational variations), and the presence of water in the upper

canyons, the monument likely supports a diverse population of resident and migrant wildlife. The canyon riparian habitats, particularly in the upper canyons, are some of the most important wildlife habitat in the monument. Wildlife populations in the monument have not been well studied. Surveys recently have been initiated on the monument's reptile, amphibian and bird populations. Older information exists on the monument's vertebrate populations (Burgess 1973).

Birds

Canyon de Chelly National Monument supports a variety of both resident and migratory birds. Hasty and Fletcher (1981) listed 143 species of birds occurring in the monument and surrounding area, of which 54 species were identified as permanent residents, 57 species were summer residents, 12 were winter residents, and 20 were migrants. Remley (1993) noted that many perching birds, ground birds, and raptors were year-round residents. Common year-round resident birds include killdeer, rock dove, mourning dove, common flicker, yellow-bellied sapsucker, Steller's jay, scrub jay, pinyon jay, common raven, mountain chickadee, pygmy nuthatch, canyon wren, mockingbird, American robin, starling, brown-headed cowbird, house sparrow, house finch, and song sparrow. Birds that are often seen in the summer include various warblers, sparrows, vireos, and flycatchers, common nighthawk, white-throated swift, violet-green swallow, and western tanager. Common migratory birds that are seen during migration, especially at Tsaile Lake on the monument's border, include mallard, redhead duck, American coot, and greater yellowlegs.

The monument also supports a variety of birds of prey. Hasty and Fletcher (1981) listed 12 species of hawks, eagles, and falcons, two owl species, and the turkey vulture. American kestrel are common year-round residents. Peregrine falcons are known to nest on the cliffs, but the number of nesting pairs is currently unknown.

Amphibian and Reptiles

Based on recent amphibian and reptile surveys, tiger salamander, red-spotted and Woodhouse toads, canyon treefrog, and at least one species of spadefoot toad occur in the monument (D. Mikesic, Navajo Nation Natural Heritage Program, pers. com., 1/5/2004). Most of these species occur in the canyon bottoms, wet side canyons, and wetlands. Nine lizard species are known to occur in the monument, of which eastern fence, sagebrush, and plateau striped lizards are most common. Five snake species have been recorded, including the prairie rattlesnake which is rarely seen.

Fish

Very little information has been collected on fish occurring in the monument. Burgess (1973) listed two fish species: speckled dace, and bluehead mountain sucker. These fish mostly occur in limited numbers in pools and deeper streambeds in the perennial upper reaches of Canyon de Chelly and Canyon del Muerto.

Mammals

Burgess (1973) recorded 41 mammal species occurring in the Canyon de Chelly region, of which 26 species were actually documented in the monument. The most common

mammals in the area are rodents, which are found in all of the monument's vegetative communities. Burgess (1973) reported 24 rodent species in the region, of which 14 species were collected in the monument, including blacktail jackrabbit, porcupine, longtail vole, and several species of squirrels, mice, chipmunks, pack rats, and pocket gophers and beavers. Thirteen species of bats live in the monument area, including big brown bat, western big eared bat, pallid bat, Mexican freetail bat, and several Myotis species. Burgess (1973) observed only two carnivores in the monument, gray fox and striped skunk. Recent observations include black bear, bobcat, ringtail cat, coyote and anecdotal reports of mountain lions (Leslie, Park Natural Resource Files). Other carnivore species that have been seen by residents or are thought to be in the area include raccoon, badger, kit fox, and spotted skunk. Black bear have been venturing farther down into the canyons from the nearby Chuska Mountains more frequently in recent years, probably due to the ongoing drought. There are likely some bear dens within the upper canyons and along the rims (J. Cole, Navajo Fish and Wildlife, pers. com., 5/20/03).

Several game species occur in the monument, including turkey, blacktail jackrabbit, desert cottontail, mule deer, black bear, and occasionally elk. Portions of the monument rim are very important winter range for mule deer, particularly around Black Rock and the chained area above Monument Canyon (J. Cole, Navajo Fish and Wildlife, pers. com., 5/20/03). The elk and turkey mainly use the area above the rim along the monument boundaries but will occasionally extend down into the upper portions of canyons.

3.3.8 Species of Management Concern

Thirty-eight plant and wildlife species of concern have been identified by the US Fish and Wildlife Service (USFWS) and/or the Navajo Nation Natural Heritage Program (NHP) as being found or potentially found within Apache County Arizona (Table 2). During informal consultation between the NPS, the USFWS and the NHP, it was determined that only four species [golden eagle (*Aquila chrysaetos*), Mexican spotted owl (*Strix occidentalis lucida*), Gooding's onion (*Allium gooddingii)*, and Navajo sedge (*Carex specuicola*)] are known to occur within the monument and the presence of three species is possible [bald eagle (*Haliaeetus leucocephalus*), southwestern willow flycatcher (*Empidonax trailii extimus*), and yellow-billed cuckoo (*Coccyzus americanus*)]. The USFWS letter of concurrence with the NPS determinations regarding potential impacts to threatened and endangered species is presented in Appendix 2.

While two of the species (Gooding's onion and Navajo sedge) are known to occur within the park they do not occur within the river bottom corridors. An historical record of Gooding's onion indicates its presence only in the upper reaches of Canyon del Muerto. Furthermore, recent (2001 and 2002) surveys did not successfully relocate this species (Rink 2003). Navajo sedge is typically only found in hanging gardens; however, one location of this species within the park is known to be occurring along the base of a cliff front with favorable wet conditions (seep). As all activities associated with this project will take place a significant distance from any cliffs, even this anomalous location is well outside project boundaries.

The remaining five species of concern (golden eagle, Mexican spotted owl, bald eagle, southwestern willow flycatcher, and yellow-billed cuckoo) may potentially occur within or adjacent to the project area, and thus be impacted by tamarisk and Russian olive control/removal activities within the canyon-bottom habitats at Canyon de Chelly National Monument. In addition to Federal and Tribal species of concern, the Arizona Wildlife Species of Concern list includes the Northern leopard frog (*Rana pipiens*, also a Navajo Group 2 species) and the black-billed magpie (*Pica hudsonia).* NPS Management Policies (2001) directs management of "state and locally listed species in a manner similar to its treatment of federally listed species, to the greatest extent possible." As shown in Table 2, Northern leopard frogs are not currently considered present within the monument. The presence of black-billed magpies is currently unknown, but this species will be included in the surveys as described below.

To address any concerns related to the above six species of special concern, the NPS has initiated a two year study to identify any potential "surveyable habitat" and/or actual presence of these species. Year one (2004) of this study involved (a) identification of "surveyable habitats" within the Chinle Wash and the riparian habitats of Canyon de Chelly (confluence with Chinle Wash to Spider Rock) and Canyon del Muerto (confluence with Chinle Wash up to ~ 2miles upstream of Massacre Cave) (Figure 2) and (b) formal surveys for breeding birds within identified "surveyable habitat" in the Chinle Wash. Year two (2005) of the study will complete both habitat identification and formal surveys for the six identified bird species within the canyon-bottom habitat of Canyon de Chelly and Canyon del Muerto. The results from this study will be used to identify any areas requiring special consideration or restriction from tamarisk and Russian olive removals. No removal activities would occur in habitat identified as containing active breeding pairs of any the above six species. If nesting sites for any of these species are identified outside, but adjacent to canyon-bottom habitats, timing restrictions for tamarisk and Russian olive removal activities would be implemented to avoid any potential negative impacts as a result of increased noise/activities during sensitive "nesting to fledging" time frames. Appropriate conservation measures will be put implemented in consultation with US Fish and Wildlife Service.

Suitable habitat for the following six threatened and endangered species have been identified in Apache County; southwestern willow flycatcher, Mexican spotted owl, Little Colorado Spinedace, loach minnow, Navajo sedge, and spikedace. None of these designations occur within Canyon de Chelly National Monument, with the exception of reaches of both Canyons de Chelly and del Muerto that are within a suitable but not suitable designation for the Mexican spotted owl. The upper-most canyon project areas termini and side canyons and tributaries are near the identified Mexican spotted owl habitat, but do not extend into known habitat. Any treatments occurring within the designated area would be limited in scope, near the boundary edge and provide benefits to the suitable habitat in the form of fire risk reduction and proactive management against further encroachment.

Table 2. Federally[1] and Navajo Nation Natural Heritage Program (NHP) Listed[2] Threatened and Endangered Plant and Animal Species of Apache County, AZ.

Common Name	Species Name	Federal Listing Status[2]	Navajo Nation Listing Status[3]	Habitat at Canyon de Chelly?
INVERTEBRATES				
Western Seep Fritillary	*Speyeria nokomis*	No Listing	GRP-3 Endangered	None present
MOLLUSCA				
Three Forks Springsnail	*Pyrgulopsis trivialis*	C	No Listing	None present
FISH				
Apache trout	*Oncorhynchus apache*	T	No Listing	None present
Loach minnow	*Tiaroga cobitis*	T	No Listing	None present
Little Colorado spinedace	*Lepidomeda vittata*	T	No Listing	None Present
Spikedace	*Meda fulgida*	T	No Listing	None Present
Humpback Chub	*Gila cypha*	No Listing	GRP-2 Endangered	None Present
Roundtail chub	*Gila robusta*	No Listing	GRP-2 Endangered	None Present
Colorado Pikeminnow	*Ptychocheilus lucius*	No Listing	GRP-2 Endangered	None Present
Razorback Sucker	*Xyrauchen texanus*	No Listing	GRP-2 Endangered	None Present
Zuni bluehead sucker	*Catostomus discorbolus yarrowi*	C	No Listing	None Present
AMPHIBIANS/REPTILES				
Chiricahua leopard frog	*Rana chiricahuensis*	T	No Listing	None Present
Northern Leopard Frog	*Rana pipiens*	No Listing	GRP-2 Endangered	None Present

Table 2. Federally and Navajo Nation Listed Threatened and Endangered Species (con't)

BIRDS				**None present**
Common Name	Species Name	Federal Listing Status[2]	Navajo Nation Listing Status[3]	Habitat at Canyon de Chelly?
Bald Eagle	Haliaeetus leucocephalus	AD, T	No Listing	Not Known - Potential
Golden Eagle	*Aquila chrysaetos*	No Listing	GRP-3 Endangered	Present
Brown pelican	*Pelecanus occidentalis*	DM,E	No Listing	None Present
California condor	*Gymnogyps californianus*	E, EXPN	No Listing	None Present
Mexican spotted owl	*Strix occidentalis lucida*	T	GRP- 3 Endangerd	Present
Southwestern willow flycatcher	*Empidonax trailii extimus*	E	GRP- 2 Endangered	Not Known - Potential
Yellow-billed Cuckoo	*Coccyzus americanus*	C	GRP-3 Endangered	Not Known - Potential
Ferruginous hawk	*Buteo regalis*	No Listing	GRP-3 Endangered	None Present
American Dipper	*Cinclus mexicanus*	No Listing	GRP-3 Endangered	None Present
PLANTS				
Gooding's onion	*Allium goodingii*	No Listing	GRP-3 Endangered	Present, but not found in river corridors
Mancos Milk-vetch	*Astragalus humillimus*	No Listing	GRP-2 Endangered	None Present
Marble Canyon Milk-vetch	*Astragalus cremnophylax* var. *hevroni*	No Listing	GRP-3 Endangered	None Present
Cutler's Milk-vetch	*Astragalus cuteri*	No Listing	GRP-3 Endangered	None Present
Navajo sedge	*Carex specuicola*	T	GRP-3 Endangered	Present, but not found in river corridors

Table 2. Federally and Navajo Nation Listed Threatened and Endangered Species (con't)

Common Name	Species Name	Federal Listing Status[2]	Navajo Nation Listing Status[3]	Habitat at Canyon de Chelly?
Acoma Fleabane	*Erigeron acomanus*	No Listing	GRP-3 Endangered	None Present
Zuni/Rhizome fleabane	*Erigeron rhizomatus*	T	GRP-2 Endangered	None Present
Brady Pincushion Cactus	*Pediocactus bradyi*	No Listing	GPR-2 Endangered	None Present
Fickeisen Cactus	*Pediocactus peeblesianus* var. *fickeiseniae*	No Listing	GRP-3 Endangered	None Present
Navajo Penstemon	*Penstemon navajoa*	No Listing	GRP-3 Endangered	None Present
Alcove Bog-orchid	*Platanthera zothecina*	No Listing	GRP-3 Endangered	None Present
Mesa Verde Cactus	*Sclerocactus mesae-verdae*	No Listing	GRP-3 Endangered	None Present
MAMMALS				
Pronghorn	*Antilocapra americana*	No Listing	GRP-3 Endangered	None Present
Black-footed ferret	*Mustela nigripes*	E, EXPN	GRP 2 - Endangered	None Present
Bighorn Sheep	*Oviscanadensis*	No Listing	GRP-3 Endangered	None Present
Gray Wolf	*Canis lupus*	DR, E, EXPN,T	Extirpated from county	None Present

[1]Source: US FWS Endangered Species List for Apache County, AZ. http://ifw2es.fws.gov/endangeredspecies/lists/, 3/20/2004.
[1]Listing status abbreviations: T=threatened; E=endangered; C=candidate; AD=proposed delisting; DM=delisted taxon, recovered, being monitored first five years; PT=proposed threatened; SAT=similarity of appearance to a threatened taxon.
[2]Source: Navajo Nation Natural Heritage Program for Navajo Nation, AZ and NM.

3.3.9 Air Quality

Canyon de Chelly National Monument is designated as a Class II air quality site, as are many of the NPS units. The Clean Air Act does not provide strict protection of Class II areas that it affords Class I areas. However, NPS guidance recommends that park leadership and resource staff engage in decisions that may affect park air quality to minimize these effects, and to invoke the NPS Organic Act (NPS 2000) when necessary as a stronger legal tool for air quality protection (NPS-ARD 2003). Overall, Canyon de Chelly and the northeast Arizona region do not experience any consistently poor air quality.

3.3.10 Natural Sound

The NPS is mandated by Director's Order 47 to articulate National Park Service operational policies that will require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources. Natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes. They are inherent components of "the scenery and the natural and historic objects and the wildlife" protected by the NPS Organic Act. Natural sounds are vital to the natural functioning of many parks and may provide indicators of the health of various ecosystems. Intrusive sounds are of concern to the NPS because they sometimes impede the Service's ability to accomplish its mission.

The natural soundscape at Canyon de Chelly National Monument is currently somewhat compromised by on-going activities of canyon residents and by guided tours operated by park concessionaires (primarily vehicle related noise). The use of chainsaws and/or heavy equipment during tamarisk and Russian olive removal activities would further diminish the natural soundscape(s), but only on a short-term basis. Removal activities would be limited to daytime hours. While these activities would add to the already existing "canyon noise", they would only represent short-term, minor to moderate negative impacts to natural sound within the areas immediately surrounding the location of removal activities.

4 Environmental Consequences

4.1 NPS Guidance on Environmental Consequence Analysis

This section analyzes the consequences of the alternatives for tamarisk and Russian olive management within the canyon-bottom habitats at Canyon de Chelly National Monument, and provides a basis for comparing alternatives. The definition of impact thresholds and the consequences of the management alternatives on each of the identified impact topics from Chapter 2 are summarized in Table 3 and 4, respectively.

Cumulative Impacts

A cumulative impact is defined in regulations developed by the Council on Environmental Quality, 40 CFR 1508.7. as "the impact on the environment which results from the incremental impact of the [proposed] action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions". Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. Therefore, it is necessary to identify other ongoing or foreseeable future actions within the project vicinity at Canyon de Chelly National Monument. For this analysis, foreseeable future actions were considered to be actions that could occur in the main canyon riparian corridors within the next five years which are either funded for implementation or are being proposed/considered for implementation. This would include any actions that occur outside park boundaries that might have potential for impact to areas covered under this environmental assessment. Foreseeable future actions that might occur are:

- **Development of a General Management Plan for Canyon de Chelly National Monument.**
- **Address livestock grazing in riparian corridors at Canyon de Chelly National Monument.**
- **Address vehicle use in riparian corridors at Canyon de Chelly National Monument.**
- **Individual/Concessionaire alterations to stream channels and/or stream channel crossings in riparian corridors at Canyon de Chelly National Monument.**
- **External up-canyon dam impoundments.** The consequences of Tsaile and Wheatfields Dams on the canyons have not been studied. The reduction of peak flows and loss of sediment replacement, which would have naturally occurred in the absence of these dams, undoubtedly has and will continue to affect the canyons riparian corridors.

Impairment

In additional to determining the environmental consequences of the preferred and other alternatives, National Park Service policy (*Management Policies 2001*) requires analysis of potential effects to determine whether or not actions would impair park resources.

The fundamental purpose of the national park system, established in the Organic Act, and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. National Park Service managers must always seek ways to avoid, or to minimize to the greatest degree possible, adverse impacts on park resources and values. However, the laws do give the National Park Service the management discretion to allow impacts to park resources and values when necessary and appropriate to fulfill the purposes of the park, as long as the impact does not constitute impairment of the affected resources and values. Although Congress has given the National Park Service the management discretion to allow certain impacts within parks, that discretion is limited by the statutory requirement that the National Park Service must

leave park resources and values unimpaired, unless a particular law directly and specifically provides otherwise. *The prohibited impairment is an impact that, in the professional judgment of the responsible National Park Service manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values*. An impact to any park resource or value may constitute an impairment. An impact would be more likely to constitute an impairment to the extent that it affects a resource or value whose conservation is:

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- key to the natural or cultural integrity of the park;
- identified as a goal in the park's general management plan or other relevant NPS planning document.

Impairment may result from National Park Service activities in managing the park, visitor activities, or activities undertaken by concessionaires, contractors, and others operating in the park. A determination on impairment is made for every impact topic in each alternative.

Table 3. Definitions of Intensity Levels for Impact Topics Analyzed

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
CULTURAL RESOURCES				
Cultural Landscapes	**Impact(s) is at the lowest levels of detection with neither adverse nor beneficial consequences**.	**Adverse impact** — alteration of a pattern(s) or feature(s) of the landscape would diminish the overall integrity of the landscape. The determination of effect for §106 would be no adverse effect. **Beneficial impact** — preservation of landscape patterns and features in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes. The determination of effect for §106 would be no adverse effect.	**Adverse impact** — alteration of a pattern(s) or feature(s) of the landscape would diminish the overall integrity of the landscape. The determination of effect for §106 would be adverse effect. Measures identified to minimize or mitigate adverse impacts reduce the intensity of impact under NEPA from major to moderate. **Beneficial impact** — rehabilitation of a landscape or its patterns and features in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes. The determination of effect for §106 would be no adverse effect.	**Adverse impact** — alteration of a pattern(s) or feature(s) of the landscape would diminish the overall integrity of the landscape. The determination of effect for §106 would be adverse effect. **Beneficial impact** — restoration of a landscape or its patterns and features in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes. The determination of effect for §106 would be no adverse effect.
Archeological Resources	Impact is at the lowest levels of detection with neither adverse nor beneficial consequences. The determination of effect for §106 would be no adverse effect.	**Adverse impact** — The impact on archeological sites is measurable or perceptible, but it is slight and localized within a relatively small area of a site or group of sites. The impact does not affect the	**Adverse impact** — The impact is measurable and perceptible. The impact changes one or more character defining feature(s) of an archeological resource but does not diminish the integrity of the	**Adverse impact** — The impact on archeological sites is substantial, noticeable, and permanent. The impact is severe or of exceptional benefit. For National Register

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
		character defining features of a National Register of Historic Places eligible or listed archeological site and would not have a permanent effect on the integrity of any archeological sites. **Beneficial impact** — maintenance and preservation of a site(s). The determination of effect for §106 would be *no adverse effect.*	resource to the extent that its National Register eligibility is jeopardized. **Beneficial impact** — stabilization of a site(s). The determination of effect for §106 would be *no adverse effect*.	eligible or listed archeological sites, the impact changes one or more character defining features(s) of an archeological resource, diminishing the integrity of the resource to the extent that it is no longer eligible for listing in the National Register. **Beneficial impact** — active intervention to preserve a site(s). The determination of effect for §106 would be *no adverse effect*.
Ethnographic Resources/ Traditional Cultural Properties	Impact(s) is at the lowest levels of detection with neither adverse nor beneficial consequences.	**Adverse impact** — impact(s) would be slight but noticeable but would neither appreciably alter resource conditions, such as traditional access or site preservation, nor the relationship between the resource and the affiliated group's body of practices and beliefs. The determination of effect on Traditional Cultural Properties (ethnographic resources eligible to be listed in the National Register) for §106 would be *no adverse effect*. **Beneficial impact** — would allow access to and/or accommodate a group's traditional practices or beliefs. The determination of	**Adverse impact** — impact(s) would be apparent and would alter resource conditions. Something would interfere with traditional access, site preservation, or the relationship between the resource and the affiliated group's practices and beliefs, even though the group's practices and beliefs would survive. The determination of effect on Traditional Cultural Properties (ethnographic resources eligible to be listed in the National Register) for §106 would be *adverse effect.* **Beneficial impact** — would facilitate traditional access and/or accommodate a group's practices	**Adverse impact** — impact(s) would alter resource conditions. Something would block or greatly affect traditional access, site preservation, or the relationship between the resource and the affiliated group's body of practices and beliefs, to the extent that the survival of a group's practices and/or beliefs would be jeopardized. The determination of effect on Traditional Cultural Properties (ethnographic resources eligible to be listed in the National Register) for §106 would be *adverse effect.*

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
		effect on Traditional Cultural Properties for §106 would be *no adverse effect*.	or beliefs. The determination of effect on Traditional Cultural Properties for §106 would be *no adverse effect*.	**Beneficial impact** — would encourage traditional access and/or accommodate a group's practices or beliefs. The determination of effect on Traditional Cultural Properties for §106 would be *no adverse effect.*
Historic Structures	Impact is at the lowest levels of detection with neither adverse nor beneficial consequences. The determination of effect for §106 would be *no adverse effect*.	**Adverse impact** — The impact is slight, but detectable. The impact does not affect the character defining features of a National Register of Historic Places eligible or listed historic structure, cultural landscape, or historic district. **Beneficial impact** — stabilization/ preservation of features in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. The determination of effect for §106 would be *no adverse effect*.	**Adverse impact** — The impact is readily apparent. For a National Register eligible or listed historic structure, cultural landscape, or historic district, the impact changes a character defining feature(s) of the resource but does not diminish the integrity of the resource to the extent that its National Register eligibility is jeopardized. **Beneficial impact** — rehabilitation of a structure in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. The determination of effect for §106 would be *no adverse effect*.	**Adverse impact** — The impact is severe or of exceptional benefit. For a National Register eligible or listed historic structure, cultural landscape, or historic district, the impact changes a character defining feature(s) of the resource, diminishing the integrity of the resource to the extent that it is no longer eligible or listed in the National Register. **Beneficial impact** — restoration of a structure in accordance with the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. The determination of effect for §106 would be *no adverse effect*.

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
NATURAL RESOURCES				
Soils	Soils would not be affected or the effects to soils would be below or at the lower levels of detection. Any effects to soil productivity or fertility would be slight and no long-term effects to soils would occur.	The effects to soils would be detectable. Effects to soil productivity or fertility would be small, as would the area affected. If mitigation were needed to offset adverse effects, it would be relatively simple to implement and would likely be successful.	The effect on soil productivity or fertility would be readily apparent, likely long-term, and result in a change to the soil character over a relatively wide area. Mitigation measures would probably be necessary to offset adverse effects and would likely be successful.	The effect on soil productivity or fertility would be readily apparent, long-term, and substantially change the character of the soils over a large area in and out of the monument. Mitigation measures to offset adverse effects would be needed, extensive, and their success could not be guaranteed.
Stream Channel Geomorphology	Stream channel geomorphological processes would not be affected or the human induced effects to these processes would be below or at the lower levels of detection. Any effects to stream channel natural function and dynamics would be slight and no long-term effects to soils would occur	The effects to stream channel geomorphological processes would be detectable. Effects to natural stream channel function and dynamics would be small, as would the area affected. If mitigation were needed to offset adverse effects, it would be relatively simple to implement and would likely be successful	The effect on natural stream channel function and dynamics would be readily apparent, likely long-term, and result in a change to the stream channel geomorphological processes over a relatively wide area. Mitigation measures would probably be necessary to offset adverse effects and would likely be successful	The effect on stream channel function and dynamics would be readily apparent, long-term, and substantially change the character of the natural geomorphological processes over a large area in and out of the monument. Mitigation measures to offset adverse effects would be needed, extensive, and their success could not be guaranteed.

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
Prime and Unique Farmlands	The impact to prime and unique is at the lowest level of detection, not perceptible and not measurable.	The impact to prime and unique farmland would be noticeable, but would not alter the function of the farmland or the criteria for which it is considered prime or unique.	The impact to prime and unique farmland would be more noticeable, and may alter the function of the farmland or the criteria for which it is considered prime or unique.	The impact to prime and unique farmland would be readily apparent, and would alter the function of the farmland or the criteria for which it is considered prime or unique.
Water Resources	Neither water quantity, quality, or natural hydrological regimes would be affected, or changes would be either non-detectable or if detected, would have effects that would be considered slight, local, and short-term.	Changes in water quantity, quality, or natural hydrological regimes would be measurable, although the changes would be small, would likely be short-term, and the effects would be localized. No mitigation measure associated with water quality or hydrology would be necessary.	Changes in water quantity, quality, or hydrological regimes would be measurable and long-term but would be relatively local. Mitigation measures associated with water quality or hydrology would be necessary and the measures would likely succeed.	Changes in water quantity, quality, or hydrological regimes would be readily measurable, would have substantial consequences, and would be noticed on a regional scale. Mitigation measures would be necessary and their success would not be guaranteed.

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
Air Quality	No changes would occur or changes in air quality would be below or at the level of detection, and if detected, would have effects that would be considered slight and short-term.	Changes in air quality would be measurable, although the changes would be small, short-term, and the effects would be localized. No air quality mitigation measures would be necessary.	Changes in air quality would be measurable, would have consequences, although the effect would be relatively local. Air quality mitigation measures would be necessary and the measures would likely be successful.	Changes in air quality would be measurable, would have substantial consequences, and be noticed regionally. Air quality mitigation measures would be necessary and the success of the measures could not be guaranteed.
Vegetation	No native vegetation would be affected or some individual native plants could be affected as a result of the alternative, but there would be no effect on native species populations. The effects would be short-term, on a small scale, and no species of special concern would be affected.	The alternative would affect some individual native plants and would also affect a relatively minor portion of that species' population. Mitigation to offset adverse effects, including special measures to avoid affecting species of special concern, could be required and would be effective.	The alternative would affect some individual native plants and would also affect a sizeable segment of the species' population in the long-term and over a relatively large area. Mitigation to offset adverse effects could be extensive, but would likely be successful. Some species of special concern could also be affected.	The alternative would have a considerable long-term effect on native plant populations, including species of special concern, and affect a relatively large area in and out of the monument. Mitigation measures to offset the adverse effects would be required, extensive, and success of the mitigation measures would not be guaranteed.
Wildlife	Wildlife would not be affected or the effects would be at or below the level of detection, would be short-term, and the changes would be so slight that they would not be of any measurable or perceptible consequence to the wildlife species' population.	Effects to wildlife would be detectable, although the effects would be localized, and would be small and of little consequence to the species' population. Mitigation measures, if needed to offset adverse effects, would be simple and successful.	Effects to wildlife would be readily detectable, long-term and localized, with consequences at the population level. Mitigation measures, if needed to offset adverse effects, would be extensive and likely successful.	Effects to wildlife would be obvious, long-term, and would have substantial consequences to wildlife populations in the region. Extensive mitigation measures would be needed to offset any adverse effects and their success would not be guaranteed.

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
Endangered or Threatened Species and Suitable habitat	No federally listed species would be affected or the alternative would affect an individual of a listed species or its suitable habitat, but the change would not be of any measurable or perceptible consequence to the protected individual or its population. Negligible effect would equate with a "no effect" determination in U.S. Fish and Wildlife Service terms.	The alternative would affect an individual(s) of a listed species or its suitable habitat, but the change would be small. Minor effect would equate with a "may effect" determination in U.S. Fish and Wildlife Service terms and would be accompanied by a statement of "likely…" or "not likely to adversely affect" the species.	An individual or population of a listed species, or its suitable habitat would be noticeably affected. The effect could have some long-term consequence to the individual, population, or habitat. Moderate effect would equate with a "may effect" determination in U.S. Fish and Wildlife Service terms and would be accompanied by a statement of "likely…" or "not likely to adversely affect" the species.	An individual or population of a listed species, or its suitable habitat, would be noticeably affected with a long-term, vital consequence to the individual, population, or habitat. Major effect would equate with a "may effect" determination in U.S. Fish and Wildlife Service terms and would be accompanied by a statement of "likely…" or "not likely to adversely affect" the species or suitable habitat.
Natural Sound	In the Developed Zone, human-caused noise may be present much of the time during daylight hours. When noise is present, it is mostly at low levels. In the Natural and Cultural Zones, natural sounds predominate. When noise is present, it is at very low levels and occurs only for short durations in most of the area. Visitors almost always have the opportunity to experience the natural soundscape free from human-caused noise.	In the Developed Zone, human-caused noise may predominate during daylight hours, but for the majority of the time the noise is at low levels, and is only rarely at greater than medium levels. In the Natural and Cultural Zones, natural sounds usually predominate. Human-caused noise is present only infrequently, and occurs only at low levels and for short durations in most of the area. Visitors have the opportunity to experience the natural soundscape free from human-caused noise most of the time in most of the area.	In the Developed Zone, human-caused noise predominates during daylight hours, but it is at medium or lower levels a majority of the time. In the Natural and Cultural Zones, human-caused noise is present infrequently to occasionally, at low to medium levels and durations.	In the Developed Zone, human-caused noise predominates during daylight hours, and is at greater than medium levels a majority of the time that noise is present. Large areas may experience human-caused noise at medium to high levels during a majority of the daylight hours. In the Natural and Cultural Zones, natural sounds commonly are masked by human-caused noise at low or greater levels for extended periods of time.

Impact Topic	IMPACT THRESHOLD DEFINITIONS			
	Negligible	**Minor**	**Moderate**	**Major**
VISITOR USE & Socioeconomic				
Public Health and Safety	Public health and safety would not be affected, or the effects would be at low levels of detection and would not have an appreciable effect on the public health or safety.	The effect would be detectable and would likely be short-term, but would not have an appreciable effect on public health and safety. If mitigation were needed, it would be relatively simple and would likely be successful.	The effects would be readily apparent and long-term, and would result in substantial, noticeable effects to public health and safety on a local scale. Mitigation measures would probably be necessary and would likely be successful.	The effects would be readily apparent and long-term, and would result in substantial, noticeable effects to public health and safety on a regional scale. Extensive mitigation measures would be needed, and their success would not be guaranteed.
Visitor Use and Experience	Visitors would not be affected or changes in visitor use and/or experience would be below or at the level of detection. Any effects would be short-term. The visitor would not likely be aware of the effects associated with the alternative.	Changes in visitor use and/or experience would be detectable, although the changes would be slight and likely short-term. The visitor would be aware of the effects associated with the alternative, but the effects would be slight.	Changes in visitor use and/or experience would be readily apparent and likely long-term. The visitor would be aware of the effects associated with the alternative and would likely be able to express an opinion about the changes.	Changes in visitor use and/or experience would be readily apparent and have important long-term consequences. The visitor would be aware of the effects associated with the alternative and would likely express a strong opinion about the changes.
Socioeconomic Conditions	Economic and socioeconomic conditions would not be affected, or effects would not be measurable.	The effects to socioeconomic conditions would be detectable, although short-term. Any effects would be small and if mitigation were needed to offset potential adverse effects, it would be simple and successful.	The effects to socioeconomic conditions would be readily apparent and likely long-term. Any effects would result in changes to socioeconomic conditions on a local scale. If mitigation is needed to offset potential adverse effects, it could be extensive, but would likely be successful.	The effects to socioeconomic conditions would be readily apparent, long-term, and would cause substantial changes to socioeconomic conditions in the region. Mitigation measures to offset potential adverse effects would be extensive and their success could not be guaranteed.

Table 4. Comparative Summary of Environmental Impacts of Management Alternatives

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
CULTURAL RESOURCES					
Cultural Landscapes	**Moderate, long-term adverse impacts.** There would be no indirect or direct impacts of tamarisk/Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use. However, tamarisk and Russian olive trees would continue to proliferate in the canyon-bottom/ riparian habitats and degrade the integrity of the associated cultural landscape(s). The cumulative effects would be continued infestation of tamarisk and Russian olive and degradation of the elements of the cultural landscape(s).	**Beneficial effects that are moderate in duration and intensity.** With a sharp reduction in the density and abundance of tamarisk and Russian olive, the cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future improvements and perpetuation of a more historically representative cultural landscape.	**Beneficial effects that are minor to moderate in intensity, and moderate in duration.** The treatment process would take longer, but would be almost as effective as the preferred alternative (Alternative A). The cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future improvements and perpetuation of a more historically representative cultural landscape.	**Beneficial effects that are minor to moderate in intensity and minor to moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/natural resources.** The cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future improvements and perpetuation of a more historically representative cultural landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.	**Beneficial effects that are minor to moderate in intensity and moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/ natural resources.** The cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future improvements and perpetuation of a more historically representative cultural landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Archeological Resources	**Moderate, long-term adverse impacts.** There would be no indirect or direct impacts of tamarisk/Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use. However, tamarisk and Russian olive trees would continue to proliferate in the canyon-bottom/ riparian habitats and obliterate traces of and degrade the integrity of archeological sites. The cumulative effects would be continued infestation of tamarisk and Russian olive, degradation of the archeological landscape, the prevention of further archeological work, and threats from uncontrolled erosion and hazardous fuel build-up..	**Beneficial effects that are minor to moderate in duration and intensity.** With a sharp reduction in the density and abundance of tamarisk and Russian olive, archeological sites associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification and study of archeological sites, and would perpetuate a more historically representative archeological landscape.	**Beneficial effects that are minor to moderate in intensity, and moderate in duration.** The treatment process would take longer, but would be almost as effective as the preferred alternative (Alternative A). The cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification and study of archeological sites, and would perpetuate a more historically representative archeological landscape.	**Beneficial effects that are minor to moderate in intensity and minor to moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/natural resources.** Archeological sites associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification and study of archeological sites, and would perpetuate a more historically representative archeological landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.	**Beneficial effects that are minor to moderate in intensity and moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/ natural resources.** Archeological sites associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-floor. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification and study of archeological sites, and would perpetuate a more historically representative archeological landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Ethnographic Resources/ Traditional Cultural Properties	**Moderate, long-term adverse impacts.** There would be no indirect or direct impacts of tamarisk/Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use. However, tamarisk and Russian olive trees would continue to proliferate in the canyon-bottom/ riparian habitats and degrade the integrity of the associated ethnographic resources and Traditional Cultural Properties. The cumulative effects would be continued infestation of tamarisk and Russian olive, elimination of ethnographic resources, discontinued use of Traditional Cultural Properties, and threats from uncontrolled erosion and hazardous fuel build-up.	**Beneficial effects that are moderate in duration and intensity.** With a sharp reduction in the density and abundance of tamarisk and Russian olive, ethnographic resources and Traditional Cultural Properties associated with canyon-bottom habitats would become more visible and accessible allowing for better identification, research, interpretation, and continued use by native peoples. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification, study, and use of ethnographic resources and Traditional Cultural Properties, and would perpetuate a more historically representative ethnographic and traditional landscape.	**Beneficial effects that are minor to moderate in intensity, and moderate in duration.** The treatment process would take longer, but would be almost as effective as the preferred alternative (Alternative A). The ethnographic resources and Traditional Cultural Properties associated with canyon-bottom habitats would become more visible and accessible, allowing for better identification, research, interpretation, and continued use by native peoples. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification, study, and use of ethnographic resources and Traditional Cultural Properties, and would perpetuate a more historically representative ethnographic and traditional landscape.	**Beneficial effects that are minor to moderate in intensity and minor to moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/natural resources.** Ethnographic resources and Traditional Cultural Properties associated with canyon-bottom habitats would become more visible and accessible allowing for better identification, research, interpretation, and continued use by native peoples, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification, study, and use of ethnographic resources and Traditional Cultural Properties, and would perpetuate a more historically representative ethnographic and traditional landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.	**Beneficial effects that are minor to moderate in intensity and moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/ natural resources.** Ethnographic resources and Traditional Cultural Properties associated with canyon-bottom habitats would become more visible and accessible, allowing for better identification, research, interpretation, interpretation, and continued use by native peoples, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification, study, and use of ethnographic resources and Traditional Cultural Properties, and would perpetuate a more historically representative ethnographic and traditional landscape within limited sections, but not throughout the entire canyon riparian corridors as with alternatives A and B.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Historic Structures	**Moderate, long-term adverse impacts.** There would be no indirect or direct impacts of tamarisk/Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use. However, tamarisk and Russian olive trees would continue to proliferate in the canyon-bottom/ riparian habitats and degrade the integrity of the associated historic structures. The cumulative effects would be continued infestation of tamarisk and Russian olive, and threat from uncontrolled erosion and hazardous fuel build-up.	**Beneficial effects that are minor to moderate in duration and intensity.** With a sharp reduction in the density and abundance of tamarisk and Russian olive, historic structures associated with canyon-bottom habitats would become more visible, and accessible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification and study of historic structures, and would perpetuate a more historically representative landscape.	**Beneficial effects that are minor to moderate in intensity, and moderate in duration.** The treatment process would take longer, but would be almost as effective as the preferred alternative (Alternative A). The historic structures associated with canyon-bottom habitats would become more visible and accessible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future identification and study of historic structures, and would perpetuate a more historically representative landscape.	**Beneficial effects that are minor to moderate in intensity and minor to moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/natural resources.** Historic structures associated with canyon-bottom habitats would become more visible and accessible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification and study of historic structures, and would perpetuate a more historically representative landscape within limited sections, but not throughout the entire canyon riparian corridor.	**Beneficial effects that are minor to moderate in intensity and moderate in duration. Effects would only be applicable to areas designated with "non-sensitive" cultural/ natural resources.** Historic structures associated with canyon-bottom habitats would become more visible and accessible, allowing for better identification, research, and interpretation, but only in limited sections of the canyon-bottom. The cumulative impact of tamarisk and Russian olive reduction would facilitate some future identification and study of historic structures, and would perpetuate a more historically representative landscape within limited sections, but not throughout the entire canyon riparian corridor.
NATURAL RESOURCES					

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Soils	**Moderate, long-term, adverse impacts.** Excessive soil erosion and soil quality within the canyon-bottoms would continue to decline with expansion of tamarisk and Russian olive infestations. Soil chemical and biological parameters would become adversely altered as salt-deposition by tamarisk increases. Soil structure would also be impacted as the finer root systems of grasses & forbs are lost. Long-term, cumulative effects would include a moderate loss of soil productivity in tamarisk and Russian olive infested sites and continued increases in unnatural rates of soil erosion.	**Short-term, minor to moderate adverse impacts, but long-term, moderate beneficial impacts.** Short-term impacts include localized increases in soil erosion due to heavy equipment disturbance and as streambanks laterally erode in order to establish a more stable channel condition. Potential impacts to soil resources as a result of herbicide contamination would be minimal. Long-term (cumulative) and beneficial impacts would include streambank stabilization as a natural channel equilibrium is reached and as native vegetation becomes established. The greatest level of protection & sustainability of canyon-bottom soil resources would be achieved under this alternative.	**Short-term, minor to moderate adverse impacts, but long-term, moderate beneficial impacts.** Alternative B would not include impacts from the use of heavy equipment, but would have similar short-term adverse increases in soil erosion as streambanks attempt to widen in re-establishing a more natural channel condition. The potential for soil contamination from herbicide is increased under this alternative, but remains minimal based on the use of identified prevention/mitigation measures. Long-term, cumulative effects would be beneficial and similar to those defined for alternative A.	**Short-term, minor to moderate adverse impacts, but long-term, minor beneficial impacts.** Alternative C would use heavy equipment to mechanically remove the above ground portions of tamarisk and Russian olive. Short-term minor to moderate increases in soil erosion would occur from the use of heavy equipment and as treated section of the channel widening and attempt to stabilize. Long-term, cumulative effects would be beneficial, but minor since this alternative would be limited to "non-sensitive" locations and could not be applied throughout the canyon-bottom. Unstable channel conditions would likely remain, leaving the system prone to unnatural rates of soil erosion.	**Short-term, moderate adverse impacts, but long-term, minor beneficial impacts.** Alternative D would use heavy equipment to mechanically remove the above and below-ground portions of tamarisk and Russian olive in "non-sensitive" locations of the canyon-floor. Short-term moderate increases in soil erosion would occur from the use of heavy equipment and from the removal of tamarisk and Russian olive root systems. Removal of root systems would allow for faster channel widening, increasing the initial erosion of soil as the channel attempts to stabilize in treated sections. Long-term, cumulative effects would be beneficial, but minor and similar to those identified for Alternative C.
Stream	**Short- and long-term, moderate adverse**	**Short-term, minor to moderate adverse**	**Short-term, minor to moderate adverse**	**Short term minor adverse impacts, with long-term**	**Short term minor to moderate adverse impacts,**

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Channel Geomorphology	**impacts.** The no-action alternative would result in continued degradation of the stream channels associated with the canyon riparian corridors. Establishment of dense thickets has, and would continue to, create a loss of natural stream meanderings and geomorphic processes, resulting in excessive and unnatural rates of stream bottom erosion & down-cutting. Long-term, cumulative effects would be adverse and moderate, with unstable channel conditions remaining prone to rapid vertical and lateral channel adjustments.	**impacts, but long-term, moderate beneficial effect.** This alternative would allow for the maximum recovery potential for currently infested and degraded lands and would combine multiple treatment options. Actions identified under this alternative would create minor to moderate increases in stream channel erosion as streambanks laterally erode in order to establish a more stable channel condition. Long-term, cumulative impacts would be beneficial and moderate in intensity. This alternative would provide the best opportunity to define removal techniques most applicable and effective, on a large scale and within the multiple conditions that exist at Canyon de Chelly NM.	**impacts, but long-term minor to moderate beneficial effects.** Tamarisk and Russian olive trees and shrubs would be cut to stump height and immediately treated with Remedy or Garlon 3A herbicide. Alternative B would have similar short- and long-term impacts to stream channel geomorphology as Alternative A, however, these short- and long-term impacts would occur over a longer period of time. Similarly, this alternative would result in good potential for restoring a more stable stream channel conditions, but would suffer from achieving the greatest efficacy due to the labor intensiveness and extended timeframes (8-10 years) needed to treat extensive areas of infestation.	**negligible to minor beneficial effects in treated areas and long-term moderate adverse effects in non-treated areas.** Actions under Alternative C would create short-term, minor adverse impacts due to increases in channel lateral erosion within treated areas. Unnatural levels of channel incision would continue in untreated areas, minimizing any benefits to stream geomorphology from tamarisk and Russian olive removals. Although some temporary minor beneficial effects may occur in treated areas, beneficial impacts are not likely to be sustainable in the long-term, since stream channel stability is not being addressed throughout the entire riparian corridors. Long-term, cumulative effects would remain, adverse and moderate in intensity throughout the majority of the canyon-bottom riparian corridors.	**with long-term negligible to minor beneficial effects in treated areas and long-term moderate adverse effects in non-treated areas.** Actions under Alternative D would create short-term, minor to moderate adverse impacts due to increases in channel lateral erosion within treated areas. Unnatural levels of channel incision would continue in untreated areas, minimizing any benefits to stream geomorphology from tamarisk and Russian olive removals. Although some temporary minor beneficial effects may occur in treated areas, beneficial impacts are not likely to be sustainable in the long-term, since stream channel stability is not being addressed throughout the entire riparian corridors. Long-term, cumulative effects would remain, adverse and moderate in intensity throughout the majority of the canyon-bottom riparian corridors.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Prime and Unique Farmlands	**Long-term, moderate adverse impacts.** The explosive spread of tamarisk and Russian olive would continue under the no-action alternative. Deterioration of canyon-bottom farmlands, through direct tamarisk invasion or by indirect soil loss resulting from stream channel incision and land erosion, would continue. These adverse effects would increase as tamarisk and Russian olive continue to spread and establish in new areas. Long-term sustainability of canyon-bottom farmlands would remain jeopardized.	**Short-term, minor to moderate adverse impacts, but long-term, beneficial moderate effects.** Short-term, adverse impacts to prime and unique farmlands as some farmable lands, immediately adjacent to streambanks, would be lost as lateral erosion increases during establishment of more stable stream channels. Adverse impacts would be most distinct adjacent to artificially channelized sections of the riparian corridors. Restoration of native vegetation, as appropriate, would assist in mitigating losses to farmable lands. Long-term, cumulative effects would be beneficial and moderate in intensity. New infestations of tamarisk and Russian olive would be prevented, affording the strongest long-term sustainability of farmable lands.	**Short-term, minor to moderate adverse impacts, but long-term, beneficial moderate effects.** Short-term impacts under alternative B would be similar to those identified for alternative A. Some farmable lands, immediately adjacent to streambanks, would be lost as lateral erosion increases during establishment of more stable stream channels. Re-establishment of native vegetation, as appropriate, would assist in mitigating losses to farmable lands. Re-establishment of native vegetation, as appropriate, would minimize losses to farmable lands. New infestations of tamarisk and Russian olive would be prevented, but control actions necessary to protect farmable lands would occur more slowly due to the labor intensiveness of actions under alternative B.	**Short term minor adverse impacts, with long-term negligible to minor beneficial effects in treated areas and long-term moderate adverse effects in non-treated areas.** Short-term, minor adverse impacts would occur in treated locations as lateral channel erosion occurs in treated areas, with negligible to minor long-term benefits once channel erosion stabilizes. Actions under alternative C would be limited in application ("non-sensitive" areas). Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, cumulative impacts to prime and unique farmlands throughout most of the canyon-bottom environments would be similar to the no-action alternative. Moderate loss of farmable lands would continue.	**Short term minor to moderate adverse impacts, with long-term negligible to minor beneficial effects in treated areas and long-term moderate adverse effects in non-treated areas.** Short-term, minor to moderate adverse impacts would occur in treated locations as a result of increased lateral channel erosion as stream channels attempt to stabilize. Negligible to minor long-term benefits may occur in treated areas once channel erosion stabilizes. Actions under alternative D would be limited in application ("non-sensitive" areas). Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, cumulative impacts to prime and unique farmlands throughout most of the canyon floor. environments would be similar to the no-action alternative. Moderate loss of farmable lands would continue.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Water Resources	**Long-term, moderate adverse impacts.** There would be direct and indirect impacts to water quantity and quality under the no-action alternative. Increased spread of tamarisk and Russian olive in canyon riparian corridors would continue to reduce water quantity over the long-term and would alter natural drainage patterns. Water quality would decline as salt-depositing tamarisk creates extensive soil salinity which would additionally impact the quality of both surface and groundwater.	**Minor to moderate, short-term adverse impacts to water quality but beneficial long-term impacts to water quality & quantity of moderate intensity.** Minor to moderate adverse short-term effects on water quality would result due to potential minor runoff as a result of herbicide treatments. Minor to moderate increases in sediment loads in surface water would occur due to ground disturbance from heavy equipment use and increased lateral widening (erosion) of streambanks as stream geomorphology re-establishes a more natural equilibrium. Long-term (cumulative), benefits would include moderate increases in water quantity and quality as large infestations of tamarisk are eliminated.	**Minor to moderate, short-term adverse impacts to water quality but beneficial long-term impacts to water quality & quantity of minor to moderate intensity.** Minor to moderate adverse short-term effects on water quality would result due to potential minor runoff as a result of herbicide treatments. Minor to moderate increases in sediment loads in surface water would occur due to ground disturbance from heavy equipment use and increased lateral widening (erosion) of streambanks as stream geomorphology re-establishes a more natural equilibrium, but this would occur over a longer time frame than with Alternative A. Cumulative effects are similar to Alternative A.	**Minor to moderate short-term adverse impacts to water quality and quantity. Long-term, negligible to minor beneficial impacts to riparian water resources.** Short-term adverse impacts to water quality would occur due to increased sedimentation from heavy equipment use and from some stream channel widening as more natural geomorphological processes attempt to re-establish in removal areas. Resprouting of tamarisk & Russian olive would occur in removal areas. Cumulative effects would be negligible to minor and beneficial for the treated locations. Tamarisk removal would only have minor beneficial impacts to water resources since removal areas would be restricted to "non-sensitive" areas and not applicable throughout the entire canyon-bottom riparian corridors.	**Minor to moderate short-term adverse impacts to water quality and quantity. Long-term, negligible to minor beneficial impacts to riparian water resources.** Short-term adverse impacts to water quality would occur as a result of increased sedimentation from heavy equipment use and from some stream channel widening as more natural geomorphological processes attempt to re-establish in removal areas. Cumulative effects would be minor to moderate and beneficial for the treated areas. Limited tamarisk/Russian olive removals would have minor to moderate beneficial impacts to water quantity/ quality, but these benefits would be limited to "non-sensitive" removal areas and not applicable throughout the entire canyon-bottom riparian corridors.

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Air Quality	**Long-term, moderate adverse impacts.** No long-term impacts to air quality, beyond existing conditions would occur under the no-action alternative. The risk of short-term, adverse impacts of moderate intensity as a result of increased risk of wildfire events would remain high under the no-action alternative.	**Short-term adverse impacts of minor intensity and duration.** Short-term, minor adverse effects to air quality would occur due to the potential for very low levels of herbicide overspray and/or volatilization. Exhaust from chainsaws and heavy equipment use and from dust from stump cutting and mulching of plant material would also increase short-term adverse impacts to air quality at very localized levels. Identified mitigation measures would ensure that these impacts would be minor with no adverse impacts to visitors, park staff, and workers engaged in the treatment effort. No long-term cumulative impacts would be created by Alternative A.	**Short-term adverse impacts of minor intensity and duration.** Short-term, minor adverse effects to air quality would occur due to the potential for very low levels of herbicide overspray and/or volatilization. Exhaust from chainsaws and dust from stump cutting and mulching of plant material would also increase short-term adverse impacts to air quality at localized levels. Identified mitigation measures would ensure that these impacts would be minor with no adverse impacts to visitors, park staff, and workers engaged in the treatment effort. No long-term cumulative impacts would be created by Alternative B.	**Short-term adverse impacts of minor to moderate intensity and duration.** Short-term, minor to moderate adverse effects to air quality would occur due to exhaust from heavy equipment use and from dust/fine particulate matter created by stump cutting and mulching of plant materials. Identified mitigation measures would ensure that any adverse impacts would be minimized. Short duration adverse impacts to visitors, park staff, and workers engaged in the treatment effort would occur. No long-term cumulative impacts would be created by Alternative C.	**Short-term adverse impacts of minor to moderate intensity and duration.** Short-term, minor adverse effects to air quality would occur due to exhaust from heavy equipment use, from dust created by ground disturbance to remove root systems and from fine debris created by the mulching of plant material. Identified mitigation measures would ensure that any adverse impacts would be minimized. Short duration adverse impacts to visitors, park staff, and workers engaged in the treatment effort would occur. No long-term cumulative impacts would be created by Alternative D.

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Vegetation	**Adverse, long-term impacts of moderate intensity.** Tamarisk and Russian olive are dominant, aggressive species that would continue to spread under the no-action alternative. These species, once established, eliminate other vegetation due to shading, increased competition for soil nutrient and water resources, and through salt-deposition by tamarisk which adversely alters the soil chemical conditions necessary to support native vegetation. Cumulative effects would be long-term and moderate in intensity. Extensive monocultures of tamarisk and Russian olive would establish throughout the canyon-bottom and invade into side canyon habitats.	**Short-term, minor adverse impacts, but long-term moderate beneficial impacts.** Short-term impacts would occur due to minimal herbicide overspray to non-targeted vegetation and/or as a result of heavy equipment use. These impacts would be minimized through use of identified mitigation measures. The long-term, cumulative effects of the preferred alternative would be beneficial to vegetation resources and would be moderate in intensity. The reduction of tamarisk and Russian olive throughout most of the canyon riparian corridors would allow for the establishment or restoration of native vegetation, increasing the overall diversity of vegetation and increasing beneficial wildlife habitat in the park.	**Short-term, negligible to minor adverse impacts, but long-term moderate beneficial impacts.** Short-term impacts would occur due to minimal herbicide overspray to non-targeted vegetation. These impacts would be minimized through use of identified mitigation measures. The long-term, cumulative effects of the environmentally preferred alternative would be beneficial to vegetation resources and would be moderate in intensity. The reduction of tamarisk and Russian olive throughout most of the canyon riparian corridors would allow for the establishment or restoration of native vegetation, increasing the overall diversity of vegetation and increasing beneficial wildlife habitat in the park.	**Short-term, minor to moderate adverse impacts, with long-term negligible to minor beneficial impacts in treated areas and moderate adverse effects in non-treated locations.** Short-term adverse impacts would occur to vegetation resources as a result of heavy equipment running over non-targeted vegetation. Since root systems would be left in place, resprouting of tamarisk and Russian olive would occur. Long-term, cumulative impacts would be beneficial, but negligible to minor due to the limited application of this treatment to "non-sensitive" areas. The potential for re-sprouting or for other invasive species to move in also limits any long-term benefits to treated locations. Tamarisk and Russian olive would continue to spread in non-treated areas.	**Short-term, minor to moderate adverse impacts, with long-term to minor to moderate beneficial impacts in treated areas and moderate adverse effects in non-treated locations.** Short-term adverse impacts would occur to vegetation resources as a result of heavy equipment running over non-targeted vegetation. Root systems would be removed under this alternative, eliminating any potential for resprouting in treatment locations, yet the created ground Disturbance would increase the opportunity for other non-native species to invade. Long-term, cumulative impacts would be beneficial, minor to moderate, but limited to the treatment locations. Tamarisk and Russian olive would continue to spread, leading to adverse moderate impacts in non-treated areas.

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Wildlife	**Long-term, adverse impacts of moderate intensity.** Continued infestation by tamarisk and Russian olive at the exclusion of understory and overstory native vegetation will lead to a continued decrease in the availability of diverse habitat resulting in the loss of wildlife diversity.	**Short-term, adverse impacts of minor intensity, but long-term beneficial effects of moderate intensity.** Short-term impacts include herbicide treatment, loss of vegetative structure, noise, and physical disturbance of the area. Long-term benefits include increased vegetative and wildlife diversity, the restoration of natural systems and processes, and allow for the maximum recovery potential for currently infested and degraded habitats.	**Short-term, adverse impacts of minor intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts include herbicide treatment and loss of vegetative structure. This alternative results in the least amount of ground disturbance and noise than the three other action alternatives. Long-term benefits include increased vegetative and wildlife diversity and the restoration of natural systems and processes; however, they may only be of minor to moderate intensity due to the length of time needed for large-scale benefits.	**Short-term, adverse impacts of minor intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts include loss of vegetative structure, noise and physical disturbance of the area. In the long term, this alternative would result in minor to moderate beneficial effects, including increased vegetative and wildlife diversity and the restoration of natural systems and processes, but potentially continued adverse impacts of minor intensity due to repeated entry to retreat sprouting stumps and continued encroachment from untreated areas.	**Short-term, adverse impacts of minor intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts include loss of vegetative structure, noise and physical disturbance of the area. In the long term, this alternative would result in minor to moderate beneficial effects, including increased vegetative and wildlife diversity and the restoration of natural systems and processes, but potentially continued adverse impacts of minor intensity due to continued encroachment from untreated areas.

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Endangered or Threatened Species and Suitable habitat	**Long-term, adverse impacts of moderate intensity.** Continued infestation by tamarisk and Russian olive at the exclusion of understory and overstory native vegetation will lead to a continued decrease in wildlife diversity. Despite southwestern willow flycatcher use of tamarisk, the lack of other habitat components (e.g., surface water during nesting) makes it unlikely this area would ever support this species. Areas of Mexican spotted owl suitable habitat relatively free of the exotics now will inevitably be infested in the future degrading suitability for that species.	**Short-term, adverse impacts of negligible intensity, but long-term beneficial effects of moderate intensity.** Short-term impacts should be relatively non-existent as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the identified species of concern. Long-term benefits include increased vegetative and wildlife diversity, restoration of natural systems and processes and the prevention of pending degradation to Mexican spotted owl suitable habitat.	**Short-term, adverse impacts of negligible intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts should be relatively non-existent as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the identified species of concern. Long-term benefits include a localized increase in vegetative and wildlife diversity, restoration of natural systems and processes and possible prevention of pending degradation to Mexican spotted owl suitable habitat.	**Short-term, adverse impacts of negligible intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts should be relatively non-existent as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the identified species of concern. Long-term benefits include a localized increase in vegetative and wildlife diversity, restoration of natural systems and processes and the possible prevention of pending degradation to Mexican spotted owl suitable habitat.	**Short-term, adverse impacts of negligible intensity, but long-term beneficial effects of minor to moderate intensity.** Short-term impacts should be relatively non-existent as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the identified species of concern. Long-term benefits include a localized increase in vegetative and wildlife diversity, restoration of natural systems and processes and the possible prevention of pending degradation to Mexican spotted owl suitable habitat.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Natural Sound	**Long-term, minor to moderate adverse existing impacts to natural sound.** As infestations of tamarisk and Russian olive continue to spread and increase, natural wildlife habitat will be lost. This would result in long-term, minor to moderate, adverse impacts to the natural soundscapes of the canyon-bottom habitats.	**Short-term, minor to moderate, adverse impacts, but long-term minor to moderate, beneficial impacts to natural sound.** The use of chainsaws, hand tools, and heavy equipment to cut and mulch treated tamarisk and Russian olive plants would result in temporary, minor to moderate, adverse increases in unnatural sound levels. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures. Long-term, minor to moderate beneficial effects to natural sound would occur as extensive areas of tamarisk and Russian olive are removed and as native vegetation re-establishes resulting in increased wildlife use.	**Short-term, minor, adverse impacts, but long-term minor to moderate, beneficial impacts to natural sound.** Short-term, minor impacts to natural sound would occur as a result of chainsaw use during treatment activities. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures. Long-term, minor to moderate beneficial effects to natural sound would occur as extensive areas of native vegetation re-establishes and wildlife use increases.	**Short-term, minor to moderate, adverse impacts, with long-term, minor beneficial impacts in treatment locations only.** The use of heavy equipment to cut and mulch tamarisk and Russian olive would result in temporary, minor to moderate, adverse increases in the level of noise in the canyon-bottom. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures. Long-term minor beneficial effects would occur in the treatment areas as native vegetation re-establishes and wildlife use increases. Tamarisk and Russian olive would continue to spread in non-treated areas, further degrading natural wildlife habitat, and diminishing the natural soundscape in non-treated locations.	**Short-term, minor to moderate, adverse impacts, with long-term, minor to moderate beneficial impacts in treatment locations only.** The use of heavy equipment to cut and mulch tamarisk and Russian olive would result in temporary, minor to moderate, adverse increases in the level of noise in the canyon-bottom. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures. Long-term minor to moderate beneficial effects would occur in the treatment areas as native vegetation re-establishes and wildlife use increases. Tamarisk and Russian olive would continue to spread in non-treated areas, further degrading wildlife habitat, and the natural soundscape in non-treated locations.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
VISITOR USE					
Public Health and Safety	**Moderate adverse impacts to public safety.** Tamarisk and Russian olive currently exist in dense infestations within the middle reaches of both main canyon-bottom corridors. These infestations have created severe down-cutting in stream channels making stream crossing difficult and dangerous for residents & concession tour buses, increasing the potential for adverse effects to public safety. These conditions will only worsen under the no-action alternative, as tamarisk and Russian olive continue to spread over time creating further moderate adverse impacts throughout the canyon-bottom.	**Short-term, minor to moderate adverse impacts to public safety, but moderate long-term beneficial impacts.** Short-term impacts to public health and safety would be greatest at treatment locations during the presence and use of heavy equipment and during tree cutting and herbicide application activities. Impacts to would be easily mitigated by keeping visitors out of the treatment locations during removal activities and herbicide use. In the long term, tamarisk and Russian olive reductions as proposed under alternative A would create safer conditions for park visitors, canyon residents, and park staff including improved stream channel crossings.	**Short-term, minor adverse impacts to visitor safety, but moderate long-term beneficial impacts.** Short-term, minor impacts would result from herbicide applications during treatment activities. These impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and/or through use of temporary closures of treatment sites during cutting and herbicide application activities. Long-term impacts, would be beneficial and of moderate intensity. Similar to alternative A the environmentally preferred alternative would ultimately improve safety conditions through removal of dense infestations & improved channel crossings.	**Short-term, minor to moderate adverse impacts to public safety, with very localized negligible to minor beneficial impacts within treatment locations.** Short-term, adverse impacts would occur as a result of heavy equipment use and tree cutting and mulching. These impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and through use of temporary closures of treatment sites during heavy equipment use. Effects from activities under alternative C would be limited to "non-sensitive" locations, minimizing any beneficial impacts to public safety. Since tamarisk & Russian olive would continue to spread under this alternative, long-term impacts would remain adverse & of moderate intensity throughout most of the canyon-bottom.	**Short-term, minor to moderate adverse impacts to public safety, with very localized negligible to minor beneficial impacts within treatment locations.** Short-term, adverse impacts would occur as a result of heavy equipment use and tree pulling and mulching. These impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and through use of temporary closures of treatment sites during heavy equipment use. Effects from activities under alternative D would be limited to "non-sensitive" locations, minimizing any beneficial impacts to public safety. Since tamarisk & Russian olive would continue to spread under this alternative, long-term impacts would remain adverse & of moderate intensity throughout most of the canyon-bottom.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Visitor Use and Experience	**Short- and long-term adverse impacts of moderate intensity.** No actions to control tamarisk or Russian olive would occur under this alternative. These non-native species currently degrade the viewshed of the canyons. As a result, park visitors do not receive an experience that truly reflects the canyon environments – open vistas from canyon wall to canyon wall. Views of archeological resources are obscured at many locations. The long-term, cumulative effect would be of moderate intensity and would further degrade the visitor experience as a result of continued spread of tamarisk and Russian olive under the no-action alternative.	**Short-term minor to moderate adverse impacts, but long-term moderate beneficial impacts.** This alternative would include actions using heavy equipment, chain sawing, and herbicide applications that could limit visitor access and cause short-term, minor to moderate impacts to visitor use during certain treatment activities. All attempts will be made to avoid closing sections of the park during removal actions, however, there is some potential that short-term closures may occur which would exclude concessionaires & visitors in work areas. The long-term, cumulative effect would enhance visitor experience as a result of the positive impacts of creating a more historically representative cultural and natural landscapes.	**Short-term minor to moderate adverse impacts, but long-term moderate beneficial impacts.** In the short-term, implementation of the environmentally preferred alternative would result in minor to moderate, adverse impacts. Although, this alternative does not include use of heavy equipment, which reduces the potential need for temporary closures, some short-term restrictions on visitor access may still be required during chainsaw and herbicide applications. However, in the long-term, the overall impact to visitor use would be moderate and beneficial, with a more historically representative cultural landscape, and improved interpretive and educational value.	**Short-term minor to moderate adverse impacts, with long-term, localized minor beneficial impacts.** Short-term impacts to the visitor experience would result from increased noise and potential, temporary closures in areas associated with heavy equipment use. After removal, the viewshed map appear degraded for a short time following treatment, and visitors may interpret the visual state of the treatment area as an unhealthy environment. Visitor education and general mitigation measures would be used to minimize these perceptions. Treatments would be restricted to "non-sensitive" areas, minimizing positive impacts to very localized canyon viewsheds. Tamarisk and Russian olive would continue to spread, resulting in long-term adverse impacts to visitor experience in most canyon-bottom areas.	**Short-term minor to moderate adverse impacts, with long-term, localized minor beneficial impacts.** Short-term impacts to the visitor experience would result from increased noise and potential temporary closures in areas associated with heavy equipment use. After removals the viewshed would appear degraded for a short time following treatment, and visitors may interpret the visual state of the treatment area as an unhealthy environment. Visitor education and general mitigation measures would be used to minimize these perceptions. Treatments would be restricted to "non-sensitive" areas, minimizing positive impacts to very localized canyon viewsheds. Tamarisk and Russian olive would continue to spread, resulting in long-term adverse impacts to visitor experience in most canyon-bottom areas.

	No Action Alternative	**Preferred Alternative (A)** Test & implement multiple control techniques	**Environmentally Preferred Alternative (B)** Stump cutting and direct herbicide application	**Additional Alternative (C)** Above ground mechanical removal only	**Additional Alternative (D)** Whole tree (above and below ground) mechanical removal only)
Socioeconomic	**Long-term, moderate, adverse impacts.** The no-action alternative would make no attempt in actively managing tamarisk and Russian olive. As a result, these invasive species would continue to spread, further degrading stream channel integrity, water resources, and farmable lands. The long-term sustainability of current levels of subsistence agriculture would be jeopardized. Cumulative effects would be long-term, adverse and of moderate intensity.	**Short-term, minor to moderate adverse impacts, with long-term, beneficial impacts of moderate intensity.** Alternative A would have short-term, minor to moderate, adverse impacts to socioeconomic conditions as some farmable land is lost due to streambank lateral erosion as more natural channel conditions are established. These impacts would be of minor to moderate intensity and would be minimized through field investigations (adaptive management study) to identify the most applicable removal techniques. Long-term, cumulative effects would be beneficial, of moderate intensity and would afford the best opportunity for improvement of canyon agriculture and long-term sustainability.	**Short-term, minor to moderate adverse impacts, with long-term, beneficial impacts of moderate intensity.** Alternative B would have similar, short-term, minor to moderate, adverse impacts to socioeconomic conditions due to streambank lateral erosion in establishing more natural, and sustainable channel conditions. This impact would be of minor to moderate intensity. The environmentally preferred alternative would be labor intensive and would require a longer timeframe to achieve full beneficial effects. In the interim, some additional losses to farmable land due to tamarisk and Russian olive spread would occur. Long-term, cumulative effects would be beneficial, of moderate and would provide opportunity for improvement of canyon agriculture and long-term sustainability.	**Short-term, minor, adverse effects, with minor, localized beneficial effects, but long-term adverse effects of moderate intensity.** Short-term, minor adverse impacts would occur in treated locations as lateral channel erosion occurs in treated areas, with negligible to minor long-term benefits once channel erosion stabilizes. Actions under alternative C would be limited in application ("non-sensitive" areas). Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, cumulative impacts to farmlands and subsistence uses throughout most of the canyon-bottom environments would be similar to the no-action alternative. Moderate, long-term, adverse effects to socioeconomics would continue in the canyon-bottom environments.	**Short term minor to moderate adverse impacts, with long-term negligible to minor beneficial effects in treated areas and long-term moderate adverse effects in non-treated areas.** Short-term, minor to moderate adverse impacts would occur in treated locations as a result of increased lateral channel erosion as stream channels attempt to stabilize. Negligible to minor long-term benefits may occur in treated areas once channel erosion stabilizes. Actions under alternative D would be limited in application ("non-sensitive" areas). Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, cumulative impacts to socioeconomic conditions throughout most of the canyon-bottom environments would be similar to the no-action alternative. Moderate, long-term, adverse effects would continue.

4.2 Consequences of Management Alternatives

Cultural Resources

4.2.1 Cultural Landscape

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The cultural landscapes associated with the canyon-bottom habitats within the Monument are explicitly tied to the cultural memory of the canyon residents and to the Navajo People as a whole. Canyon residents have voiced their frustration and distress over the loss of the canyon's monumental scale – as young people they remember being able to see from wall to wall – a magnificent vision of the landscape. At least one elderly resident has expressed her desire to see the canyon the way it was meant to be before she passes on. Under the no-action alternative there would be no indirect or direct impacts of tamarisk/Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use. However, the no-action alternative would allow for the continued spread of tamarisk and Russian olive and for further deterioration of existing historic/cultural landscapes associated with the floor of the canyon.

Cumulative Impacts. The cultural landscapes associated with the Chinle Wash and the main riparian corridors of Canyon de Chelly and Canyon del Muerto Chelly have been altered by over 3000 years of human related disturbances. The most significant alterations, however, have been the result of intensive historic grazing and the historic plantings, and continued spread, of invasive non-native tamarisk and Russian olive. Tamarisk and Russian olive would continue to proliferate under the no-action alternative. The cultural landscape(s) and associated values of the canyon-bottom habitats at Canyon de Chelly National Monument would experience a moderate, adverse, long-term cumulative impact, as continued tamarisk and Russian olive invasions further degrade the cultural landscape/viewshed. Additionally, the continued spread of these non-native, woody plants would further reduce the presence of landscape factors that are related to the various human occupations of the canyon over time, and would make these elements more difficult to delineate. Historic and modern activities related to unregulated livestock grazing and vehicle access are conducive to further establishment and spread of tamarisk and Russian olive in the canyon-bottom habitats. With no tamarisk and Russian olive management, the effects of these past and modern uses of the canyon floor would perpetuate into the future and continue to promote the establishment and spread of these noxious weed species throughout the cultural landscape.

Conclusion. There would be no short-term, indirect or direct adverse impacts of tamarisk and Russian olive management activities such as herbicide spraying, cutting, or heavy equipment use on the park under the no-action alternative. However, there would be no change to the status quo of tamarisk and Russian olive infestations in the cultural

landscape(s) of the canyon-bottom/riparian corridors within the park. Tamarisk and Russian olive would continue to proliferate in both up- and downstream within the canyons, further degrading the integrity of the cultural landscape. In sum, there would be moderate, long-term adverse impacts to the cultural landscape if tamarisk and Russian olive management did not occur.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Implementation of an "action" alternative, and the associated reduction of tamarisk and Russian olive in the Chinle Wash and/or within the main riparian corridors of the canyons, would partially restore the appearance of these areas to one more historically and naturally representative, and would have long-term beneficial impacts. With a sharp reduction in the density and abundance of tamarisk and Russian olive, the cultural landscape(s) associated with canyon-bottom habitats would become more visible, allowing for better identification, research, and interpretation. The cumulative impact of tamarisk and Russian olive reduction in the canyon-bottom riparian zones would facilitate future improvements and perpetuation of a more historically representative cultural landscape.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims, including logging, grazing, and agricultural practices have significantly increased erosion in the monument. Historically, the canyon would have been more open, allowing individuals in the canyon to see from wall to wall. The natural courses of Canyon De Chelly and Del Muerto washes would have been more of a braided sheetwash. Currently, the canyon continues to be impacted by unnatural levels of erosion and downcutting due to the extensive presence of tamarisk and Russian olive and by unregulated livestock grazing, human visitation, and vehicle use. These unregulated activities, and continued expansion by invasive non-native plant species, have accelerated erosion by water and wind, resulting in high levels of soil loss and creation of sections of highly incised stream channels.

Although alternative A cannot address, or alleviate, all human-related impacts to the cultural landscape, the large-scale control of tamarisk and Russian olive identified under this alternative would be long-term and beneficial. Alternative A would also assist in creating conditions that would contribute significantly to generating long-term

sustainability of canyon-bottom systems, and would restore the original view of the culturally important landscape.

Conclusion. It is possible that minor, short-term, adverse impacts to the cultural landscape could occur as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums. However, Alternative A provides the strongest opportunity for long-term sustainability of canyon stream channel processes and the cultural landscape.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Under the environmentally preferred alternative, the distribution and abundance of tamarisk and Russian olive in the proposed treatment area would be dramatically reduced through stump cutting and herbicide applications. This would allow for park staff to more accurately identify, study, interpret, and restore the cultural landscape elements associated with the canyon riparian corridors. Beneficial, long-term impacts would result to the cultural landscape(s) of canyon-bottom habitats of both moderate duration and intensity. The removal of cut trees would occur at the time of treatment, resulting in a more compressed period of time during which management areas would be in a treatment state. Additionally, the management of tamarisk and Russian olive in the riparian corridors would allow for other native species to re-establish in areas where they have been previously out-competed by dense stands of these invasive species. This would foster a higher interpretive value in terms of understanding and preserving biotic cultural resources that are integral components of the overall cultural landscape(s).

Cumulative Impacts. The cumulative effects of this alternative would be beneficial, moderate in duration, and of moderate intensity. Since there would not be any ground-disturbing activities associated with this management option, there would be no impact on below-ground cultural resources associated with the cultural landscape. Extensive reduction in the presence of tamarisk and Russian olive throughout the main canyon-bottom habitats would accommodate research and interpretation of the cultural landscape in the future. This includes elements that are not currently visible due to the encroachment of these invasive woody species. Additionally, the reduction of tamarisk and Russian olive would significantly reduce the availability of associated seed propagules. Additional re-vegetation work would be necessary in some treatment locations to assist in restoring accurate cultural landscape to a historically representative state, the reduction of honey mesquite trees and shrubs in the core battlefield would be a major component of the work required to achieve such a state.

Conclusion. The effects of the environmentally preferred alternative on the cultural landscape would be beneficial, moderate in duration, and of moderate intensity. The cultural landscape would become more visible, allowing for better identification, research, and interpretation. Additionally, the cumulative impact of honey mesquite reduction in the core battlefield zone would facilitate future improvements and perpetuation of a more historically representative cultural landscape.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. If the additional alternative were implemented, herbicide would be applied to the foliar tissues of tamarisk and Russian olive trees and shrubs in the core battlefield, and the plants would be removed from the area after they died. The cultural landscape would experience minor to moderate beneficial effects of moderate duration. The treatment process would take longer than the environmentally preferred alternative, but the immediate outcome would be similar in the sense that the distribution and abundance of tamarisk and Russian olive in the core battlefield zone would be sharply reduced. This would allow for park staff to more accurately identify, study, interpret, and restore the cultural landscape elements at the battlefield.

Cumulative Impacts. The cumulative impacts of this treatment option would be moderate, beneficial, and of moderate duration. This treatment option is slightly less effective for tamarisk and Russian olive control than the environmentally preferred alternative. Therefore, re-encroachment of tamarisk and Russian olive into the core battlefield area is would likely occur more rapidly because more trees and shrubs would survive the treatment. These remaining tamarisk and Russian olive trees could provide a seed source into the cleared battlefield zone more readily than the environmentally preferred alternative. Although some additional restoration work would be necessary in the core battlefield zone to restore the cultural landscape to a historically representative state, the reduction of tamarisk and Russian olive trees in the core battlefield would be a major component of the work required to achieve such a state.

Conclusion. The effects of the additional alternative on the cultural landscape would be beneficial, minor to moderate in intensity, and moderate in duration. This option entails a two-step treatment plan; first, the application of herbicide to tamarisk and Russian olive foliar tissues, and second, the removal of dead plants from the treatment area after they have reached mortality. Therefore, the direct impacts to the cultural landscape would be minor to moderate but beneficial, while the cumulative impact to the cultural landscape would be moderate, beneficial, and of moderate duration.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Alternative D would rely solely on heavy equipment to remove above ground and below ground portions of tamarisk and Russian olive, and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity would occur to the cultural landscape as a result of heavy equipment use, increased ground disturbance from root system removals, and as lateral streambank erosion increases at treated locations. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion.

Although there would be some longer-term benefits to "sensitive" areas near treatment locations, alternative D would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative D would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. The cultural landscape would continue to be adversely impacted as described under the no-action alternative.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact the cultural landscape. Some longer-term, negligible to minor beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon. The lack of visual improvement and measurable benefits under alternative D would be less likely to assist in facilitating integrated management strategies of the cultural landscape at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations, however the cultural landscape would continue to incur long-term adverse impacts, of moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.2 Archeological Resources

Effects of the No-Action Alternative:

Analysis. Under the no-action alternative there would be no control or treatment of tamarisk and Russian olive infestations. Currently, several archeological resources are jeopardized and risk long-term adverse impacts as a result of dense infestations of tamarisk and Russian olive. Excessive soil erosion, created by the loss of soil stabilizing understory vegetation in dense stands of tamarisk and Russian olive, are undercutting two major archeological sites and places these sites at serious risk. Additionally, the dense stands of tamarisk and Russian olive further threaten numerous archeological resources as a result of direct scraping and/or creating a significant increase in the potential for damage as a result of wildfire.

The presence of dense stands of tamarisk and Russian olive within the canyon-bottom habitats creates a situation of continual threat to the archeological resources within the park. This threat will only continue to increase as these highly invasive non-native species continue to spread. Thus, under the no-action alternative, long-term, moderate adverse impacts to archeological resources would occur as a direct result of no implementation of management actions to control tamarisk and Russian olive within the park.

Cumulative Impacts. The canyon floor has had an extensive history of grazing. Although more intensive in the past, grazing continues today at a moderate, but unregulated level. Visitor access to the majority of the canyon areas is only allowed through guided activities. Park concessionaires provide routine and multiple large truck tours on a daily basis. Currently, there are no designated vehicle use routes within the canyons allowing tour trucks and canyon residents to drive vehicles at their own discretion. Tamarisk and Russian olive were intentionally planted on the canyon floor during the 1940's and 50's. These activities were undertaken in an attempt to stabilize stream channels and to protect streambanks from undesirable erosion. Most planting occurred in the middle sections of Canyon de Chelly and Canyon del Muerto. Due to the highly aggressive nature of these two non-native woody species and to the continued ground disturbances created by unregulated grazing and vehicle use, tamarisk and Russian olive have spread substantially both up-canyon and down-canyon from the original plantings. Further spread of tamarisk and Russian olive, and additional threats to

park archeological resources, is inevitable as a result of historic, modern-day, and/or foreseeable future disturbance regimes that occur in the park.

Conclusion. The no-action alternative would result in moderate, long-term, adverse impacts to park archeological resources as a result of failure to implement active tamarisk and Russian olive control actions.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Alternative A would use a variety of treatment/removal techniques to mitigate adverse direct and indirect impacts created by extensive and dense infestations of tamarisk and Russian olive. Large-scale removals would be necessary to mitigate the existing adverse effects. However, large-scale removal of tamarisk and Russian olive in over 40 miles of riparian corridor in canyons creates a risk for excessive, adverse, and unpredictable erosion unless an additional study is performed to determine which removal/control techniques are most effective and applicable to Canyon de Chelly National Monument. Alternative A would implement a smaller-scale, detailed adaptive management study to identify which techniques would provide the strongest levels of improvement with the greatest time, cost efficacy, and least damage to archeological resources. Areas of known archeological sites near the removal areas will be deemed "sensitive", and avoided as much as possible, however, in cases where avoidance is not prudent (excessive fuel build-up near rock art panels or other sites), appropriate removal of exotics and subsequent erosion control methods will take place, followed by an active monitoring program to assess the post-removal condition of the sites. Results from this study will guide the development and implementation of a larger "Tamarisk and Russian olive Management Program" at Canyon de Chelly National Monument.

Alternative A might have short-term, minor adverse impacts to previously unidentified archeological resources due to heavy equipment use and as streambanks undergo an increased rate of lateral erosion in creating a more stable, and sustainable, stream channel condition. These impacts would include minor to moderate losses of smaller sections of land which may include previously unidentified sites (buried deposits). Additionally, a minor potential for adverse impacts resulting from soil contamination from herbicide overspray or drip also exists under alternative A. The effects of these herbicides on archeological materials are not known. However, the herbicides proposed for use break down readily in the soil, forming non-toxic salts that are readily degraded by soil microorganisms, and hence, most likely do not pose a threat to archeological materials (personal communication, Curt Deuser, July 9, 2004). Soil erosion would also be

temporarily increased due to losses of canopy cover, and greater soil exposure, in tamarisk and Russian olive removal locations. This erosion could possibly expose or remove previously unidentified cultural material. All short-term impacts would be minimized through use of the identified mitigation measures (see section 2.2.6).

There may be some ground losses, which possibly include previously unknown archeological sites, to areas that are associated more immediate to existing channelized sections of streambanks, however, alternative A would ultimately provide a stream channel that is more natural and stable in structure and function. The loss of any land (whether culturally significant or not) would remain far below the level of losses that would occur under a no-action alternative. Alternative A would reduce future adverse impacts and soil losses and create a more sustainable condition for archeological resources located on or near the canyon floor. Long-term impacts under this alternative would be beneficial and of moderate intensity.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims, including logging, grazing, and agricultural practices have significantly affected erosion in the monument. Currently, the canyon's archeological resources continue to be impacted by unnatural levels of erosion due to the extensive presence of tamarisk and Russian olive and by unregulated livestock grazing, human visitation, and vehicle use. These unregulated activities, and continued expansion by invasive non-native plant species, have accelerated erosion by water and wind, resulting in high levels of soil loss and creation of sections of highly incised stream channels that endanger numerous archeological sites (including human burials).

Although alternative A cannot address, or alleviate, all human-related impacts to archeological resources, the large-scale control of tamarisk and Russian olive identified under this alternative would be long-term and beneficial. Alternative A would also assist in creating conditions that would contribute significantly to generating long-term sustainability of canyon-bottom systems at the national monument.

Conclusion. It is possible that minor, short-term, adverse impacts to previously unknown archeological sites could occur as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums. However, with proper documentation, condition assessment, monitoring, and mitigation measures taken to avoid such impacts, Alternative A provides the strongest opportunity for long-term sustainability of canyon stream channel processes and protection of archeological resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service

planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Short-term, adverse impacts, of minor to moderate intensity, would occur under the environmentally preferred alternative. No heavy equipment would be used under this alternative. Temporary impacts resulting from tamarisk and Russian olive would be similar to those described for the above preferred alternative (Alternative A). Some loss of land adjacent to channelized sections of stream channels would occur as lateral streambank erosion takes place to re-establish a more natural and sustainable channel condition. Restoration of native vegetation or other erosion control methods (in treatment locations), as appropriate, would assist in mitigating most loss of land containing cultural material.

Since Alternative B would rely completely on the use of herbicide applications (cut stumps or low volume basal spray) potential for negligible to minor impacts to archeological material as a result of herbicide overspray or drip could occur. Herbicide applications, however, would be distinctly targeted, greatly minimizing the potential for adverse impact. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to archeological sites.

As with alternative A, alternative B would have long-term beneficial effects of moderate intensity. The environmentally preferred alternative is labor (and cost) intensive, relying completely on chainsaw and hand work. As such, it would require a much longer timeframe (up to 10 years) to achieve similar results as with alternative A. Some additional adverse impact(s) to archeological sites could occur as a result of the extended timeframe necessary to fully implement alternative B.

Cumulative Impacts. Alternative B would not mitigate all human-related disturbances to archeological sites, but this alternative would provide management actions necessary to mitigate the largest immediate threat to this resource – tamarisk and Russian olive infestation. Similar to alternative A, the environmentally preferred alternative is likely to assist in developing more integrated management strategies throughout the canyon-bottom environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative B would be beneficial and of moderate intensity. Implementation of this alternative affords strong protection to archeological sites located on the canyon floor and provides the opportunity for facilitating a more integrated and sustainable approach in managing archeological resources located on or near the canyon floor. Alternative B, though similar to Alternative A in its beneficial effects, would require a much longer timeframe to fully implement.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would rely solely on heavy equipment to remove above ground portions of tamarisk and Russian olive and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity could occur to previously unknown (buried) archeological resources as a result of heavy equipment use and as lateral streambank erosion increases at treated locations. Lateral erosion would be somewhat mitigated by the remaining presence of root systems that would serve to stabilize streambanks. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near archeological sites.

Although there would be some longer-term benefits to archeological sites near treatment locations, alternative C would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Additionally, the remaining root systems have potential to re-sprout, minimizing long-term benefits in treatment locations. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative C would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Archeological sites would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative C would not mitigate other human-related disturbances that currently impact archeological sites. Some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, but these benefits would be jeopardized by potential re-sprouting from remaining root systems. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative C would be less likely to assist in facilitating integrated management strategies of archeological resources at Canyon de Chelly National Monument.

Conclusion. Limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of archeological sites associated with canyon-bottom

habitats would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would rely solely on heavy equipment to remove above ground and below ground portions of tamarisk and Russian olive, and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity would occur to previously unknown (buried) archeological sites as a result of heavy equipment use, increased ground disturbance from root system removals, and as lateral streambank erosion increases at treated locations. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near archeological sites. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to archeological resources.

Although there would be some longer-term benefits to archeological sites near treatment locations, alternative D would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative D would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Archeological resources would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact archeological resources. Some longer-term, negligible to minor beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative D would be less likely to assist in facilitating integrated management strategies of archeological resources at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of archeological sites associated with canyon-bottom habitats would incur long-term adverse impacts, of moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.3 Ethnographic Resources

Effects of the No-Action Alternative:

Analysis. The no-action alternative would have a direct, moderate, and long-term adverse effect on traditional cultural properties and ethnographic resources. With no management intervention, tamarisk and Russian olive would continue to spread and would further impact or limit the areas available on the canyon floor that are considered as traditional farmlands, homelands, resource gathering areas, or areas of ceremonial or religious importance (and other Traditional Cultural Properties). High densities of tamarisk and Russian olive would continue to threaten resource collection areas, including currently non-infested side-canyon habitats, resulting in a loss of native biological diversity associated with traditional uses. Tamarisk and Russian olive infested areas would be abandoned by the Navajo People, and subsequently, the knowledge of Traditional Cultural Properties and resources contained there would become lost.

The dense stands of tamarisk and Russian olive further threaten numerous ethnographic resources by creating a significant increase in the potential for damage as a result of wildfire.

The presence of dense stands of tamarisk and Russian olive within the canyon-bottom habitats creates a situation of continual threat to the ethnographic resources within the park. As these highly invasive non-native species continue to spread, traditional cultural properties would be abandoned and traditional knowledge and life ways would be lost. This threat will only continue to increase if a no-action alternative is implemented. Thus, under this alternative, long-term, moderate adverse impacts to ethnographic resources would occur as a direct result of no implementation of management actions to control tamarisk and Russian olive within the park.

Cumulative Impacts. The canyon riparian corridors have historically been used, and remain active with, unregulated livestock grazing and vehicle use. These activities create ground disturbances and impacts to soil resources and native vegetation that further favor

the continued spread and establishment of tamarisk of Russian olive under the no-action alternative.

The presence of dense stands of tamarisk and Russian olive on the canyon floor creates a situation of continual threat to the ethnographic resources within the park. As these highly invasive non-native species continue to spread, traditional cultural properties would be abandoned and traditional knowledge and life ways would be lost. This threat will only continue to increase if a no-action alternative is implemented. Thus, under this alternative, long-term, moderate adverse impacts to ethnographic resources would occur as a direct result of no implementation of management actions to control tamarisk and Russian olive within the park.

Conclusion. After applying the Advisory Council on Historic Preservation criteria of adverse effects (36CFR part 800.5, *Assessment of Adverse Effects*), the no-action alternative would result in long-term, moderate adverse effects to park ethnographic resources, including traditional cultural properties.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis: Alternative A would use a variety of treatment/removal techniques to mitigate adverse direct and indirect impacts created by extensive and dense infestations of tamarisk and Russian olive. Large-scale removals would be necessary to mitigate the existing adverse effects. However, large-scale removal of tamarisk and Russian olive in over 40 miles of riparian corridor in canyons creates a risk for excessive, adverse, and unpredictable erosion unless an additional study is performed to determine which removal/control techniques are most effective and applicable to Canyon de Chelly National Monument. Alternative A would implement a smaller-scale, detailed adaptive management study to identify which techniques would provide the strongest levels of improvement with the greatest time, cost efficacy, and least damage to traditional cultural properties and other ethnographic resources. Areas of known ethnographic resources near the removal areas will be deemed "sensitive", and avoided as much as possible, however, in cases where avoidance is not prudent (excessive fuel build-up near a traditional cultural property), appropriate removal of exotics and subsequent erosion control methods will take place, followed by an active monitoring program to assess the post-removal condition of the area. Results from this study will guide the development and implementation of a larger "Tamarisk and Russian olive Management Program" at Canyon de Chelly National Monument.

Alternative A might have short-term, minor adverse impacts to previously unidentified ethnographic resources due to heavy equipment use and as streambanks undergo an increased rate of lateral erosion in creating a more stable, and sustainable, stream channel condition. These impacts would include minor to moderate losses of smaller sections of land which may include previously unidentified resources (possibly buried deposits). Additionally, a minor potential for adverse impacts resulting from soil contamination from herbicide overspray or drip also exists under alternative A. Soil erosion would also be temporarily increased due to losses of canopy cover, and greater soil exposure, in tamarisk and Russian olive removal locations. This erosion could possibly expose or remove previously unidentified ethnographic material. All short-term impacts would be minimized through use of the identified mitigation measures (see section 2.2.6).

There may be some ground losses, which possibly include previously unknown ethnographic areas, to areas that are associated more immediate to existing channelized sections of streambanks, however, alternative A would ultimately provide a stream channel that is more natural and stable in structure and function. The loss of any land (whether culturally significant or not) would remain far below the level of losses that would occur under a no-action alternative. Alternative A would reduce future adverse impacts and soil losses and create a more sustainable condition for ethnographic resources located on or near the canyon floor. Long-term impacts under this alternative would be beneficial and of moderate intensity.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims, including logging, grazing, and agricultural practices have significantly affected erosion in the monument. Currently, some of the canyon's traditional cultural properties are threatened by unnatural levels of erosion due to the extensive presence of tamarisk and Russian olive and by unregulated livestock grazing, human visitation, and vehicle use. These unregulated activities, and continued expansion by invasive non-native plant species, have accelerated erosion by water and wind, resulting in high levels of soil loss and creation of sections of highly incised stream channels that endanger numerous archeological sites (including human burials).

Although alternative A cannot address, or alleviate, all human-related impacts to archeological resources, the large-scale control of tamarisk and Russian olive identified under this alternative would be long-term and beneficial. Alternative A would also assist in creating conditions that would contribute significantly to generating long-term sustainability of canyon-bottom systems at the national monument.

Conclusion. It is possible that minor, short-term, adverse impacts to previously unknown archeological sites could occur as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums. However, with proper documentation, condition assessment, monitoring, and mitigation measures taken to avoid such impacts, Alternative A provides the strongest opportunity for long-term sustainability of canyon-bottom stream channel processes and protection of archeological resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Short-term, adverse impacts, of minor to moderate intensity, would occur under the environmentally preferred alternative. No heavy equipment would be used under this alternative. Temporary impacts resulting from tamarisk and Russian olive would be similar to those described for the above preferred alternative (Alternative A). Some loss of land adjacent to channelized sections of stream channels would occur as lateral streambank erosion takes place to re-establish a more natural and sustainable channel condition. Restoration of native vegetation or other erosion control methods (in treatment locations), as appropriate, would assist in mitigating most loss of land containing ethnographic material.

Since Alternative B would rely completely on the use of herbicide applications (cut stumps or low volume basal spray) potential for negligible to minor impacts to previously unidentified ethnographic material as a result of herbicide overspray or drip could occur. Herbicide applications, however, would be distinctly targeted, greatly minimizing the potential for adverse impact. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to areas of ethnographic interest.

As with alternative A, alternative B would have long-term beneficial effects of moderate intensity. The environmentally preferred alternative is labor (and cost) intensive, relying completely on chainsaw and hand work. As such, it would require a much longer timeframe (up to 10 years) to achieve similar results as with alternative A. Some additional adverse impact(s) to ethnographic resources could occur as a result of the extended timeframe necessary to fully implement alternative B.

Cumulative Impacts. Alternative B would not mitigate all human-related disturbances to ethnographic resources, but this alternative would provide management actions necessary to mitigate the largest immediate threat to this resource – tamarisk and Russian olive infestation. Since this alternative would take longer to implement, these invasive trees would continue to spread from non-treated locations. Long-term effects, such as the loss of traditional knowledge of canyon resources, would remain adverse and of moderate intensity throughout most of the canyon. Similar to alternative A, the environmentally preferred alternative is likely to assist in developing more integrated management strategies throughout the canyon floor environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative B would be beneficial and of moderate intensity. Implementation of this alternative will help to preserve the life ways of the Navajo people, and provides the opportunity for facilitating a more integrated and sustainable approach in managing canyon ethnographic resources. Alternative B, though similar to Alternative A in its beneficial effects, would require a much longer timeframe to fully implement.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would rely solely on heavy equipment to remove above ground portions of tamarisk and Russian olive and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity could occur to previously unknown ethnographic resources as a result of heavy equipment use and as lateral streambank erosion increases at treated locations. Lateral erosion would be somewhat mitigated by the remaining presence of root systems that would serve to stabilize streambanks. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near areas of ethnographic importance.

Although there would be some longer-term benefits to important ethnographic areas near treatment locations, alternative C would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. The spread of these trees would eventually prevent Native peoples from using the canyon and its resources in traditional ways. Over time, as the old ways are abandoned, a significant portion of traditional knowledge of the area and its resources will be lost. Additionally, the remaining root systems have potential to re-sprout, minimizing long-term benefits in treatment locations. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative C would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Ethnographic resources would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative C would not mitigate other human-related disturbances that currently impact ethnographic resources. Some longer-term,

negligible to minor, beneficial effects could be realized in treatment locations, but these benefits would be jeopardized by potential re-sprouting from remaining root systems. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative C would be less likely to assist in facilitating integrated management strategies of ethnographic resources at Canyon de Chelly National Monument.

Conclusion. Limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of ethnographic resources associated with canyon-bottom habitats would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would rely solely on heavy equipment to remove above ground and below ground portions of tamarisk and Russian olive, and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity could occur to previously unknown ethnographic resources as a result of heavy equipment use, increased ground disturbance from root system removals, and as lateral streambank erosion increases at treated locations. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near ethnographic resources. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to ethnographic resources.

Although there would be some longer-term benefits to ethnographic resources near treatment locations, alternative D would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. The spread of these trees would eventually prevent Native peoples from using the canyon and its resources in traditional ways. Over time, as the old ways are abandoned, a significant portion of traditional knowledge of the area and its resources will be lost. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative D would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any

effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Ethnographic resources would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact ethnographic resources. Some longer-term, negligible to minor beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative D would be less likely to assist in facilitating integrated management strategies of ethnographic resources at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of ethnographic resources associated with canyon-bottom habitats would incur long-term adverse impacts, of moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.4 Historic Structures

Effects of the No-Action Alternative:

Analysis. Under the no-action alternative there would be no control or treatment of tamarisk and Russian olive infestations. Canyon de Chelly National Monument has many historic structures which are jeopardized and risk long-term adverse impacts as a result of dense infestations of tamarisk and Russian olive. Excessive soil erosion, created by the loss of soil stabilizing understory vegetation in dense stands of tamarisk and Russian olive, is undercutting major prehistoric structures and numerous historic Navajo structures, and places these sites at serious risk. Additionally, the dense stands of tamarisk and Russian olive further threaten numerous historic structures as a result of direct scraping and/or creating a significant increase in the potential for damage as a result of wildfire.

The presence of dense stands of tamarisk and Russian olive within the canyon-bottom habitats creates a situation of continual threat to the archeological resources within the park. This threat will only continue to increase as these highly invasive non-native species continue to spread. Thus, under the no-action alternative, long-term, moderate

adverse impacts to archeological resources would occur as a direct result of no implementation of management actions to control tamarisk and Russian olive within the park.

Cumulative Impacts. The floor of the canyon have seen and felt the effects of a history of extensive grazing. Although more intensive in the past, grazing does continue today at a moderate, but unregulated level. Visitor access to most of the canyon is only allowed through guided activities. Park concessionaires provide routine and multiple large truck tours on a daily basis. Currently, there are no designated vehicle routes within the canyons allowing tour trucks and canyon residents to drive vehicles at their own discretion. Tamarisk and Russian olive were intentionally planted on the canyon floor during the 1940's and 50's. These activities were undertaken in an attempt to stabilize stream channels and to protect streambanks from undesirable erosion. Most planting occurred in the middle sections of Canyon de Chelly and Canyon del Muerto. Due to the highly aggressive nature of these two non-native woody species and to the continued ground disturbances created by unregulated grazing and vehicle use, tamarisk and Russian olive have spread substantially both up-canyon and down-canyon from the original plantings. Further spread of tamarisk and Russian olive, and additional threats to the park's historic structures, are inevitable as a result of historic, modern-day, and/or foreseeable future disturbance regimes that occur in the park.

Conclusion. The no-action alternative would result in moderate, long-term, adverse impacts to historic structures as a result of failure to implement active tamarisk and Russian olive control actions.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Alternative A would use a variety of treatment/removal techniques to mitigate adverse direct and indirect impacts created by extensive and dense infestations of tamarisk and Russian olive. Large-scale removals would be necessary to mitigate the existing adverse effects. However, large-scale removal of tamarisk and Russian olive on over 40 miles of riparian corridor in canyons creates a risk for excessive, adverse, and unpredictable erosion unless an additional study is performed to determine which removal/control techniques are most effective and applicable to Canyon de Chelly National Monument. Alternative A would implement a smaller-scale, detailed adaptive management study to identify which techniques would provide the strongest levels of improvement with the greatest time, cost efficacy, and least damage to historic structures. Historic structures and associated cultural features near the removal areas will be deemed

"sensitive", and avoided as much as possible, however, in cases where avoidance is not prudent (excessive fuel build-up near structures), appropriate removal of exotics and subsequent erosion control methods will take place, followed by an active monitoring program to assess the post-removal condition of the sites. Results from this study will guide the development and implementation of a larger "Tamarisk and Russian olive Management Program" at Canyon de Chelly National Monument.

Alternative A might have short-term, minor adverse impacts to historic structures as streambanks undergo an increased rate of lateral erosion in creating a more stable, and sustainable, stream channel condition. These impacts would include minor to moderate losses of smaller sections of land which may include previously unidentified structures (buried deposits). Additionally, a minor potential for adverse impacts resulting from soil contamination from herbicide overspray or drip also exists under alternative A. The effects of these herbicides on structural materials are not known. However, the herbicides proposed for use break down readily in the soil, forming non-toxic salts that are readily degraded by soil microorganisms, and hence, most likely do not pose a threat to historic structures (personal communication, Curt Deuser, July 9, 2004). Soil erosion would also be temporarily increased due to losses of canopy cover, and greater soil exposure, in tamarisk and Russian olive removal locations. This erosion could possibly expose or remove previously unidentified cultural material. All short-term impacts would be minimized through use of the identified mitigation measures (see section 2.2.6).

There may be some ground loss in areas that are associated more immediately to existing channelized sections of streambanks, however alternative A would ultimately provide a stream channel that is more natural and stable in structure and function. The loss of any land (whether culturally significant or not) would remain far below the level of losses that would occur under a no-action alternative. Alternative A would reduce future adverse impacts and soil losses and create a more sustainable condition for historic structures on the canyon floor. Long-term impacts under this alternative would be beneficial and of moderate intensity.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities (including logging, grazing, and agricultural practices) in the watershed and along the canyon rims, have significantly affected erosion in the monument. Currently, the canyon's historic sites continue to be impacted by unnatural levels of erosion due to the extensive presence of tamarisk and Russian olive and by unregulated livestock grazing, human visitation, and vehicle use. These unregulated activities, and continued expansion by invasive non-native plant species, have accelerated erosion by water and wind, resulting in high levels of soil loss and creation of sections of highly incised stream channels that endanger numerous historic structures.

Although alternative A cannot address, or alleviate, all human-related impacts to historic structures, the large-scale control of tamarisk and Russian olive identified under this alternative would be long-term and beneficial. Alternative A would also assist in creating

conditions that would contribute significantly to generating long-term sustainability of canyon-bottom systems at the national monument.

Conclusion. It is possible that minor, short-term, adverse impacts to previously unknown historic structures could occur as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums. However, with proper documentation, condition assessment, monitoring, and mitigation measures taken to avoid such impacts, Alternative A provides the strongest opportunity for long-term sustainability of canyon stream channel processes and protection of historic structures.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Short-term, adverse impacts, of minor to moderate intensity, would occur under the environmentally preferred alternative. No heavy equipment would be used under this alternative. Temporary impacts resulting from tamarisk and Russian olive would be similar to those described for the above preferred alternative (Alternative A). Some loss of land adjacent to channelized sections of stream channels would occur as lateral streambank erosion takes place to re-establish a more natural and sustainable channel condition. Restoration of native vegetation or other erosion control methods (in treatment locations), as appropriate, would assist in mitigating most loss of land containing cultural material.

Since Alternative B would rely completely on the use of herbicide applications (cut stumps or low volume basal spray) potential for negligible to minor impacts to historic structures as a result of herbicide overspray or drip could occur. Herbicide applications, however, would be distinctly targeted, greatly minimizing the potential for adverse impact. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to historic structures.

As with alternative A, alternative B would have long-term beneficial effects of moderate intensity. The environmentally preferred alternative is labor (and cost) intensive, relying completely on chainsaw and hand work. As such, it would require a much longer timeframe (up to 10 years) to achieve similar results as with alternative A. Additional adverse impacts, such as fire, could occur to historic structures as a result of the extended timeframe necessary to fully implement alternative B.

Cumulative Impacts. Alternative B would not mitigate all human-related disturbances to historic structures, but this alternative would provide management actions necessary to mitigate the largest immediate threat to this resource – tamarisk and Russian olive infestation. Similar to alternative A, the environmentally preferred alternative is likely to assist in developing more integrated management strategies throughout the canyon-bottom environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative B would be beneficial and of moderate intensity. Implementation of this alternative affords strong protection to historic structures located on and near the canyon floor and provides the opportunity for facilitating a more integrated and sustainable approach in managing historic structures located on or near the canyon floor. Alternative B, though similar to Alternative A in its beneficial effects, would require a much longer timeframe to fully implement.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would rely solely on heavy equipment to remove above ground portions of tamarisk and Russian olive and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity could occur to previously unknown (buried) historic structures as a result of heavy equipment use and as lateral streambank erosion increases at treated locations. Lateral erosion would be somewhat mitigated by the remaining presence of root systems that would serve to stabilize streambanks. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near historic structures.

Although there would be some longer-term benefits to historic structures near treatment locations, alternative C would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Additionally, the remaining root systems have potential to re-sprout, minimizing long-term benefits in treatment locations. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative C would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any

effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Historic structures would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative C would not mitigate other human-related disturbances that currently impact historic structures. Some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, but these benefits would be jeopardized by potential re-sprouting from remaining root systems. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative C would be less likely to assist in facilitating integrated management strategies of historic structures at Canyon de Chelly National Monument.

Conclusion. Limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of historic structures associated with canyon-bottom habitats would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would rely solely on heavy equipment to remove above and below ground portions of tamarisk and Russian olive, and would be used only in areas deemed "non-sensitive". Short-term, adverse impacts of minor to moderate intensity would occur to previously unknown (buried) historic structures as a result of heavy equipment use, increased ground disturbance from root system removals, and as lateral streambank erosion increases at treated locations. Re-vegetation with native species in treatment locations and other erosion control methods, as appropriate, would also assist in minimizing undesirable bank erosion near historic structures. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to historic structures.

Although there would be some longer-term benefits to historic structures which are located near treatment locations, alternative D would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative D would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Historic structures would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact historic structures. Some longer-term, negligible to minor beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative D would be less likely to assist in facilitating integrated management strategies of historic structures at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations. Most of the historic structures associated with canyon-bottom habitats would incur long-term adverse impacts, of moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

Natural Resources

4.2.5 Soils

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. Under the no-action alternative, there would be short- and long-term, adverse impacts of moderate intensity to soil resources on the canyon floor. Unnatural rates of soil erosion and deceases in soil quality would continue as a result of sustained and expanding tamarisk and Russian olive infestations. Soil chemical and biological parameters would remain adversely altered as salt-deposition by tamarisk increases. Soil structure would continue to be adversely impacted as the finer root systems of native grass and forb species are lost from the understory of infested areas. The no-action alternative would sustain, and perpetuate additional, long-term adverse impacts to soil resources on the floor of the canyon.

Cumulative Impacts. Soil resources within the canyon-bottom habitats have been, and continue to be, impacted by human-related disturbances. The canyon floor has had an extensive history of grazing and farming. Although more intensive in the past, grazing continues today at a moderate, but unregulated level. Visitor access to the majority of the canyon areas is only allowed through guided activities. Park concessionaires provide routine and multiple large truck tours on a daily basis. Currently, there are no designated vehicle routes within the canyons, which allows tour trucks and canyon residents to drive vehicles at their own discretion. Historic, intentional, plantings of tamarisk and Russian olive during the 1930's to 50's were undertaken in an attempt to stabilize stream channels and to protect streambanks from undesirable erosion. Although the plantings of tamarisk and Russian olive, which have extensively expanded since the 1960's, have proved beneficial in preventing some lateral streambank erosion, they have resulted in excessive lateral erosion in others (loss of farmable land), stream channelization, and severe downcutting of the stream beds. Any losses of farmable land would remain far below the level of losses that would occur under a no-action alternative. The end result of these actions has been an excessive and unnatural loss of soil resources from the riparian corridors. These losses would continue at a moderate intensity under the no-action alternative.

Conclusion. The no-action alternative would have moderate, long-term, adverse impacts on the soil resources at Canyon de Chelly National Monument. These impacts would include moderate levels of loss of currently available farmland.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

.***Effects of the Preferred Alternative (Alternative A):***

Analysis. Alternative A would use a variety of treatment/removal techniques to mitigate adverse direct and indirect impacts created by extensive and dense infestations of tamarisk and Russian olive. Large-scale removals would be necessary to mitigate the existing adverse effects. However, large-scale removal of tamarisk and Russian olive in over 40 miles of riparian corridor in canyons, however, creates a risk for excessive, adverse, and unpredictable erosion unless an additional study is performed to determine which removal/control techniques are most effective and applicable to Canyon de Chelly National Monument. Alternative A would implement a smaller-scale, detailed adaptive management study to identify which techniques would provided the strongest levels of improvement with the greatest time and cost efficacy. Results from this study would guide the development and implementation of a larger "Tamarisk and Russian olive Management Program" at Canyon de Chelly National Monument.

Alternative A would have short-term, minor to moderate, adverse impacts to soil resources due to heavy equipment use and as streambanks undergo an increase rate of lateral erosion in creating a more stable, and sustainable, stream channel condition. These impacts would include minor to moderate losses of smaller sections of currently farmable land areas. Additionally, a minor potential for adverse impacts resulting from soil contamination from herbicide overspray or drip also exist under alternative A. However, the herbicides proposed for use break down readily in the soil, forming non-toxic salts that are readily degraded by soil microorganisms. Soil erosion would also be temporarily increased due to losses of canopy cover, and greater soil exposure, in tamarisk and Russian olive removal locations. All short-term impacts would be minimized through use of the identified mitigation measures (see section 2.2.6).

There may be some losses to farmable areas that are associated more immediate to existing channelized sections of streambanks, however, alternative A would ultimately provide a stream channel that is more natural and stable in structure and function. Any losses of farmable land would remain far below the level of losses that would occur under a no-action alternative. Alternative A would reduce future adverse impacts and soil losses and create a more sustainable condition for soil resources on the floor of the canyon. Long-term impacts under this alternative would be beneficial and of moderate intensity.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims (which include logging, grazing, and agricultural practices) have significantly affected erosion in the monument. Currently, these resources continue to be impacted by unnatural levels of erosion due to the extensive presence of tamarisk and Russian olive and by unregulated livestock grazing and vehicle use. These unregulated activities, and continued expansion by invasive non-native plant species, have accelerated erosion by water and wind, resulting in high levels of soil loss and creation of sections of highly incised stream channels that make it difficult to irrigate agricultural fields. Numerous areas of cultural resources have also been impacted by accelerated water and wind erosion of soil resources. Natural aggradations of new sediments into the canyon systems remain limited due to the presence of upstream dams (Tsaile and Wheatfield).

Although alternative A cannot address, or alleviate, all human-related impacts to soil resources, the large-scale control of tamarisk and Russian olive identified under this alternative would be long-term and beneficial. Alternative A would also assist in creating conditions that would contribute significantly to generating long-term sustainability of canyon-bottom systems at the national monument.

Conclusion. Alternative A would provide long-term, beneficial effects to soil resources of moderate intensity. Although alternative A cannot address, or alleviate, all human-related impacts to soil resources, the control of extensive infestations of tamarisk and Russian olive as identified by this alternative, would provide a significant contribution in creating conditions that would favor more sustainable conditions for soil resources on the floor of the canyon.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

***Effects of the Environmentally Preferred Alternative (Alternative B)**:*

Analysis. Alternative B would have similar short-term, minor to moderate, adverse impacts to soil resources as alternative A. Although no heavy equipment would be used under Alternative B, short-term adverse increases in soil erosion would occur as streambanks undergo an increase rate of lateral erosion in creating a more stable, and sustainable, stream channel condition.

Since activities under alternative B rely entirely on stump cutting followed by herbicide application and/or on low-volume basal spray of herbicide on smaller diameter trees, there is an increased chance of adverse impacts to soil resources as a result of herbicide overspray or drip. Potential for soil contamination under actions identified in alternative B would be negligible to minor, since herbicide applications would be very targeted and adverse impacts would be minimized through use of the identified mitigation measures (see section 2.2.6). Also, in soil environments, the ester and amine salt formations associated with the proposed types of herbicides rapidly neutralize into relatively non-toxic salts that are degraded by soil microorganisms.

Similar to alternative A, alternative B would have long-term, beneficial effects of moderate intensity. However, this alternative is labor intensive and would require a longer timeframe to achieve. Some soil resources could suffer additional adverse impacts as a consequence of the extended timeframe needed to treat and remove tamarisk and Russian olive infestations.

Cumulative Impacts. Cumulative impacts are similar to those identified for Alternative A. Alternative B would provide long-term, beneficial effects to soil resources of moderate intensity. These benefits would be realized over a longer timeframe due to the labor intensiveness of activities defined in alternative B. As a result, some soil resources could suffer additional adverse impacts as a consequence of the extended timeframe needed to treat and remove tamarisk and Russian olive infestations.

Conclusion. Alternative B would provide long-term, beneficial effects to soil resources of moderate intensity. Similar to alternative A, alternative B cannot address, or alleviate, all human-related impacts to soil resources. However, the control of extensive infestations of tamarisk and Russian olive as identified by this alternative, would provide a significant contribution in creating conditions that would favor more sustainable conditions for soil resources on the floor of the canyon.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Under alternative C, there would be short-term, minor to moderate, adverse impacts to soil resources as result of increases in stream channel lateral erosion and loss of canopy cover in association with tamarisk and Russian olive removals. Although lateral streambank erosion would be minimized by root systems being left in place, the presence of these root systems combined with the limited use of this treatment alternative to "non-sensitive" locations, minimizes any benefits achieved under alternative C. Since this alternative could not be applied to the entire canyon floor, unstable stream channels would remain, leaving the canyon-bottom environments prone to unnatural rates of soil erosion. There would be no potential for adverse impact to soil resources as a result of herbicide use under alternative C. Negligible to minor, long-term benefits may be realized in localized treatment areas, but soil resources overall would continue to suffer long-term, adverse effects of moderate intensity throughout most of the canyon floor.

Cumulative Impacts. Cumulative impacts are similar to those identified for alternative A. But, because alternative C would only address "non-sensitive" sections of the canyon floor, any long-term, benefits would be minimal and restricted to treated sections of the canyon-bottom riparian corridors. Excessive and unnatural rates of soil erosion would continue throughout most of the canyon floor, including further erosion of agricultural lands. Tamarisk and Russian olive infestations would continue to expand, creating additional adverse impacts (erosion, salt-deposition) to soil resources. Under alternative C, long-term impacts to soil resources would remain negative and of moderate intensity throughout most of the canyon-bottom.

Conclusion. Although some negligible to minor beneficial effects would occur to soil resources within treated sections of the canyon floor, the limited applicability of actions identified under alternative C (restricted to "non-sensitive" locations) would allow the continuation of long-term, adverse impacts of moderate intensity throughout the majority of canyon-bottom habitats.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Under alternative D, there would be short-term, moderate, adverse impacts to soil resources as result heavy equipment use, increases in stream channel lateral erosion, and loss of canopy cover in association with tamarisk and Russian olive removals. Soil loss due to lateral streambank erosion would be greater under alternative D since soil stabilizing root systems would be removed. Similar to alternative C, alternative D would be limited in its application and would be restricted to "non-sensitive" locations. Since this alternative would not be applied to the entire canyon floor, unstable stream channels would remain, leaving the canyon-bottom environments prone to unnatural rates of soil erosion. There would be no potential for adverse impact to soil resources as a result of herbicide use under alternative D. Localized, negligible to minor, long-term benefits may be realized in treatment areas, but soil resources overall would continue to suffer long-term, adverse effects of moderate intensity throughout most of the canyon floor.

Cumulative Impacts. Cumulative impacts are similar to those identified for alternative A. But, because alternative D would only address "non-sensitive" sections of the canyon floor, any long-term, benefits would be minimal and restricted to treated sections of the canyon-bottom riparian corridors. Excessive and unnatural rates of soil erosion would continue in untreated areas, including further erosion of agricultural lands. Tamarisk and Russian olive infestations would continue to expand, creating additional adverse impacts (erosion, salt-deposition) to soil resources. Under alternative D, long-term impacts to soil resources would remain negative and of moderate intensity throughout most of the canyon floor.

Conclusion. Although some negligible to minor beneficial effects would occur to soil resources within treated sections of the canyon-bottom, the limited applicability of actions identified under alternative D (restricted to "non-sensitive" locations) would allow the continuation of long-term, adverse impacts of moderate intensity throughout the majority of canyon-bottom habitats.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.6 Geomorphological Processes

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The extensive presence of tamarisk and Russian olive add to the existing unstable and unnatural channel conditions. Implementation of a no-action alternative would allow for a continued spread of tamarisk and Russian olive further adding to conditions of channel instability, primarily through excessive channel incision throughout the main channel reaches of canyon de Chelly and Canyon del Muerto. These channel incisions would also eventually begin to create unnatural erosion and incision within smaller drainages associated with side-canyon areas within the park.

Cumulative Impacts. Although erosion and shifts in stream flows within the canyons are partly due to natural processes, human activities in the watershed and along the canyon rims, including logging, grazing, and agricultural practices have significantly affected stream geomorphology and channel erosion in the monument. Channel erosion has been exacerbated by past and present grazing of horses, sheep, goats and cattle, the invasion of non-native plant species such as salt cedar and Russian olive (which have shaded out understory plants that bind the soil and help to stabilize stream banks), roads in the canyons, and the construction of the Tsaile and Wheatfield Dams upstream of the monument (which altered peak flows in the canyons, enabled vegetation to confine channels, and may have increased the erosive potential of the flows). In the past, local residents have noted that water releases from the dams have caused notable erosion.

Although stream bank erosion control efforts, initiated in the 1930s, have been successful in places, such as at White House Ruins and Antelope House Ruins where water control gabions were installed, most attempts, especially those involving tamarisk and Russian olive plantings, have not proven successful and have further contributed to the unstable conditions of canyon-bottom riparian corridors. Channel erosion along the stream beds continues to threaten agricultural fields, historic structures, and archaeological sites along the floor of Canyon de Chelly, Canyon del Muerto, and their tributary canyons. None of these circumstances would be improved under the no-action alternative.

Conclusion. The no-action alternative would have moderate, long-term, adverse impacts on the stream channel geomorphology at Canyon de Chelly National Monument and would contribute to additional loss of agricultural fields, historic structures, and archaeological sites along the floor of Canyon de Chelly, Canyon del Muerto, and their tributary canyons.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

.***Effects of the Preferred Alternative (Alternative A):***

Analysis. Implementation of either the "preferred" (alternative A) would have the greatest application and long-term benefit to the main canyon channels within Canyon de Chelly and Canyon del Muerto. Alternative A identifies management options that are applicable to the largest areas of tamarisk and Russian olive infestations within the park and, thus, would allow for the greatest restoration of more natural channel geomorphological processes. Alternative A could, however, have minor to moderate short-term, adverse impacts as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums.

Cumulative Impacts. Alternative A would provide long-term, moderate, beneficial effects to canyon-bottom stream channels through the removal of large and expansive infestations of tamarisk and Russian olive. Although removal activities would not correct all historic and current impacts to natural channel geomorphologies created by human activities in the watershed (logging, grazing, agricultural practices, dams), there would be significant long-term improvements as a result of implementation of tamarisk and Russian olive management within the canyon-bottom habitats. This alternative would provide the best opportunity to define removal techniques most applicable and effective, on a large scale and within the multiple conditions that exist at Canyon de Chelly NM and provides the best opportunity for facilitating additional awareness and development of a more appropriate integrated management of stream channel resources within the park.

Conclusion. There would be minor to moderate short-term, adverse impacts as a result of initial channel widening and streambank erosion while the stream channels attempts to re-establish more natural stream channel equilibriums. However, alternative A provides the strongest opportunity for long-term sustainability of canyon stream channel processes and protection of associated resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

***Effects of the Environmentally Preferred Alternative (Alternative B)**:*

Analysis. Implementation of the "environmentally preferred" alternative (alternative B) would have similar large-scale application and long-term benefits to the main canyon channels within Canyon de Chelly and Canyon del Muerto. However, use of management actions identified in alternative B would be labor intensive and would require a much longer timeframe (8-10 years) to fully match the restoration and benefits to stream channel geomorphological processes as identified under Alternative A. Alternative B would have minor to moderate short-term, adverse impacts as a result of

initial channel widening and streambank erosion while the stream channels attempts to re-establish a more natural stream channel equilibrium.

Cumulative Impacts. There would be both direct and indirect cumulative impacts of the environmentally preferred alternative on stream channel geomorphology at Canyon de Chelly National Monument. Similar to alternative A, the environmentally preferred alternative would not correct all historic and current impacts to natural channel geomorphology created by human activities in the watershed. However, alternative B would contribute (over a longer timeframe) to significant long-term improvements as a result of implementation of tamarisk and Russian olive management within the canyon-bottom habitats. Alternative B would also contribute to the facilitation increased awareness of human impacts to stream geomorphology and to the development of more appropriate integrated management actions for stream channel resources within the park.

Conclusion. There would be short-term, minor adverse impacts but long-term, moderate beneficial impacts to stream channel geomorphology under Alternative B. Long-term cumulative effects would be beneficial and moderate intensity. However, maximum benefits would require a much longer timeframe to achieve due to the labor intensiveness of the activities identified under alternative B.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

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Analysis. Alternative C involves the use of heavy equipment to remove above ground portions of tamarisk and Russian olive. Actions under alternative C would create short-term, minor adverse impacts due to increases in channel lateral erosion within treated areas. However, lateral erosion would be partially mitigated by bank stabilizing functions of the remaining root systems. Alternative C would be restricted to use in "non-sensitive" areas, greatly diminishing the potential for large-scale beneficial effects. Unnatural levels of channel incision would continue in untreated areas, minimizing any benefits to stream geomorphology from tamarisk and Russian olive removals. Although some temporary minor beneficial effects may occur in treated areas, beneficial impacts are not likely to be sustainable in the long-term, since stream channel stability is not being addressed throughout the entire riparian corridors. Continued channel deterioration would likely occur throughout the majority of the riparian corridors within Canyon de Chelly and Canyon del Muerto as a result of the more restrictive use of this ground disturbing treatment alternative.

Cumulative Impacts. Alternative C would not mitigate other human-related impacts to stream geomorphology within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread throughout from untreated areas, resulting in long-term, adverse impacts as identified for the no-action alternative. Lack of visual improvements and measurable results would likely reduce the opportunity for development of more integrated strategies to address overall management of stream geomorphic processes.

Conclusion. Some negligible to minor beneficial effects may result in treatment locations under alternative C. However, tamarisk and Russian olive would continue to spread. Long-term, adverse impacts to stream geomorphology, of moderate intensity, would continue throughout most of the canyon-bottom environments.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D involves the use of only heavy equipment to remove above and below ground portions of tamarisk and Russian olive. Actions under Alternative D would create short-term, minor to moderate adverse impacts to stream channel conditions due to temporary increases in channel lateral erosion within treated areas. Alternative D would be restricted to use in "non-sensitive" areas, greatly diminishing the potential for large-scale beneficial effects. Unnatural levels of channel incision would continue in untreated areas, minimizing any benefits to stream geomorphology from tamarisk and Russian olive removals. Although some temporary minor beneficial effects may occur in treated areas, beneficial impacts are not likely to be sustainable in the long-term, since stream channel stability is not being addressed throughout the entire riparian corridors. Continued channel deterioration would likely occur throughout the majority of the riparian corridors within Canyon de Chelly and Canyon del Muerto as a result of the more restrictive use ("non-sensitive" locations) of this ground disturbing treatment alternative.

Cumulative Impacts. Alternative D would not mitigate other human-related impacts to stream geomorphology within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread throughout from untreated areas, resulting in long-term, adverse impacts as identified for the no-action alternative. Lack of visual improvements and measurable results would likely reduce the opportunity for development of more integrated strategies to address overall management of stream geomorphic processes.

Conclusion. Some negligible to minor beneficial effects may result in treatment locations under alternative D. However, tamarisk and Russian olive would continue to spread. Long-term, adverse impacts to stream geomorphology, of moderate intensity, would continue throughout most of the canyon-bottom environments.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.7 Prime and Unique Farmlands

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The aggressive spread of tamarisk and Russian olive would continue under the no-action alternative. Deterioration of canyon-bottom farmlands would continue as a result of direct invasion by these invasive species, increased soil contamination through salt deposition by tamarisk, and reduced groundwater levels due to the exceptionally high water use and evaporation by tamarisk. Irrigation would become more difficult over a wider area of the canyon floor as the presence of tamarisk and Russian olive continue to create lowered stream channels as a result of unnatural levels of incision. Additional farmable land would be lost due to unnatural erosion. Under the no-action alternative short- and long-term impacts would be adverse and of moderate intensity.

Cumulative Impacts. Agricultural use of lands within Canyon de Chelly National Monument has been carried on continually from ancient times to present day. Cultivation has decreased by almost half over the last few decades. Tamarisk and Rusian olive spread has played a significant role in this decline. Although high erosion rates are natural for the soil and stream channel types at Canyon de Chelly National Monument, the aggressive expansion of tamarisk and Russian olive from their historic plantings have created highly unstable and unnatural erosion rates. These unnatural rates of erosion and impacts to farmable lands within canyon-bottom habitats are further supported by upstream, external dam impoundments (Tsaile and Wheatfield), unregulated livestock grazing and ungregulated vehicle use.

The explosive spread of tamarisk and Russian olive would continue under the no-action alternative further exacerbating existing direct adverse impacts (increases in farmable land area occupied by tamarisk and Russian olive, salt-deposition to soils, lowered groundwater levels, unnatural rates of land erosion) and indirect (increased difficulties with irrigation, difficulties in manuvering vehicles on the canyon floor, limited area

available for livestock use) impacts to the unique farmlands of Canyon de Chelly National Monument. Long-term sustainability of exiting farmable areas would remain jeopardized under the no-action alternative.

Conclusion. Although several human-related disturbances contribute to unnatural rates of land erosion and to the long-term sustainability of the unique farmlands of Canyon de Chelly National Monument, by far the extensive presence of tamarisk and Russian olive has created the most distinct adverse impacts. The no-action alternative would result in continued spread of these species, creating long-term, adverse impacts of moderate intensity to the farmlands associated canyon-bottom environments.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

A**nalysis.** Short-term, adverse impacts to unique farmlands would occur under preferred alternative. These temporary impacts would include some minor to moderate loss of farmable land within tamarisk and Russian olive removal locations as stream channels attempt to develop a more natural (meandering versus channelized) condition, increasing lateral streambank erosion. Restoration of native vegetation, as appropriate (some stream sections are naturally without vegetation), would assist in mitigating (but not preventing) farmable land losses. Minimal potential for adverse impacts to farmable lands exist as a result of herbicide overspray or drip. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to farmlands.

Activities identified under alternative A would provide the park with the needed information and tools to implement effective, large-scale tamarisk and Russian olive removals throughout the canyon-bottom habitats, significantly reducing the direct and indirect impacts identified under the no-action alternative. Tamarisk and Russian olive spread would halt and most areas of current infestation, unless associated with a species of special concern (see section 3.3.8), would be mitigated or fully restored. Impacts to farmable lands created by salt deposition, lowered groundwater and unnatural levels of land erosion would also be mitigated by actions identified under the preferred alternative. Long-term impacts would be beneficial to prime or unique farmlands, and of moderate intensity.

Cumulative Impacts. Direct and indirect impacts to farmable lands, created by other human-related disturbances (external dams, unregulated livestock and vehicle uses) would remain under alternative A. However, the management of tamarisk and Russian olive would provide mitigation to the largest immediate threat to farmable lands and

would assist in facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative A would be beneficial and of moderate intensity. Implementation of the preferred alternative (alternative A) affords the strongest level of protection to farmable lands within the canyon-bottom habitats and provides the greatest opportunity for facilitating a more integrated and sustainable approach in managing agricultural resources on the floor of the canyon.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

***Effects of the Environmentally Preferred Alternative (Alternative B)**:*

Analysis. Short-term, adverse impacts, of minor to moderate intensity, would occur under the environmentally preferred alternative. No heavy equipment would be used under this alternative. Temporary impacts resulting from tamarisk and Russian olive would be similar to those described for the above preferred alternative (Alternative A). Some loss of farmable lands, adjacent to channelized sections of stream channels, would occur as lateral streambank erosion takes place to re-establish a more natural and sustainable channel condition. Restoration of native vegetation (in treatment locations), as appropriate, would assist in mitigating (but not preventing) losses to farmable lands.

Since Alternative B would rely completely on the use of herbicide applications (cut stumps or low volume basal spray) potential for negligible to minor impacts to farmable lands as a result of herbicide overspray or drip could occur. Herbicide applications, however, would be distinctly targeted, greatly minimizing the potential for adverse impact. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to farmlands.

As with alternative A, alternative B would have long-term beneficial effects of moderate intensity. The environmentally preferred alternative is labor (and cost) intensive, relying completely on chainsaw and hand work. As such, it would require a much longer timeframe (up to 10 years) to achieve similar results as with alternative A. Some additional adverse impact(s) to farmable lands could occur as a result of the extended timeframe necessary to fully implement alternative B.

Cumulative Impacts. Alternative B would not mitigate all human-related disturbances to unique farmlands, but this alternative would provide management actions necessary to mitigate the largest immediate threat to this resource – tamarisk and Russian olive

infestation. Similar to alternative A, the environmentally preferred alternative is likely to assist in developing more integrated management strategies throughout the canyon-bottom environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative B would be beneficial and of moderate intensity. Implementation of the this alternative affords strong protection to farmable lands located on the canyon floor, and provides the opportunity for facilitating a more integrated and sustainable approach in managing canyon-bottom agricultural resources. Alternative B, though similar to Alternative A in its beneficial effects, would require a much longer timeframe to fully implement.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would rely solely on heavy equipment to remove above ground portions of tamarisk and Russian olive. Short-term, adverse impacts of minor to moderate intensity would occur as a result of heavy equipment use and as lateral streambank erosion increases at treated locations. Lateral erosion would be somewhat mitigated by the remaining presence of root systems that would serve to stabilize streambanks. Re-vegetation with native species in treatment locations, as appropriate, would also assist in minimizing (but not in preventing) undesirable bank erosion.

Although, there would be some longer-term benefits to unique farmlands in association with treatment locations, alternative C would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Additionally, the remaining root systems have potential to re-sprout, minimizing long-term benefits in treatment locations. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative C would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater levels. Farmable land would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative C would not mitigate other human-related disturbances that currently impact unique farmlands. Some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, but these benefits would be jeopardized by potential re-sprouting from remaining root systems. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative C would be less likely to assist in facilitating integrated management strategies for developing sustainable agriculture at Canyon de Chelly National Monument.

Conclusion. Limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of farmable land associated with canyon-bottom habitats would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would rely solely on heavy equipment to remove above ground and below ground portions of tamarisk and Russian olive. Short-term, adverse impacts of minor to moderate intensity would occur as a result of heavy equipment use, increased ground disturbance from root system removals, and as lateral streambank erosion increases at treated locations. Re-vegetation with native species in treatment areas, as appropriate, would also assist in minimizing (but not in preventing) undesirable bank erosion. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to farmlands.

Although, there would be some longer-term benefits to unique farmlands in association with treatment locations, alternative D would be applicable for use only in areas identified as being "non-sensitive." This restricted use would allow for the continued spread of tamarisk and Russian olive throughout most of the canyon-bottom habitats. Additionally, the remaining root systems have potential to re-sprout, minimizing longer-term benefits in treatment locations. Most direct and indirect adverse effects created by the presence of tamarisk and Russian olive would remain in untreated areas.

Since alternative D would be fairly limited in application ("non-sensitive" locations), it is unlikely that the limited areas of tamarisk and Russian olive removals would have any effect on existing unnatural rates of stream channel incision and/or lowered groundwater

levels. Farmable land would continue to be adversely impacted as described under the no-action alternative for most of the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact unique farmlands. Some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative D would be less likely to assist in facilitating integrated management strategies for developing sustainable agriculture at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations. The majority of farmable land associated with canyon-bottom habitats would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.8 Water Resources

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. There would be both direct and indirect impacts to water quality and quantity under the no-action alternative. Tamarisk and Russian olive are high water uses species. Tamarisk especially has a root system that is capable of tapping into ground water. Increased spread of tamarisk and Russian olive in canyon riparian corridors would continue to reduce water quantity over the short- and long-term and would alter natural drainage patterns. Water quality would continue to decline as salt-depositing tamarisk creates excessive soil salinity which would additionally impact the quality of both surface and groundwaters. Additionally, surface water flows would continue to contain unnaturally high levels of sediments due to excessive erosion created by tamarisk and Russian olive would be adverse and of moderate intensity.

Cumulative Impacts. Unnatural water flow and erosion have been major problems in the monument along the canyon floor. Under natural conditions, the geology and soils of the canyon habitats would support high erosion rates and rapid heavy flows of water from

the canyon rims and from areas upstream of the monument, and would continually shift the water courses within the canyons. However, distinct human-related disturbances have resulted in unnatural (often channelized) water flows through the canyons, resulting in severe bank cutting and downcutting of the stream beds and to unnaturally high levels of erosion of the lands on the canyon floor. Current and historic disturbances that impact water resources in the canyon include logging along canyon rims, grazing, and various agricultural practices. The canyon-bottom also contains hundreds of vehicle, pedestrian, and livestock trails which also contribute to unnatural drainage and water flow.

The two most contributing, human-related disturbances to existing adverse conditions of canyon water resources are the up-stream Tsaile and Wheatfield dams, and the historic planting (and continued expansion) of tamarisk and Russian olive. Altered water flows have allowed for the establishment and spread of tamarisk and Russian olive. The presence of these species has resulted in severe channel incisions and reduced groundwater availability. The ability to irrigate agricultural fields has become difficult, and even impossible, in areas where stream channels have become severely incised. These identified disturbances would not be addressed under the no-action alternative, resulting in long-term, moderate, adverse impacts to water resources.

Conclusion. The no-action alternative would not implement any management of tamarisk and Russian olive. These species would continue to spread to new areas, further degrading the riparian corridors, reducing water quality and quantity, and altering natural water flow conditions. Impacts under the no-action alternative would be long-term, adverse and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. The preferred alternative would use multiple treatment techniques to implement large-scale removals for tamarisk and Russian olive, including chainsaws, heavy equipment and targeted herbicide applications. Short-term, adverse impacts to water resources, of minor to moderate intensity, would result from actions identified under alternative A. Temporary impacts to water quality would include minor potential for groundwater contamination as a result of herbicide overspray or drip. The active ingredients in the herbicides chosen for use (Garlon 3A and Remedy®), however, have very low leeching ability and easily breakdown into ester and amine salts which are non-toxic and rapidly degraded by soil microorganisms. No herbicides would be applied during times of surface water flows. Additional short-term, minor to moderate, adverse impacts to water quality include increases in sediment loads in surface waters due to

ground disturbance from heavy equipment use and increased lateral widening (erosion) of streambanks as stream geomorphology re-establishes a more natural equilibrium. All impacts would be minimized through the use of general mitigation measures as identified in section 2.2.6.

The level and quantity of ground water should improve as large areas of tamarisk are removed. The specific level of improvement is not known due to lack of specific data or research related to groundwater improvements after tamarisk removals. It is likely that this improvement would be measurable. Long-term benefits would include moderate increases in water quantity and quality as large infestations of tamarisk are eliminated.

Cumulative Impacts. Alternative A would directly address one of the most significant sources of adverse impact to canyon-bottom water resources – tamarisk and Russian olive. As a result of large-scale removals of these non-native species, water quality would, temporarily, undergo minor-to moderate adverse effects due to increased sediment loading from equipment use, increased lateral stream bank erosion, and as salts are flushed from soils previously associated with tamarisk infestations. Use of targeted applications of herbicide would minimize the potential for surface or groundwater contamination from herbicide use, yet the potential for short-term, minor impacts still exists.

Direct and indirect impacts to water resources created by other human-related disturbances (external dams, unregulated livestock, and vehicle uses) would remain under alternative A, however the management of tamarisk and Russian olive would provide relief from one of the largest immediate threats to water resources and would assist in facilitating additional innovative approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects resulting from the preferred alternative would be long-term, beneficial, and of moderate intensity.

Conclusion. Short-term, minor to moderate, adverse impacts to water resources would occur as a result of actins identified for alternative A. However, long-term, impacts of the preferred alternative would be beneficial and of moderate intensity. Implementation of this alternative affords the best opportunity for facilitating a more integrated and sustainable approach in managing external and canyon-bottom water resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

***Effects of the Environmentally Preferred Alternative (Alternative B)**:*

Analysis. Alternative B would rely on chainsaw removals with targeted herbicide applications to cut stumps for larger diameter trees and on low-volume basal spray of herbicides for small diameter trees. Short-term, adverse impacts to water resources, of minor to moderate intensity, would result from actions identified under alternative A. The potential from temporary, adverse impacts to water quality as a result of herbicide overspray or drip would be higher under alternative B. These impacts would remain of minor intensity due to the low leeching ability, quick breakdown, and rapid degradation of the herbicides active ingredients by soil microorganisms. No herbicides would be applied during times of surface water flows. Also similar to alternative A, short-term, minor to moderate, adverse impacts to water quality would occur due to increases in sediment loads in surface waters from heavy equipment use and increased lateral widening (erosion) of streambanks. All impacts would be minimized through the use of general mitigation measures as identified in section 2.2.6.

The level and quantity of ground water should improve as large areas of tamarisk are removed. The specific level of improvement, is not known due to lack of specific data or research related to groundwater improvements after tamarisk removals. It is likely that this improvement would be measurable. Long-term benefits would occur under alternative B, including minor to moderate increases in water quantity and quality as large infestations of tamarisk and Russian olive are eliminated. Alternative B is labor intensive, however, and would require a longer timeframe (up to 10 years) to achieve full beneficial effects.

Cumulative Impacts. Alternative B would also result in large-scale removals of tamarisk and Russian olive. Water quality would, temporarily, undergo minor-to moderate, adverse effects due to increased sediment loading from increased lateral stream bank erosion and as salts are flushed from soils previously associated with tamarisk infestations. Negligible to minor potential for groundwater contamination from herbicide use would exist with this alternative, although the use of readily degradeable herbicides and targeted applications would greatly minimize the potential for any surface or groundwater contamination from herbicide use. All adverse impacts from actions identified under alternative B would be of short-duration, but would only temporarily add to already existing adverse impacts to water resources located on or near the canyon floor.

Direct and indirect impacts to water resources created by other human-related disturbances (external dams, unregulated livestock and vehicle uses) would remain under alternative B. The management of tamarisk and Russian olive would provide mitigation to one of the largest immediate threats to water resources and would assist in facilitating additional innovative approaches to mitigating other adverse human-related disturbances to water resources. Long-term, cumulative effects of alternative B would be beneficial and of moderate intensity. A longer-timeframe would be needed (due to the labor intensiveness of this alternative) to obtain maximum benefits to water resources.

Conclusion. Short-term, minor to moderate, adverse impacts to water resources would occur as a result of actions identified for alternative B. Long-term, impacts of the

preferred alternative would be beneficial and of moderate intensity, but would require a longer timeframe to achieve. Implementation of this alternative would similarly provide strong opportunity for facilitating a more integrated and sustainable approach in managing external and canyon-bottom water resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Short-term, adverse impacts to water quality would occur under alternative C due to increased sedimentation from heavy equipment use and from some stream channel widening as more natural geomorphological processes attempt to re-establish in removal areas. There would be no impacts from herbicides to water resources under this alternative. Resprouting of tamarisk and Russian olive from remaining root systems would occur in removal areas. Longer-term, negligible to minor, beneficial effects in treated locations could occur, including lower salt deposition to soil and water and slight improvements to local groundwater levels. However, since this alternative would be restricted to "non-sensitive" areas and not applicable throughout the entire canyon-bottom riparian corridors, tamarisk and Russian olive would continue to spread. Long-term impacts to water resources would be adverse, of moderate intensity, and similar to those identified under the no-action alternative.

Cumulative Impacts. Direct and indirect impacts to water resources created by tamarisk and Russian olive and by other human-related disturbances (external dams, unregulated livestock and vehicle uses) would remain under alternative C. The management of tamarisk and Russian olive would provide minor mitigation to adverse impacts to water resources, but only in very localized areas. Implementation of alternative C would not mitigate or alleviate existing water resource issues. Alternative C would result in very little visual or measurable effects, lessening chances for developing integrated strategies to address other adverse human-related disturbances to water resources within the canyon environments.

Conclusion. Alternative C could result in some beneficial effects to treatment locations, but these effects would be negligible to minor in intensity. Canyon-wide impacts to water resources from tamarisk and Russian olive infestations would not be alleviated. Overall, long-term impacts to water resources would remain adverse and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes

identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Short-term adverse impacts to water quality would occur as a result of increased sedimentation from heavy equipment use and from some stream channel widening as more natural geomorphological processes attempt to re-establish in removal areas. There would be no potential for adverse impact by herbicides under alternative D. Limited tamarisk and Russian olive removals could have some localized negligible to minor, beneficial effects to water quantity or quality, (decreased salinity of soil and water, slight increases in groundwater levels) but these benefits would not be applicable throughout the entire canyon-bottom riparian corridors. Alternative D would be limited to use in "non-sensitive areas" only, allowing tamarisk and Russian olive to spread from non-treated locations. Long-term impacts to water resources in the majority of the canyon-bottom habitats would be adverse and of moderate intensity.

Cumulative Impacts. Direct and indirect impacts to water resources created by tamarisk and Russian olive and by other human-related disturbances (external dams, unregulated livestock and vehicle uses) would remain under alternative D. The management of tamarisk and Russian olive would provide minor mitigation to adverse impacts to water resources, but only in very localized areas. Implementation of alternative D would not mitigate or alleviate existing water resource issues. Alternative D would result in very little visual or measurable effects, lessening chances for developing integrated strategies to address other adverse human-related disturbances to water resources within the canyon environments.

Conclusion. Alternative D could result in some beneficial effects to treatment locations, but these effects would be negligible to minor in intensity. Canyon-wide impacts to water resources from tamarisk and Russian olive infestations would not be alleviated. Overall, long-term impacts to water resources would remain adverse and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.9 Air Quality

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. No long-term impacts to air quality, beyond existing conditions, would result from the no-action alternative. The risk of short-term, adverse impacts to air quality remains high under this alternative due to the increased potential for wildfire as a result hazardous fuel conditions created by dense stands of tamarisk and Russian olive.

Cumulative Impacts. Overall, Canyon de Chelly and the northeast Arizona region do not experience any consistently poor air quality. Localized impacts of relatively minor intensity, currently exist within the canyons as a result of vehicle operations (residential and tour trucks). There may also be limited impacts as a result of utilization of farm equipment and from activities associated with the nearby town of Chinle.

Conclusion. No long-term impacts to air quality, beyond existing conditions, would result from the no-action alternative. However, the no-action alternative runs the highest risk of short-term, moderate adverse impacts due to an increased potential for wildfire.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Short-term, adverse impacts of minor to moderate intensity would result from heavy equipment use under alternative A. Additionally, potential exists for minor, short-term impacts to air quality as a result of herbicide overspray or volatilization. Minor to moderate, increases in air-borne fine particulate matter would occur as a result of tree cutting and mulching. These impacts would be temporary and minimized through use of the general mitigation measures as identified in section 2.2.6. There would be no long-term impacts to air quality as a result of actions identified under alternative A.

Cumulative Impacts. Implementation of the preferred alternative would cause localized, minor to moderate adverse impacts to air quality. Any impacts would be of short duration, but would add to, or improve, existing air quality impacts resulting from residential and park concessionaire vehicle emissions and from pollution associated with the nearby town of Chinle.

Conclusion. The overall impact of the preferred alternative on air quality would be minor, adverse, and short-term. Mitigation measures would be used and likely to be successful at reducing air quality impacts to visitors, park staff, and workers engaged in the treatment efforts. No long-term impacts to air quality, beyond existing conditions, would result from the no-action alternative. There would be no long-term impacts to air quality as a result of actions identified under alternative A.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. The environmentally preferred alternative includes spraying herbicide onto cut tamarisk and Russian olive stumps. There would be localized, short-term, minor effects to the air quality in the treatment area, resulting from increases in fine particulate matter from tree cutting and mulching and from herbicide overspray or volatilization. Mitigation measures as identified in section 2.2.6 would be used to minimize any temporary impacts to air quality. Negligible to minor adverse air quality impacts are expected from chainsaw emissions. There would be no long-term, adverse impacts to air quality as a result of actions identified for alternative B.

Cumulative Impacts. Implementation of alternative B would cause localized, minor to moderate adverse impacts to air quality. Any impacts would be of short duration, but would add to existing air quality impacts resulting from residential and park concessionaire vehicle emissions and from pollution associated with the nearby town of Chinle.

Conclusion. The overall impact of the environmentally preferred alternative on air quality would be minor, adverse, and short-term. Mitigation measures would be used and likely to be successful at reducing air quality impacts to visitors, park staff, and workers engaged in the treatment efforts. No long-term impacts to air quality, beyond exiting conditions, would result from actions identified under alternative B.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. There would be short-term, minor to moderate, adverse impacts to air quality as a result of emissions from heavy equipment and from increases in air-borne fine particulate matter resulting from the cutting and mulching of trees. Mitigation measures as identified in section 2.2.6 would be used to minimize any temporary impacts to air quality. There would be no long-term, adverse impacts to air quality as a result of actions identified for alternative C.

Cumulative Impacts. Implementation of alternative C would cause localized, minor to moderate adverse impacts to air quality. Any impacts would be of short duration, but would add to existing air quality impacts resulting from residential and park concessionaire vehicle emissions and from pollution associated with the nearby town of Chinle.

Conclusion. The overall impact of alternative C on air quality would be minor, adverse, and short-term. Mitigation measures would be used and likely to be successful at reducing air quality impacts to visitors, park staff, and workers engaged in the treatment efforts. No long-term impacts to air quality, beyond existing conditions, would result from actions identified under alternative C.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would result in short-term, moderate, adverse impacts to air quality as a result of heavy equipment emissions, from increased air-borne fine particulate matter from ground disturbance associated with root system removals, and from the cutting and mulching of trees. These impacts would be localized and mitigation measures as identified in section 2.2.6 would be used to minimize any temporary impacts to air quality. There would be no long-term, adverse impacts to air quality as a result of actions identified for alternative D.

Cumulative Impacts. Implementation of alternative D would cause localized, minor to moderate adverse impacts to air quality. Any impacts would be of short duration, but would add to existing air quality impacts resulting from residential and park concessionaire vehicle emissions and from pollution associated with the nearby town of Chinle.

Conclusion. The overall impact of alternative D on air quality would be minor, adverse, and short-term. Mitigation measures would be minor and likely to be successful at reducing air quality impacts to visitors, park staff, and workers engaged in the treatment effort. No long-term impacts to air quality, beyond existing conditions, would result from actions identified under alternative D.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.10 Vegetation

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The no-action alternative would continue the existing trends in tamarisk and Russian olive spread and the loss of native canyon-bottom riparian vegetation. There would be no direct impacts to vegetation as a result of non-native species management. However, the continued spread of tamarisk and Russian olive would have long-term, adverse impacts of moderate intensity to the vegetation resources associated with the riparian corridors and canyon floor, as well as, to smaller drainages and side canyons. Tamarisk and Russian olive would exclude and out-compete native plant species and agricultural crops for valuable resources such as nutrient and water. The presence of tamarisk is further damaging to vegetation due to this species' high level of salt deposition and contamination of soils. Tamarisk and Russian olive would continue to migrate both up and down canyon, with infestations eventually spreading and impacting areas external to the park (e.g. San Juan River, impoundment areas associated with Tsaile and Wheatfield dams). This aggressive spread of tamarisk and Russian olive has been observed in numerous riparian areas throughout the southwestern United States. A constant source of seed would remain available in the park's riparian corridor. There would by both short- and long-term, adverse impacts of moderate intensity to the vegetation resources under the no-action alternative.

Cumulative Impacts. There would be no new impacts to vegetation under this alternative. On-going adverse impacts to vegetation resources would continue due to unnatural rates of soil erosion and as a result of direct trampling/consumption associated with current conditions of unregulated livestock grazing and vehicle use.

Agricultural practices persist within the canyons on a subsistence basis. Crops include corn, squashes, alfalfa, apricots, apples and peaches. Sheep, goats and cattle are grazed,

with reports of cattle interests above the rim of the canyon pressing for greater allowances for their cattle to roam canyon areas. Range conditions within the canyon-bottom habitats are currently considered in poor to fair condition, having been exposed to historic events of overgrazing. No estimates for grazer carrying capacity within canyon-bottom habitats have been established to date.

Currently, there is extensive use of the canyon floor by various types of vehicle traffic. This traffic is primarily restricted to canyon residents, tour trucks operated by the park concessionaire, and vehicles used by park staff. There are no designated vehicle use routes on the canyon floor, leaving vehicle operators to their own discretion as to the path followed in many areas. The presence of dense thickets of tamarisk and Russian olive, which forces vehicles onto alternate paths, has distinctly contributed to continued impacts to vegetation resources located on the canyon floor. As areas infested by these species fill in, they create either direct physical blocks to vehicle use or excessive soil erosion. Both of these resulting conditions stimulate the creation of new vehicle paths and, thus, new impacts to vegetation resources. The no-action alternative would do nothing to resolve current cumulative impacts to vegetation resources. As a result, long-term effects under the no-action alternative would be adverse and of moderate intensity.

Conclusion. Under the no-action alternative there would be no direct impacts to vegetation as a result of tamarisk and Russian olive removals. However, there would be continued spread of these aggressive, nonnative species resulting in long-term, adverse impacts, of moderate intensity to native plant communities and agricultural crops. The cumulative effect of the no-action alternative on vegetation resources, in combination with other past, present, and reasonably foreseeable future actions, would be adverse, and of moderate intensity throughout the majority of canyon-bottom riparian habitats.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Under the preferred alternative, there would be short-term, adverse impacts, of minor to moderate intensity to vegetation resources within treatment areas. These impacts would include negligible to minor impacts resulting from herbicide overspray or drip onto non-targeted vegetation, minor to moderate vegetation losses due to heavy equipment use while accessing treatment sites, and minor trampling by removal crews. Work limits would be clearly defined under alternative A to minimize impacts to non-targeted vegetation. There would be no impacts to agricultural crops. Re-vegetation with native species in treatment areas, as appropriate, would be used to mitigate impacts to no-

targeted vegetation. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to vegetation resources.

Non-native tamarisk and Russian olive can out-compete native plant species and create an environment in which native species cannot regenerate. Existing infestations of these species are dense and widespread throughout the middle sections of Canyon de Chelly and Canyon del Muerto, requiring large-scale removals to mitigate the current adverse direct and indirect impacts created by these species. Under alternative A, a variety of removal/treatment methodologies would be tested for their efficacy and then implemented, as appropriate, for removal of the existing large-scale infestations of tamarisk and Russian olive. This alternative has been identified as preferred since it would result in the highest level of removals of tamarisk and Russian olive (except for areas identified as critical to species of special concern) throughout the canyon floor corridors.

Although seed propagules would remain after removals, most actions needed to control new seedlings would be achievable with hand-pulling or minor herbicide applications. Removal of tamarisk and Russian olive throughout most of the riparian corridors would allow for natural re-establishment or active restoration of native vegetation, increasing the overall biological diversity and health of vegetation resources. Alternative A would provide both short- and long term beneficial effects of moderate intensity.

Cumulative Impacts. On-going adverse impacts to vegetation resources would continue as a result of direct trampling/consumption associated with current conditions of unregulated livestock grazing and vehicle use. However, removal of dense stands of tamarisk and Russian olive would remove or mitigate existing physical barriers and greatly assist in delineating more distinct vehicle routes, and reducing on-going impacts to vegetation from multiple vehicle paths. Although alternative A would not resolve all human-related impacts to vegetation resources, the distinct visual improvements and increased functionality of the canyon floor would likely facilitate the strongest opportunity to develop integrated management strategies to improve long-term sustainability of canyon-bottom vegetation resources.

Alternative A would have no adverse impacts to agricultural crops. Tamarisk and Russian olive removals as proposed under the preferred alternative would result in conditions that would enhance (and possibly expand) current agricultural uses of the canyon floor. Alternative A would result in long-term, beneficial cumulative effects, of moderate intensity.

Conclusion. Although the preferred alternative would have short-term, minor to moderate, adverse effects on limited areas of vegetation resources, long-term impacts of alternative A would be beneficial and of moderate intensity. Implementation of the preferred alternative affords the strongest level of protection to vegetation resources through the direct removal of most existing infestations of tamarisk and Russian olive (and containment from any future spread) and by providing the greatest opportunity for

facilitating a more integrated and sustainable approach in managing canyon-bottom vegetation resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Alternative B would result in short-term, negligible to minor, adverse impacts resulting from herbicide overspray or drip onto non-targeted vegetation and in minor impacts to non-targeted vegetation resources as a result of trampling by removal crews. There would be no impacts to vegetation as a result of heavy equipment use under the environmentally preferred alternative. Work limits would be clearly defined under alternative B to minimize impacts to non-targeted vegetation. There would be no impacts to agricultural crops. Re-vegetation with native species in treatment areas, as appropriate, to mitigate impacts to no-targeted vegetation. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to vegetation resources.

Similar to the above preferred alternative, alternative B would result in extensive removals of tamarisk and Russian olive throughout most of the canyon-bottom corridors, resulting in long-term beneficial effects of moderate intensity. Actions under alternative B, however, are more labor and cost intensive requiring a greater length of time (up to 10 years and assuming funding remains available throughout this timeframe) to achieve. This longer timeframe would allow for some additional spread of tamarisk and Russian olive and continuation of some of the direct and indirect impacts associated with these species until removal actions could "catch-up". Similar to alternative A, the environmentally preferred alternative would result in long-term beneficial effects of moderate intensity.

Cumulative Impacts. Similar to cumulative effects defined under alternative A, on-going adverse impacts to vegetation resources would continue as a result of direct trampling/consumption associated with current conditions of unregulated livestock grazing and vehicle use. The environmentally preferred alternative would not have impacts to vegetation resources as a result of heavy equipment use. Large-scale removal of existing, dense stands of tamarisk and Russian olive would occur under the environmentally preferred alternative, but these removals would require a longer timeframe to achieve and could be more prone to funding delays than alternative A. Alternative B would not resolve all current human-related impacts to vegetation resources, but the resulting visual improvements and increased functionality of sections of the canyon floor would likely facilitate additional opportunities to develop integrated

management strategies to improve long-term sustainability of canyon-bottom vegetation resources.

Alternative B would have no adverse impacts to agricultural crops. Tamarisk and Russian olive removals as proposed under this alternative would similarly result in conditions that would enhance (and possibly expand) current agricultural uses of the canyon floor. Alternative B would result in long-term, beneficial cumulative effects, of moderate intensity.

Conclusion. Alternative B would have short-term, minor, adverse effects on limited, non-targeted areas of vegetation resources as a result of herbicide overspray or drip. Additionally, the labor intensiveness of this alternative would allow for some continued spread of tamarisk and Russian olive until removal efforts could "catch-up". However, alternative B would result in eventual large-scale removal and containment of tamarisk and Russian olive along the entire canyon floor. Implementation of the preferred alternative affords strong protection to vegetation resources and provides additional opportunity for facilitating a more integrated and sustainable approach in managing canyon-bottom vegetation resources. Long-term impacts of the environmentally preferred alternative would be beneficial and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would use heavy equipment to remove the above ground portions of tamarisk and Russian olive. There would be no herbicide use under alternative C. Short-term, minor to moderate, adverse impacts would occur to non-targeted vegetation resources as a result of vegetation losses due to heavy equipment use while accessing treatment sites and minor trampling by removal crews. Work limits would be clearly defined under alternative C to minimize impacts to non-targeted vegetation. There would be no impacts to agricultural crops. Re-vegetation with native species in treatment areas, as appropriate, would be used to mitigate impacts to no-targeted vegetation. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to vegetation resources.

Application of actions identified under alternative C would be restrictive and limited to use only in areas identified as "non-sensitive". As a result, removal activities would occur on a smaller-scale and would not be applied to the entirety of the canyon floor. While some short- and relatively longer term minor benefits would occur to vegetation resources in removal locations, resprouting of tamarisk and Russian olive from remaining

root systems and re-infestation from surrounding untreated areas would result in conditions that would not allow for sustainable benefits over the long-term. Additionally, tamarisk and Russian olive would continue to spread into new locations from untreated locations, resulting in long-term, moderate adverse impacts, similar to those identified for the no-action alternative.

Cumulative Impacts. Alternative C would not mitigate other human-related impacts to vegetation resources within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread from untreated areas, resulting in long-term, adverse impacts similar to those identified for the no-action alternative. Lack of visual improvements and measurable results would likely minimize any opportunity for development of more integrated strategies to address overall management of canyon-bottom vegetation resources.

Conclusion. Some negligible to minor beneficial effects may result in treatment locations under alternative C. However, tamarisk and Russian olive would continue to spread. Long-term, adverse impacts to vegetation resources, of moderate intensity, would continue throughout most of the canyon-bottom environments.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would use heavy equipment to remove the above and below ground portions of tamarisk and Russian olive. There would be no herbicide use under alternative D. Short-term, minor to moderate, adverse impacts would occur to non-targeted vegetation resources as a result of vegetation losses due to heavy equipment use while accessing treatment sites and minor trampling by removal crews. Work limits would be clearly defined under alternative D to minimize impacts to non-targeted vegetation. There would be no impacts to agricultural crops. Re-vegetation with native species in treatment areas, as appropriate, would be used to mitigate impacts to no-targeted vegetation. Additionally, all general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to vegetation resources.

Application of actions identified under alternative D would be, similarly, restrictive and limited to use only in areas identified as "non-sensitive". As a result, removal activities would occur on a smaller-scale and would not be applied to the entire canyon floor. While some short- to relatively longer term minor benefits would occur to vegetation resources in removal locations, the potential for re-infestation from surrounding untreated areas would remain high. There would be no resprouting of tamarisk and Russian olive

since root systems would be removed under this alternative. However, propagules from the soil seed bank would result in new seedlings and need for additional follow-up hand removal activities. Additionally, tamarisk and Russian olive would continue to spread into new areas from untreated locations, resulting in long-term, moderate adverse impacts, similar to those identified for the no-action alternative.

Cumulative Impacts. Alternative D would not mitigate other human-related impacts to vegetation resources within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread from untreated areas, resulting in long-term, adverse impacts similar to those identified for the no-action alternative. Lack of visual improvements and measurable results would likely minimize any opportunity for development of more integrated strategies to address overall management of canyon-bottom vegetation resources.

Conclusion. Some negligible to minor beneficial effects may result in treatment locations under alternative D. However, tamarisk and Russian olive would continue to spread from untreated locations. Long-term, adverse impacts to vegetation resources, of moderate intensity, would continue throughout most of the canyon-bottom environments.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.11 Wildlife

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis: Under the No-Action Alternative, there would be no direct impacts to wildlife; however, the spread of tamarisk and Russian olive at the complete exclusion of the diverse native flora could cause numerous long-term indirect impacts. Despite some wildlife species continued use of the exotic thickets, loss of habitat diversity will ultimately lead to an overall decrease in the wildlife diversity within the park. Therefore, the long-term impacts of the No-Action Alternative on wildlife at Canyon de Chelly would be adverse and moderate in intensity.

Cumulative Impacts: There would be no new direct cumulative impacts on wildlife under the No-Action Alternative. However, past and current land-use practices in the southwest including unregulated grazing and diversion of water for agriculture have severely impacted the regional natural habitats and processes resulting in a loss of habitat

diversity. Therefore, protected areas such as Canyon de Chelly serve an important role in preserving diverse wildlife habitat. The cumulative impact of the No-Action Alternative on wildlife in the proposed treatment area and on nearby lands would be long-term, adverse, and moderate in intensity.

Conclusion: The overall impacts of the No-Action Alternative on wildlife would be long-term, moderate in intensity, and adverse. Although some species at Canyon de Chelly may use tamarisk and Russian olive thickets, the larger wildlife diversity of the park would decline if no management action is taken to reduce the abundance and density of these exotics in the park. As encroachment of exotic vegetation continues and replaces other types of vegetation, the distribution and variety of other wildlife habitat would decline.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis: Alternative A may result in minor adverse impacts on wildlife in the short-term. The possibility of herbicide runoff might result in some negative effects to wildlife species if ingested. Additionally, the reduction of tamarisk and Russian olive in the project area would result in a loss of vegetative structure (e.g., overstory), and temporary intrusions from noise and physical disturbances of the area. However, in the long term, this alternative would result in the restoration of native vegetation, increasing the diversity of habitats available to wildlife. This would likely attract a more diverse suite of wildlife and assist in the retention of existing native wildlife populations. The adaptive flexibility of using a variety of techniques based on the characteristics of the area to be treated, would allow for the maximum recovery potential for currently infested and degraded habitats. Additionally, the low volume basal spray method retains intact snags, a habitat component important to a variety of wildlife species. In the long-term, this alternative would have beneficial effects of moderate intensity.

Cumulative Impacts: The cumulative effect of this action alternative on wildlife in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by wildlife with the successful restoration of native habitats. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. The use of herbicide as a treatment method may have, minor, short-term, adverse impacts; however,

the herbicide's rapid break-down time, and the nature of the direct application minimizes risk to surrounding non-targeted flora and fauna, and thus poses a negligible cumulative effect to wildlife. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of moderate intensity.

Conclusion: This alternative would result in short-term, adverse impacts that would be minor in intensity, as herbicide treatment and habitat reduction may affect certain species or individuals. In the long-term however, this alternative would result in moderate beneficial impacts to wildlife at Canyon de Chelly, as habitat diversity would increase, attracting a more diverse suite of wildlife and assisting in the retention on existing native wildlife populations. Additionally, this alternative would allow for the maximum recovery potential for currently infested and degraded habitats.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis: Alternative B, the environmentally preferred alternative, may result in minor adverse impacts on wildlife in the short-term. The possibility of herbicide runoff might result in some negative effects to wildlife species if ingested, and the reduction of tamarisk and Russian olive in the project area would result in a loss of vegetative structure (e.g., overstory). Since proposed treatments do not require use of heavy equipment, this alternative results in the least amount of ground disturbance and noise than the other three action alternatives. In the long term, this alternative would result in the restoration of native vegetation, increasing the diversity of habitats available to wildlife. This would likely attract a more diverse suite of wildlife and assist in the retention on existing native wildlife populations. However, since this alternative relies entirely on hand-labor, it is cost prohibitive to employ on a large-scale. Extensive time periods (8-10 years) would likely be required to remove large-scale beneficial levels of tamarisk and Russian olive using this treatment option alone. Therefore, while long-term effects on species of concern should be beneficial, they may only be of minor to moderate intensity due to the length of time needed for large-scale benefits.

Cumulative Impacts: The cumulative effect of this action alternative on wildlife in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by wildlife with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Additionally, future management actions for

tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. Since this alternative would require an extensive time period (8-10 years) for large-scale benefits, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. The use of herbicide as a treatment method may have, minor, short-term, adverse impacts; however, the herbicide's rapid break-down time, and the nature of the direct application minimizes risk to surrounding non-targeted flora and fauna, and thus poses a negligible cumulative effect to wildlife. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: The environmentally preferred alternative may result in short-term, adverse impacts of minor intensity, as herbicide runoff and habitat loss may negatively affect some species or individuals. In the long-term, this alternative would result in moderate beneficial impacts to wildlife at Canyon de Chelly. This alternative would result in the restoration of native vegetation, increasing the diversity of habitats available to wildlife, attracting a more diverse suite of wildlife and assisting in the retention of existing native wildlife populations; however, they may only be of minor to moderate intensity due to the length of time needed for large-scale benefits.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis: Alternative C may result in minor adverse impacts on wildlife in the short-term through the loss of vegetative structure (e.g., overstory), and intrusions from noise and physical disturbances of the area. This alternative will only be implemented in areas determined to be "non-sensitive," thus treatment will occur on a smaller more patchy spatial scale than either Alternative A or B. This alternative will not use herbicide; therefore, the potential for herbicide impacts on wildlife does not exist with this alternative. However, the lack of herbicide use nearly ensures re-sprouting from the intact living root systems. Successful control would then require repeated entries over time to retreat cut plants, thereby extending the period of disturbance to wildlife over a longer time frame. Additionally, the restrictive application requirements with this alternative may improve localized sections of the park, but would fail to maximize the recovery potential within many areas of the park allowing continued spread of tamarisk and Russian olive in untreated areas. In the long term, this alternative would result in minor to moderate beneficial effects but potentially continued adverse impacts of minor intensity.

Cumulative Impacts: The cumulative effect of this action alternative on wildlife in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by wildlife with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. Since this alternative would have restrictive application and require multiple entries for re-treatment over time, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: Alternative C may result in minor adverse impacts on wildlife in the short-term through the loss of vegetative structure and intrusions from noise and physical disturbances of the area. However because of the restrictive and less effective nature of the treatments, this alternative would only result in localized beneficial effects of minor to moderate intensity with the potential of continuing adverse impacts of minor intensity due to the necessity to retreat areas over multiple years.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis: Alternative D may result in minor adverse impacts on wildlife in the short-term through the loss of vegetative structure (e.g., overstory), and intrusions from noise and physical disturbances of the area. However, as this alternative will only be implemented in areas determined to be "non-sensitive," treatment will occur on a smaller more patchy spatial scale than either Alternative A or B. This alternative will not use herbicide; therefore the potential for herbicide impacts on wildlife does not exist. However, the restrictive application requirements with this alternative may improve localized sections of the park, but would fail to maximize the recovery potential within many areas of the park allowing continued spread of tamarisk and Russian olive in untreated areas. In the long term, this alternative would result in minor to moderate beneficial effects but potentially continued adverse impacts of minor to moderate intensity.

Cumulative Impacts: The cumulative effect of this action alternative on wildlife in the majority of the project area will vary depending on changes in current land-use practices.

Benefits of tamarisk and Russian olive removal will be best realized by wildlife with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. Since this alternative would have restrictive application, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: Alternative D may result in minor adverse impacts in the short-term through the loss of vegetative structure and intrusions from noise and physical disturbances of the area. However, because of the restrictive nature of the treatments, this alternative would only result in localized beneficial effects of minor to moderate intensity with the potential of continuing adverse impacts of minor to moderate intensity due to the continued spread of tamarisk and Russian olive in untreated areas.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.12 Threatened and Endangered Species

Effects of the No-Action Alternative:

Analysis: Under the no-action alternative, there would be no direct impacts to species of concern; however, the spread of tamarisk and Russian olive at the complete exclusion of the diverse native flora could cause numerous long-term indirect impacts. Of the 39 Federal, Tribal and State listed species, only six are known to occur or may potentially occur within the project area. This determination is based on specific knowledge of the areas, knowledge of the species in question, and professional judgment. Southwestern willow flycatchers are known to utilize dense tamarisk stands for nesting and breeding. Therefore, continued spread and colonization of tamarisk may provide long-term habitat for this endangered bird species. However, the lack of other habitat components (e.g., presence of surface water during nesting) makes it unlikely this area would ever support southwestern willow flycatchers. Suitable habitat exists in the upper reaches of both Canyons de Chelly and del Muerto for the Mexican spotted owl, areas at the fringe of tamarisk and Russian olive encroachment. The no-action alternative would provide for the encroachment of the exotics further into Mexican spotted owl suitable habitat areas,

decreasing habitat suitability over time and the potential recovery for this endangered bird. In general, while any of the bird species of concern may at times utilize tamarisk and/or Russian olive, homogenized habitats typically support a less diverse suite of wildlife species and thus the lack of removal of these exotics associated with the no-action alternative could potentially result in long-term adverse impacts of moderate intensity to species of concern.

Cumulative Impacts: There would be no new direct cumulative impacts on species of concern under the No-Action Alternative. Current land uses, including unregulated grazing and vehicle use and altered geomorphic processes will aid in the continued infestation of tamarisk and Russian olive within the park. The increase of these exotics may or may not benefit the southwestern willow flycatcher, an endangered bird known to utilize dense tamarisk thickets. The lack of other habitat components (e.g., presence of surface water during nesting) makes it unlikely this area would ever support southwestern willow flycatchers. In contrast, continued encroachment of these exotics further into Mexican spotted owl suitable habitat with decrease the suitability of those areas and hinder recovery of this endangered bird species. In general, the increase of these exotics over time will have a long-term, adverse impact of moderate intensity on species of concern.

Conclusion: The no-action alternative would not have any direct impacts to species of concern. The continued spread of tamarisk may have beneficial effects for the southwestern willow flycatcher; however, the lack of other habitat requirements (e.g., presence of surface water during nesting) makes it unlikely this area would ever support this species. Suitable habitat for the Mexican spotted owl would degrade over time as encroachment of the exotic flora continues to replace native species. In general, long-term impacts to species of concern would be adverse and moderate in intensity as homogenized habitats typically support a less diverse suite of wildlife species.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the Monument; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, there would be no impairment of park resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis: Of the 39 Federal, Tribal and State listed species, only six are known to occur or may potentially occur within the project area. This determination is based on specific knowledge of the areas, knowledge of the species in question, and professional judgement. Short-term impacts associated with Alternative A on species of concern should be negligible as no removal activities would occur in habitat identified as containing breeding pairs of any of the six identified bird species of concern. If nesting sites for any of these species are identified outside, but adjacent to canyon-bottom habitats, timing restrictions for tamarisk and Russian olive removal activities would be implemented to avoid any potential negative impacts as a result of increased noise/activities during sensitive "nesting to fledging" time frames. Long-term benefits may include proactive removal of exotics near the edges of areas designated Mexican spotted owl suitable habitat, helping to maintain habitat suitability for recovery of that endangered bird species. Likewise, the treatments associated with this alternative would provide for the restoration of natural systems and processes resulting in increased availability of diverse habitats, benefiting the other bird species of concern.

Cumulative Impacts: The cumulative effect of this action alternative on species of concern in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by sensitive species with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Over time, the restoration of native riparian habitat, including the presence of surface water may provide natural habitat for the southwestern willow flycatcher. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. Pending encroachment by these exotics into Mexican spotted owl suitable habitat can be averted with these treatments and the efficacy again would be further enhanced by changes in current land-use patterns. The use of herbicide as a treatment method may have minor, short-term, adverse impacts; however, the herbicide's rapid break-down time, and the nature of the direct application minimizes risk to surrounding non-targeted flora and fauna, and thus poses a negligible cumulative effect to species of concern. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of moderate intensity.

Conclusion: Short-term impacts associated with Alternative A on species of concern should be negligible as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the six identified species of concern. Long-term effects would be beneficial in nature and of moderate intensity as treatments would prevent further encroachment of exotics into Mexican spotted owl suitable habitat and would increase availability of diverse natural habitats for the remaining species of concern.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis: Of the 39 Federal, Tribal and State listed species, only six are known to occur or may potentially occur within the project area. This determination is based on specific knowledge of the areas, knowledge of the species in question, and professional judgment. Short-term impacts associated with Alternative B on species of concern should be negligible as no removal activities would occur in habitat identified as containing breeding pairs of any of the six identified bird species of concern. If nesting sites for any of these species are identified outside, but adjacent to canyon-bottom habitats, timing restrictions for tamarisk and Russian olive removal activities would be implemented to avoid any potential negative impacts as a result of increased noise/activities during sensitive "nesting to fledging" time frames.

Long-term benefits may include proactive removal of exotics near the edges of areas designated Mexican spotted owl suitable habitat helping to maintain habitat suitability for recovery of that endangered bird species. Likewise, the treatments associated with this alternative would provide for the restoration of natural systems and processes resulting in increased availability of diverse habitats, benefiting the other bird species of concern. However, since this alternative relies entirely on hand-labor, it is cost prohibitive to employ on a large-scale. Extensive time periods (8-10 years) would likely be required to remove large-scale beneficial levels of tamarisk and Russian olive using this treatment option alone. Therefore, while long-term effects on species of concern should be beneficial, they may only be of minor to moderate intensity due to the length of time needed for large-scale benefits.

Cumulative Impact: The cumulative effect of this action alternative on species of concern in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by sensitive species with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphologic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Over time, the restoration of native riparian habitat, including the presence of surface water may provide natural habitat for the southwestern willow flycatcher. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife. Pending encroachment by these exotics into Mexican spotted owl suitable habitat can be averted

with these treatments and the efficacy again would be further enhanced by changes in current land-use patterns.

Since this alternative would require an extensive time period (8-10 years) for large-scale benefits, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. The use of herbicide as a treatment method may have, minor, short-term, adverse impacts; however, the herbicide's rapid break-down time, and the nature of the direct application minimizes risk to surrounding non-targeted flora and fauna, and thus poses a negligible cumulative effect to species of concern. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: Short-term impacts to species of concern which are associated with Alternative B should be negligible, as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the six identified species of concern. Long-term effects would be beneficial in nature and of minor to moderate intensity as treatments would increase availability of diverse natural habitats in localized areas for the bird species of concern, and may prevent further encroachment of exotics into Mexican spotted owl suitable habitat; however, large-scale benefits would be realized over a longer time period than Alternative A.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis: Of the 39 Federal, Tribal and State listed species, only six are known to occur or may potentially occur within the project area. This determination is based on specific knowledge of the areas, knowledge of the species in question, and professional judgment. Short-term impacts associated with Alternative C on species of concern should be negligible as no removal activities would occur in habitat identified as containing breeding pairs of any of the six identified bird species of concern. If nesting sites for any of these species are identified outside, but adjacent to canyon-bottom habitats, timing restrictions for tamarisk and Russian olive removal activities would be implemented to avoid any potential negative impacts as a result of increased noise/activities during sensitive "nesting to fledging" time frames.

Depending on the determination of the Mexican spotted owl suitable habitat as "sensitive" or "non-sensitive," these areas may or may not benefit from the removal of exotics. The use of heavy equipment associated with this alternative may preclude

treatment near the edges of areas designated Mexican spotted owl suitable habitat, thus not preventing the future spread of exotics and degradation of these areas. Similarly, while the treatments associated with this alternative would provide for the restoration of natural systems and processes resulting in increased availability of diverse habitats, benefiting the other bird species of concern, this treatment option would only benefit limited locations and fail to maximize recovery opportunities on a large-scale basis. Spread of tamarisk and Russian olive would continue to degrade habitats within the canyon floor from untreated areas.

Cumulative Impact: The cumulative effect of this action alternative on species of concern in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by sensitive species with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Over time, the restoration of native riparian habitat, including the presence of surface water may provide natural habitat for the southwestern willow flycatcher. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife.

Pending encroachment by these exotics into Mexican spotted owl suitable habitat can be averted with these treatments and the efficacy again would be further enhanced by changes in current land-use patterns. Since this alternative would have restrictive application and require multiple entries for re-treatment over time, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: Short-term impacts to species of concern associated with Alternative C should be negligible, as no removal activities would occur in areas containing breeding pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the six identified species of concern. Long-term effects would be beneficial in nature and of minor to moderate intensity as treatments would increase availability of diverse natural habitats in localized areas for the bird species of concern, and may or may not prevent further encroachment of exotics into Mexican spotted owl suitable habitat.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis: Of the 39 Federal, Tribal and State listed species, only six are known to occur or may potentially occur within the project area. This determination is based on specific knowledge of the areas, knowledge of the species in question, and professional judgment. Short-term impacts associated with Alternative D on species of concern should be negligible as no removal activities would occur in habitat identified as containing breeding pairs of any of the six identified bird species of concern. If nesting sites for any of these species are identified outside, but adjacent to canyon-bottom habitats, timing restrictions for tamarisk and Russian olive removal activities would be implemented to avoid any potential negative impacts as a result of increased noise/activities during sensitive "nesting to fledging" time frames.

Depending on the determination of the Mexican spotted owl suitable habitat as "sensitive" or "non-sensitive," these areas may or may not benefit from the removal of exotics. The use of heavy equipment associated with this alternative may preclude treatment near the edges of areas designated Mexican spotted owl suitable habitat, thus not preventing the future spread of exotics and degradation of these areas. Similarly, while the treatments associated with this alternative would provide for the restoration of natural systems and processes resulting in increased availability of diverse habitats, benefiting the other bird species of concern, this treatment option would only benefit limited locations and fail to maximize recovery opportunities on a large-scale basis. Spread of tamarisk and Russian olive would continue to degrade habitats on the canyon floor from untreated areas.

Cumulative Impact: The cumulative effect of this action alternative on species of concern in the majority of the project area will vary depending on changes in current land-use practices. Benefits of tamarisk and Russian olive removal will be best realized by sensitive species with the successful restoration of native habitats, which are hindered by current land-use practices. Better regulation of grazing and vehicle use and the return or simulation of natural geomorphic processes currently altered by dam impoundments would intensify the benefits of these treatments to wildlife. Over time, the restoration of native riparian habitat, including the presence of surface water may provide natural habitat for the southwestern willow flycatcher. Additionally, future management actions for tamarisk and Russian olive prevention and control would beneficially impact diversity of habitats and their associated wildlife.

Pending encroachment by these exotics into Mexican spotted owl suitable habitat can be averted with these treatments and the efficacy again would be further enhanced by changes in current land-use patterns. Since this alternative would have restrictive application, the intensity of the benefits realized by wildlife would be more dependent upon changes in current land-use practices than Alternative A. Overall, depending on changes in land-use practices, this alternative would add a beneficial cumulative impact of minor to moderate intensity.

Conclusion: Short-term impacts to species of concern associated with Alternative D should be negligible, as no removal activities would occur in areas containing breeding

pairs, nor would activity occur during the nesting season in areas containing nests that are outside, but adjacent to canyon-bottom habitats for any of the six identified species of concern. Long-term effects would be beneficial in nature and of minor to moderate intensity as treatments would increase availability of diverse natural habitats in localized areas for the bird species of concern, and may or may not prevent further encroachment of exotics into Mexican spotted owl suitable habitat.

Impairment Determination: Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.13 Natural Sound

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The no-action alternative would not involve any management of tamarisk and Russian olive and, thus, would contribute no additional noise impacts to the existing sound conditions within the canyons. However, as infestations of tamarisk and Russian olive continue to spread and increase, natural wildlife habitat will be lost. This would result in long-term, minor to moderate, adverse impacts to the natural soundscapes of the canyon-bottom habitats.

Cumulative Impacts. Currently, several activities distract from the natural soundscapes within the canyons. Existing impacts to natural sound are predominately limited to vehicle noise from pickup trucks and concessionaire tour trucks. There may also be limited impacts to natural sounds resulting from farm equipment and activities associated with the nearby town of Chinle. These activities are more seasonal or limited to more localized sections of the canyon. Overall, localized impacts to natural sound, of minor to moderate intensity, currently exist within the canyons.

There would be no management of tamarisk and Russian olive under the no-action alternative. As a result, there would be no additional short-term impacts to the natural soundscape. However, as tamarisk and Russian olive continue to invade additional land areas, wildlife habitat would be lost. These loses would result in long-term adverse impacts, of moderate intensity to natural canyon sounds.

Conclusion. There would be no added adverse impacts to natural sound as a result of tamarisk and Russian olive management. However, as tamarisk and Russian olive continue to invade additional land areas, wildlife habitat would be lost. These loses

would result in long-term adverse impacts, of moderate intensity, to natural canyon sounds.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Alternative A would use multiple management techniques to reduce tamarisk and Russian olive infestations throughout approximately 26 miles of canyon floor. The use of chainsaws, hand tools, and heavy equipment to cut and mulch treated tamarisk and Russian olive plants would result in temporary, minor to moderate, adverse increases in unnatural sound levels. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures in section 2.2.6. Long-term, minor to moderate beneficial effects to natural sound would occur as extensive areas of tamarisk and Russian olive are removed and as native vegetation re-establishes resulting in increased wildlife use.

Cumulative Impacts. Several on-going activities in canyon habitats distract from the natural soundscapes. Existing impacts to natural sound are predominately limited to vehicle noise from pickup trucks and concessionaire tour trucks. There may also be limited impacts to natural sounds resulting from farm equipment and activities associated with the nearby town of Chinle. These activities are seasonal in occurrence or are limited to more localized sections of the canyon. Overall, existing localized impacts to natural sound are of minor to moderate intensity. Alternative A would not resolve on-going, existing adverse impacts to natural sound, but could, as large areas of tamarisk and Russian olive are removed, increase the "echo" effect between canyon walls. This increase would be minor to moderate in intensity and would again reduce as natural vegetation re-establishes.

Under actions identified for the preferred alternative (alternative A), noise levels would increase above existing levels for short durations as a result of sounds created by chainsaws and heavy equipment (tree cutting and mulching) management of tamarisk and Russian olive under the no-action alternative. These impacts would occur in the warmer seasons (May-October) and would be limited to daytime hours. Although there would be short-term adverse impacts to natural sound, wildlife habitat would be improved as tamarisk and Russian olive infestations are removed. Long-term impacts under alternative A would improve, would be beneficial and of minor to moderate intensity

Conclusion. Alternative A would not improve existing impacts to natural sound and would contribute additional short-term, increases in noise in localized areas, as a result of management actions to remove tamarisk and Russian olive under alternative A. Some

increases in "echo" effects may occur as large areas of tamarisk and Russian olive are removed and until natural vegetation re-establishes. However, long-term impacts would be beneficial, restoring more natural wildlife habitat conditions and, ultimately, contributing to the natural sounds of the canyon environments. These positive impacts would be of minor to moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Alternative B would rely on chainsaw removals of above ground portions of tamarisk and Russian olive followed by targeted herbicide application to the cut stump. Targeted, low-volume basal spay of herbicide would also be used under alternative B. Short-term, minor impacts to natural sound would occur as a result of chainsaw use and tree mulching during treatment activities. These impacts would be limited to daylight hours and would be minimized as best as possible using the identified mitigation measures in section 2.2.6. Long-term, minor to moderate beneficial effects to natural sound would occur as extensive areas of native vegetation re-establishes and wildlife use increases. However, the timeframe for achieving these results would be longer than with alternative A due to the labor intensiveness of this predominately "hand-removal" alternative.

Cumulative Impacts. Cumulative impacts would be similar to those identified under alternative A. The environmentally preferred alternative (alternative B) would not resolve existing impacts to natural sound as a result of on-going vehicle use on the canyon floor. These impacts could become more distinct as large areas of tamarisk and Russian olive are removed, increasing the "echo" effect between canyon walls. Additionally, alternative B would create short-term, adverse impacts to natural sound as a result of chainsaw use and tree cutting and mulching activities. These impacts would be localized and of minor intensity. Similar to alternative A, the environmentally preferred alternative would distinctly improve wildlife habitat as tamarisk and Russian olive are removed and replaced by native vegetation. Removal actions, under alternative B would be slower due to the use of hand equipment only, thus, positive benefits would take a longer timeframe to achieve. These impacts would be beneficial and of minor to moderate intensity.

Conclusion. Short-term, adverse impacts of minor to moderate intensity would occur as a result of removal activities and within potential increases in "echo" effects as large areas of tamarisk and Russian olive are removed. Long-term impacts would be beneficial

as wildlife habitat is improved, adding to the natural soundscapes of the canyon floor. These beneficial effects would be of minor to moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would rely on the use of heavy equipment to remove above ground portions of tamarisk and Russian olive in areas identified as being "non-sensitive" to natural and cultural resources. The use of heavy equipment to cut and mulch tamarisk and Russian olive would result in temporary, minor to moderate, adverse increases in the level of noise in the canyon-bottom. These impacts would be localized and limited to daylight hours. General mitigation measures as identified in section 2.2.6 would be used to mitigate any short-term adverse impacts to natural sound. There would be no herbicide use under alternative C and resprouting would occur from remaining root systems requiring additional follow-up treatments. Long-term, minor beneficial effects would occur in the treatment areas as native vegetation re-establishes and some wildlife use increases. However, tamarisk and Russian olive would continue to spread from non-treated areas throughout most of the canyon floor, further degrading natural wildlife habitat, and diminishing the natural soundscapes. The overall, long-term effects under alternative C would similar to the no-action alternative and would adverse and of moderate intensity.

Cumulative Impacts. Alternative C would not resolve any existing adverse impacts to the natural soundscape as a result of on-going vehicle uses. Since this alternative would be limited in application (restricted to use in "non-sensitive" areas), any increases in "echo" effects would be minimal and restricted to localized areas. Additional short-term, adverse impacts to natural sound would occur under alternative C as a result of heavy equipment uses. Some longer-term beneficial effects to natural sound would occur in treatment locations as wildlife habitat improves, but overall, these benefits would be relatively minor in their contributions to natural sound. Tamarisk and Russian olive would continue to spread from non-treated areas, further degrading wildlife habitat and natural sounds throughout most of the canyon-bottom environments.

Conclusion. Short-term, moderate, adverse effects to natural sound in localized treatment areas would occur as a result of heavy equipment use during removal activities. Improvements in wildlife habitat would contribute minor beneficial effects to natural sound within treatment locations. However, tamarisk and Russian olive would continue to spread from non-treated locations, resulting in long-term adverse impacts similar to those identified fro the no-action alternative. These adverse impacts would be moderate in intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Similar to the above alternative, alternative D would use heavy equipment only, but removal activities would include both above and below ground portions of tamarisk and Russian olive. The use of heavy equipment to cut and mulch tamarisk and Russian olive would result in temporary, minor to moderate, adverse increases in the level of noise in the canyon floor. These impacts would be localized and limited to daylight hours. General mitigation measures as identified in section 2.2.6 would be used to mitigate any short-term adverse impacts to natural sound. There would be no herbicide use under alternative D and resprouting would not occur since this alternative includes removal of below ground root systems.

Long-term, minor beneficial effects would occur in the treatment areas as native vegetation re-establishes and some wildlife use increases. However, tamarisk and Russian olive would continue to spread from non-treated areas throughout most of the canyon floor, further degrading natural wildlife habitat, and diminishing the natural soundscapes. The overall, long-term effects under alternative D would similar to the no-action alternative and would adverse and of moderate intensity.

Cumulative Impacts. Alternative D would not resolve any existing adverse impacts to the natural soundscape as a result of on-going vehicle use. Since this alternative would be limited in application (restricted to use in "non-sensitive" areas), any increases in "echo" effects would be minimal and restricted to localized areas. Additional short-term, adverse impacts to natural sound would occur under alternative D as a result of heavy equipment uses. Some longer-term beneficial effects to natural sound would occur in treatment locations as wildlife habitat improves, but overall, these benefits would be relatively minor in their contributions to natural sound. Tamarisk and Russian olive would continue to spread from non-treated areas, further degrading wildlife habitat and natural sounds throughout most of the canyon-bottom environments.

Conclusion. Short-term, moderate, adverse effects to natural sound in localized treatment areas would occur as a result of heavy equipment use during removal activities under alternative D. Improvements in wildlife habitat would contribute minor beneficial effects to natural sound within treatment locations. However, tamarisk and Russian olive would continue to spread from non-treated locations, resulting in long-term adverse impacts similar to those identified from the no-action alternative. These adverse impacts would be moderate in intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

Visitor Experience/Socioeconomic Conditions

4.2.14 Public Health and Safety

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The no-action alternative would allow tamarisk and Russian olive to continue to spread further, limiting safe access routes through the canyon-bottom environments. Severe down-cutting in stream channels, created by dense stands of tamarisk and Russian olive, has already occurred in several locations making stream crossing for canyon residents and concession tour trucks difficult and dangerous. These conditions would only worsen under the no-action alternative. Canyon residents spend the warm, dry, summer months living in the canyon and working their traditional lands. More and more tourists are looking for an extended stay in the canyon, and so are backcountry hiking and camping in remote areas. Hazardous fuel conditions exist in tamarisk and Russian olive infestation, and these conditions would expand as tamarisk and Russian olive continue to spread over time placing all people who actively use the canyon at risk. The no-action alternative would result in long-term, moderate adverse impacts to public health and safety throughout the canyon bottom.

Cumulative Impacts. Currently, canyon residents, park concessionaires, and park staff must maneuver through several highly incised and tenuous stream channel crossings within both Canyon de Chelly and Canyon del Muerto. Although several attempts have been made by local landowners and by the park concessionaire to mitigate these adverse conditions, these solutions have been temporary at best (since stream geomorphology is not being addressed throughout the canyon floor) and can often create confounding results at other locations further downstream. To date, there has been no integrated assessment or approach to mitigating high-risk stream channel crossing conditions. The long-term presence of tamarisk and Russian olive in the middle reaches of both canyons has exacerbated stream channelization and unnatural rates of streambed incision. These adverse conditions would continue under the no-action alternative, resulting in long-term, increased risks to public health and safety. These adverse impacts would be of moderate intensity.

Conclusion. The no-action alternative would not mitigate any current adverse conditions related to public health and safety on the canyon floor. The continued spread of tamarisk and Russian olive would perpetuate and expand limited access conditions and adverse impacts to stream channel crossings. Under the no-action alternative, these increasing adverse effects to public health and safety would be of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Alternative A would use a variety of management techniques to reduce tamarisk and Russian olive in approximately 26 miles of canyon floor These techniques include use of chainsaws and heavy equipment to cut or mulch tamarisk and Russian olive and the use of herbicides. Short-term, minor to moderate, adverse impacts to public safety would occur as a result of these activities. Impacts would be greatest in the immediate locations of treatment actions and as heavy equipment moves to different locations along the canyon floor. The potential for adverse impact to public health and safety would be greatly minimized through use of general mitigation measures identified in section 2.2.6 and through temporary closures, or limited public access, to treatment areas while active work is being performed. Additionally, large-scale reductions in hazardous fuels conditions would significantly reduce the potential of adverse impacts due to wildfire events.

In the long-term, tamarisk and Russian olive reductions as proposed under alternative A would create safer conditions for park visitors, canyon residents, and park staff including decreased risk of fire and improved stream channel crossings as varying levels of channel aggradations begin to occur. Long-term impacts of the preferred alternative would be beneficial and of moderate intensity.

Cumulative Impacts. The long-term presence of tamarisk and Russian olive in the middle reaches of both canyons has exacerbated stream channelizations and unnatural rates of streambed incision. As identified above, canyon residents, park concessionaires, and park staff must maneuver through several highly incised and tenuous stream channel crossings within both Canyon de Chelly and Canyon del Muerto. Although several attempts have been made by local landowners and by the park concessionaire to mitigate these adverse conditions, these solutions have been temporary at best (since stream geomorphology is not being addressed throughout the canyon floor) and can often create confounding results at other locations either up- or downstream. To date, there has been no integrated assessment or approach to mitigating high-risk stream channel crossing conditions.

The removal of large areas of tamarisk and Russian olive as identified under alternative A, would greatly assist in returning canyon-bottom wide stream geomorphological processes and in the reduction of fire potential. As a result, unnatural rates of channel incision would be minimized and natural aggradations of sediments would assist in improving some areas of incised stream channels. Implementation of the preferred alternative would not resolve or mitigate all existing, adverse stream channel crossing conditions, but it would assist in facilitating more integrated approaches to creating long-term sustainable conditions. The actions under alternative A would result in long-term, beneficial impacts, of moderate intensity, to public health and safety.

Conclusion. Alternative A would create short-term, increases in risk to public safety as a result of large scale removals of tamarisk and Russian olive requiring the use heavy equipment, chainsaws, and targeted herbicide applications. These temporary impacts would be of minor to moderate intensity. The preferred alternative would result in long-term, beneficial effects, of moderate intensity, to public health and safety. No long-term adverse impacts would be created by alternative A.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Alternative B, would not require the use of any heavy equipment, but would use chainsaws and herbicide applications to treat existing infestations of tamarisk and Russian olive. Potential exists for short-term, minor, adverse impacts to public health and safety as a result of tree felling and herbicide applications activities. These impacts would be limited to treatment locations. Potential short-term adverse impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and/or through use of temporary closures of treatment sites during cutting and herbicide application activities. The labor intensiveness of actions under alternative B would extend the timeframe of which management actions for tamarisk and Russian olive would be needed. Long-term impacts to public health and safety would be similar to those identified under alternative A, and would be beneficial and of moderate intensity including improved canyon floor access and reductions in hazardous fuel conditions.

Cumulative Impacts. Canyon residents, park concessionaires, and park staff must currently maneuver through several highly incised and tenuous stream channel crossings within both Canyon de Chelly and Canyon del Muerto. Although several attempts have been made by local landowners and by the park concessionaire to mitigate these adverse conditions, these solutions have been temporary at best (since stream geomorphology is not being addressed throughout the entire canyon floor) and have often created

confounding results at other locations, both up- and downstream. To date, there has been no integrated assessment or approach to mitigating high-risk stream channel crossing conditions.

The removal of large areas of tamarisk and Russian olive, as identified under alternative B, would similarly result in long-term, beneficial direct and indirect effects to stream geomorphology, channel crossing stability, and reduction in hazardous fuel conditions. However, the labor intensiveness of the predominately "hand-removal" activities identified under this alternative would require a longer timeframe to achieve. Additional minor to moderate, adverse impacts would continue until treatment actions are completed for the entire canyon system floor. Long-term effects would be beneficial and of moderate intensity.

Conclusion. Short-term, minor increases in adverse impacts to public health and safety would occur as a result of chainsaw use and targeted herbicide applications under the environmentally preferred alternative. Alternative B would result in long-term, beneficial effects, of moderate intensity, to public health and safety. However, some additional adverse conditions from continued unnatural erosion would occur due to the increased timeframe necessary to fully implement this alternative. No long-term adverse impacts would be created by alternative B.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would use heavy equipment to remove above ground portions of tamarisk and Russian olive in "non-sensitive" areas along the canyon floor. Short-term, adverse impacts would occur as a result of heavy equipment use and tree cutting and mulching. These impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and through use of temporary closures of treatment sites during heavy equipment use. There would be no herbicide use under alternative C. Since use of management activities under alternative C are not applicable to the entirety of the canyon floor, beneficial effects to public health and safety would be minimal and restricted to the immediate removal locations. Stream channel incisions/crossings are not likely to display improvement since geomorphological processes are not being improved throughout the canyons. Similarly, hazardous fuel conditions would only be improved at removal locations and would not reduce potential for wildfire events in untreated locations. Tamarisk & Russian olive would continue to spread under this alternative, resulting in long-term, moderate and adverse effects throughout most of the canyon floor.

Cumulative Impacts. Alternative C would not resolve existing, dangerous steam channel crossings or hazardous fuel conditions. Stream geomorphology would not be addressed throughout the entirety of the canyon floor, distinctly reducing abilities for integrated, sustainable solutions to unnatural channel erosion. As a result adverse impacts to public health and safety, of moderate intensity, would remain and expand under this alternative.

Conclusion. Alternative C would not mitigate any current adverse conditions related to public health and safety on the canyon floor. Although some minor improvement to safety conditions would occur in treatment locations, the continued spread of tamarisk and Russian olive would perpetuate and expand from untreated locations. Access to most canyon floor locations would remain limited, hazardous fuel conditions would still exist, and there would be expanded adverse impacts to stream channel crossings, and thus, public health and safety. Long-term effects would be adverse, similar to the no-action alternative, and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would use heavy equipment to remove both above- and below-ground portions of tamarisk and Russian olive in "non-sensitive" areas of the canyon floor. Short-term, adverse impacts would occur as a result of heavy equipment use for tree cutting, pulling, and mulching. These impacts would be minimized through use of "general mitigation measures" as identified in section 2.2.6 and through use of temporary closures of treatment sites during heavy equipment use. There would be no herbicide use under alternative D. Since use of management activities under alternative D are not applicable to the entirety of the canyon floor, beneficial effects to public health and safety would be minimal and restricted to the immediate removal locations. Stream channel incisions/crossings are not likely to display any improvement since geomorphological processes are not being improved throughout the entire canyon-bottom environments. Similarly, hazardous fuel conditions would only be improved at removal locations and would not reduce potential for wildfire events in untreated locations. Tamarisk & Russian olive would continue to spread under this alternative, resulting in long-term, moderate and adverse effects throughout most of the canyon floor.

Cumulative Impacts. Alternative D would not resolve existing, dangerous stream channel crossings. Stream geomorphology would not be addressed throughout the entirety of the canyon floor, distinctly reducing abilities for integrated, sustainable solutions to unnatural channel erosion. Hazardous fuel levels would not be reduced, and

therefore the potential for fire would remain elevated. As a result adverse impacts to public health and safety, of moderate intensity, would remain and expand under this alternative.

Conclusion. Alternative D would not mitigate any current adverse conditions related to public health and safety on the canyon floor. Although some minor improvement to safety conditions would occur in treatment locations, the continued spread of tamarisk and Russian olive would perpetuate and expand from untreated locations. Access to the floor of the canyon would remain limited, hazardous fuel levels would elevate, and adverse impacts would occur to stream channel crossings, thus negatively impacting public health and safety. Long-term effects under alternative D would be adverse, similar to the no-action alternative, and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.15 Visitor Use and Experience

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. Under the no-action alternative both short- and long-term, adverse impacts to the visitor experience, of moderate intensity would occur. No actions to control tamarisk or Russian olive would take place under this alternative. These non-native species currently obscure large areas of the both the modern and historic viewsheds associated with the canyon habitats. As a result, park visitors do not receive an experience that truly reflects the canyon environments – open vistas from canyon wall to canyon wall. Views of cultural resources are obscured at many locations by extensive dense stands of tamarisk and Russian olive. Excessive erosion created by these species threatens numerous cultural and natural resources, risking further degradation of visitor use and experience. The long-term effects under the no-action alternative would be adverse, of moderate intensity, and would further degrade the visitor experience as a result of continued spread of tamarisk and Russian olive.

Cumulative Impacts. Other human-related disturbances on the canyon floor, including unregulated vehicle use and human attempts to repair excessively eroded stream channel crossings, also detract from the current visitor experience. These activities and disturbances would not improve under the no-action alternative, and would assist in creating conditions favorable to the continue spread of tamarisk and Russian olive. Any

integrated efforts to resolve other human-related disturbances would be limited in effect due to the continued presence and expansion of these undesirable non-native species,

Conclusion. As tamarisk and Russian olive continue to spread, opportunities to view canyon resources (natural and cultural) would continue to diminish. The long-term effects to visitor use and experience under the no-action alternative would be adverse and of moderate intensity.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. The preferred alternative would have short-term minor to moderate adverse impacts to visitor use and experience during tamarisk and Russian olive removal activities, but long-term moderate beneficial impacts would be achieved. Specifically, this alternative would include actions using heavy equipment, chain sawing, and herbicide applications that would increase noise levels and that could limit visitor access, causing short-term, minor to moderate impacts to visitor use of treatment sites during certain removal activities. All attempts would be made to avoid closing sections of the park during removal actions. However, there is some potential that short- term closures would occur which would exclude concessionaires and visitors in work areas.

After removals, the viewshed may appear degraded for a short time following treatment and visitors may interpret the visual state of the treatment area as an unhealthy environment. Visitor education, re-vegetation (as appropriate), and implementation of general mitigation measures (see section 2.2.6) would be used to minimize short-term impacts to the visitor experiences. The long-term effects to visitor use and experience would be positive and of moderate intensity as large-scale tamarisk and Russian olive removals open viewsheds throughout the canyon floor, improving vistas, interpretive opportunities, and creating more historically representative cultural and natural landscapes.

Cumulative Impacts. Currently, other human-related disturbances on the canyon floor, including unregulated vehicle use and human attempts to repair excessively eroded stream channel crossings, also detract from the visitor use and experience. Although alternative A would not directly resolve these other human-related disturbances, this alternative would likely assist in developing more integrated management strategies throughout the canyon-bottom environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances to visitor use. As a result of both the direct large-scale removals of tamarisk and Russian olive and indirect

benefits of a more integrated approach to managing canyon-bottom resources, long-term, moderate, and positive effects to visitor use and experience would be realized.

Conclusion. The preferred alternative would result in some short-term adverse impacts, of minor to moderate intensity, to visitor use and experience. These impacts would include increased noise due to heavy equipment use and potential temporary closure or limited access to specific removal locations. However, long-term benefits to visitor use and experience would be beneficial, of moderate intensity, and would create more historically representative cultural and natural landscapes.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Alternative B would rely entirely on more labor intensive removal techniques (above ground tree removals with targeted stump treatment with herbicide or low volume basal spraying) in reducing existing infestations of tamarisk and Russian olive. Short-term minor to moderate adverse impacts to visitor use and experience removal activities would occur as a result of increased noise from chain sawing and mulching and from potential temporary closures due to herbicide applications in treatment areas. Park visitors may perceive the removal actions under alternative B to be less impacting on the environment since this alternative does not rely on any heavy equipment use. However, impacts would occur over a longer timeframe due to the labor intensiveness of the environmentally preferred alternative.

Similar to alternative A, treatment locations may appear degraded for a short time with the potential for visitors to interpret the visual state of the treatment area as an unhealthy environment. Visitor education, re-vegetation (as appropriate), and implementation of general mitigation measures (see section 2.2.6) would be used to minimize short-term impacts to visitor use and experience. The long-term effects would be positive and of moderate intensity as large-scale tamarisk and Russian olive removals open viewsheds throughout the canyon floor, improving vistas, interpretive opportunities, and creating more historically representative cultural and natural landscapes.

Cumulative Impacts. Other human-related disturbances on the canyon floor, including unregulated vehicle use and human attempts to repair excessively eroded stream channel crossings, also detract from the visitor use and experience. Although alternative B would not directly resolve these other human-related disturbance, distinct visual and measurable improvements would be realized. The environmentally preferred alternative would, similarly, assist in developing more integrated management strategies throughout the

canyon-bottom environments, facilitating additional innovative approaches to mitigating other adverse human-related disturbances to visitor use. Long-term effects to visitor use and experience would be beneficial and of moderate intensity.

Conclusion. Alternative B would result in short-term adverse impacts, of minor to moderate intensity, to visitor use and experience. These impacts would include potential temporary closure, or limited access, to specific treatment locations. Long-term benefits to visitor use and experience would be beneficial and of moderate intensity, similar to those for identified for alternative A. However, the labor intensiveness of this predominately "hand-removal" alternative would require a much longer timeframe (up to 10 years) in order to achieve maximum beneficial results.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would use heavy equipment to remove above ground portions of tamarisk and Russian olive. This alternative is cost-effective in removing extensive, dense infestations but would use no herbicides, resulting in high potential for resprouting from remaining root systems. Short-term impacts to the visitor experience would result from increased noise from heavy equipment use and from potential, temporary closures in treatment areas during equipment use.

After removals the viewshed would appear degraded for a short duration following treatment, and visitors may interpret the visual state of the treatment area as an unhealthy environment. Visitor education and general mitigation measures would be used to minimize these perceptions. Treatments would be restricted to "non-sensitive" areas, minimizing positive impacts to canyon vistas to very localized treatment areas. Tamarisk and Russian olive would continue to spread from untreated locations, resulting in long-term adverse impacts to visitor experience (similar to the no-action alternative) in most canyon-bottom areas.

Cumulative Impacts. Alternative C would not mitigate other existing human-related impacts to visitor use and experience within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread from untreated areas, resulting in long-term, adverse impacts similar to those identified for the no-action alternative. Lack of visual improvements and measurable results would likely minimize any opportunity for development of more integrated strategies to address overall management of natural and cultural resources which are located on the canyon floor.

Conclusion. Under alternative C, short-term, minor to moderate adverse impacts would occur to visitor use and experience due to increased noise and temporary closures during heavy equipment use and removal activities. Some, minor, longer-term benefits to viewsheds and visitor experience would be realized, but these benefits would be restricted to treatment locations. Tamarisk and Russian olive would continue to spread from untreated locations, further diminishing the visual conditions of the canyons and the visitors understanding of the parks cultural and natural resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would use heavy equipment to remove both above and below ground portions of tamarisk and Russian olive. Similar to alternative C, this alternative is cost-effective in removing extensive, dense infestations and would not use any herbicide applications. As a result of root system removals, the potential for resprouting would be eliminated. Short-term impacts to the visitor experience would result from increased noise from heavy equipment use and from temporary closures in treatment areas during removal and mulching activities.

After removals the viewshed would appear degraded for a short duration following treatment. Alternative D is likely to be perceived by park visitors as being most disruptive to the landscape due to the disturbance that would be temporarily created during below ground root system removals. Visitor education and general mitigation measures would be used to minimize both adverse effects and public perceptions.

Since removal activities would be restricted to "non-sensitive" areas, beneficial impacts to canyon vistas would be minor and localized to treatment areas. Tamarisk and Russian olive would continue to spread from untreated locations, resulting in long-term adverse impacts to visitor experience (similar to the no-action alternative) on most of the canyon floor.

Cumulative Impacts. Alternative D would not mitigate other existing human-related impacts to visitor use and experience within canyon-bottom habitats. Additionally, tamarisk and Russian olive would continue to spread from untreated areas, resulting in long-term, adverse impacts similar to those identified for the no-action alternative. Limited visual improvements and measurable results would likely minimize any opportunity for development of more integrated strategies to address overall management of canyon-bottom natural and cultural resources.

Conclusion. Under alternative D, short-term, minor to moderate adverse impacts would occur to visitor use and experience due to increased noise and temporary closures during heavy equipment use and removal activities. Some, minor, longer-term benefits to viewsheds and visitor experience would be realized, but these benefits would be restricted to treatment locations. Tamarisk and Russian olive would continue to spread from untreated locations, further diminishing the visual conditions of the canyons and the visitors understanding of the parks cultural and natural resources.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

4.2.16 Socioeconomic Conditions

See Table 3 for definitions of intensity levels.

Effects of the No-Action Alternative:

Analysis. The aggressive spread of tamarisk and Russian olive would continue under the no-action alternative. Further degradation of the canyon floor and associated agricultural resources would occur as a result continued loss of stream channel integrity, water resources (condition and availability), and farmable lands. The long-term sustainability of current levels of subsistence agriculture would be jeopardized. Irrigation would become more difficult over a wider area of the canyon floor as the presence of tamarisk and Russian olive continue to create lowered stream channels as a result of unnatural levels of incision. Under the no-action alternative short- and long-term impacts to socioeconomic conditions would be adverse and of moderate intensity.

Cumulative Impacts. Subsistence agriculture has occurred for thousands of years in Canyon de Chelly and Canyon del Muerto. Ancestral Puebloan populations and Hopi grew corn, beans, squash, melons, gourds, and cotton. The Hopi also planted peach trees in the monument. When they settled the monument in the 20th century, the Navajo planted crops of corn, melons, squash, and beans. Alfalfa and hay cultivation were added in later historic times. Cultivated fields are located along the canyon floor, including alcoves, on embankments on the sides of the streams, and on natural terraces. Orchards were also planted near the canyon walls, as to maximize the use of wall runoff water. Farming is not, currently, as prevalent as it has historically been, however, agricultural activities (including grazing) still occur in many areas of the canyon.

The presence of tamarisk and Russian olive has had several direct and indirect adverse impacts to the agricultural areas of the canyons. These invasive species have directly invaded once farmable areas, have created conditions of unnatural erosion and loss of

farmable lands, and serve as barriers to livestock, both physically and through loss of native understory vegetation. Agricultural lands have been further impacted through salt-deposition (from tamarisk) to soils, lowered groundwater levels, and difficulties with irrigation. Long-term sustainability of exiting socioeconomic conditions would not improve, and would remain jeopardized, under the no-action alternative.

Conclusion. No improvement to degrading agricultural conditions would be realized under the no-action alternative. Adverse impacts, of moderate intensity would continue to increase. The long-term sustainability of exiting socioeconomic conditions would remain jeopardized.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under the no-action alternative.

Effects of the Preferred Alternative (Alternative A):

Analysis. Alternative A would have short-term, minor to moderate, adverse impacts to socioeconomic conditions as some farmable land is lost due to streambank lateral erosion as more natural channel conditions are established. These impacts would be of minor to moderate intensity and would be minimized through field investigations (adaptive management study) to identify the most applicable removal techniques. Minimal potential for adverse impacts to farmable lands exist as a result of herbicide overspray or drip. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to existing socioeconomic conditions.

Activities identified under alternative A would provide the park with the needed information and tools to implement effective, large-scale tamarisk and Russian olive removals throughout the canyon-bottom habitats, significantly reducing the direct and indirect impacts identified under the no-action alternative. Tamarisk and Russian olive spread would halt, and most areas of current infestation, unless associated with a species of special concern (see section 3.3.8), would be mitigated or fully restored. Impacts to farmable lands created by salt deposition, lowered groundwater and unnatural levels of land erosion would also be mitigated by actions identified under the preferred alternative. Long-term impacts would be beneficial to socioeconomic conditions, and of moderate intensity.

Cumulative Impacts. Direct and indirect impacts to socioeconomic conditions, created by other human-related disturbances (external dams and logging, unregulated livestock, and vehicle use) would remain under alternative A. However, the management of tamarisk and Russian olive would provide mitigation to the largest immediate threat to socioeconomic conditions and would assist in facilitating additional innovative

approaches to mitigating other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. The preferred alternative would result in short-term, minor to moderate adverse impacts, but would have long-term, beneficial impacts of moderate intensity. Long-term, cumulative effects would be beneficial, of moderate intensity and would afford the best opportunity for improvement of canyon agriculture and long-term sustainability.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative A.

Effects of the Environmentally Preferred Alternative (Alternative B):

Analysis. Alternative B would have similar, short-term, minor to moderate, adverse impacts to socioeconomic conditions due to streambank lateral erosion in establishing more natural, and sustainable channel conditions. This impact would be of minor to moderate intensity. Short-term, adverse impacts, of minor to moderate intensity, would occur under the environmentally preferred alternative. No heavy equipment would be used under alternative B. Temporary impacts resulting from tamarisk and Russian olive would be similar to those described for the above preferred alternative (Alternative A). Some loss of farmable lands, adjacent to channelized sections of stream channels, would occur as lateral streambank erosion takes place to re-establish a more natural and sustainable channel condition.

Since Alternative B would rely completely on the use of herbicide applications (cut stumps or low volume basal spray) potential for negligible to minor impacts to farmable lands as a result of herbicide overspray or drip could occur. Herbicide applications, however, would be distinctly targeted, greatly minimizing the potential for adverse impacts. All general mitigation measures as identified in section 2.2.6 would assist in minimizing adverse impacts to farmlands.

Alternative B would have long-term beneficial effects of moderate intensity. However, the environmentally preferred alternative would be labor intensive and would require a longer timeframe to achieve full beneficial effects. In the interim, some additional losses to farmable land (and socioeconomic conditions) due to tamarisk and Russian olive spread would occur. Long-term, effects would be beneficial, of moderate intensity, and would provide a strong opportunity for improvement of canyon agriculture and long-term sustainability.

Cumulative Impacts. Alternative B would not mitigate all human-related disturbances to socioeconomic conditions within the canyon-bottom environments (impacts from external dams, logging, unregulated grazing and vehicle use), but this alternative would provide management actions necessary to mitigate one of the most immediate threats – tamarisk and Russian olive infestation. Similar to alternative A, the environmentally preferred alternative is likely to assist in developing more integrated management strategies throughout the canyon-bottom environments, facilitating additional innovative approaches to mitigating some of these other adverse human-related disturbances. As a result, cumulative effects would be beneficial and of moderate intensity.

Conclusion. Long-term, impacts of alternative B would be beneficial and of moderate intensity. Implementation of this alternative affords strong opportunity for facilitating a more integrated and sustainable approach in managing canyon-bottom socioeconomic conditions. Alternative B, though similar to Alternative A in its beneficial effects, would require a much longer timeframe to fully implement.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative B.

Effects of the Alternative C (above ground mechanical removal only):

Analysis. Alternative C would use heavy equipment only to remove above ground portions of tamarisk and Russian olive. No herbicide use would occur under alternative C. Short-term, minor adverse impacts would occur in treated locations as lateral channel erosion occurs in treated areas, with negligible to minor long-term benefits once channel erosion stabilizes. Actions under alternative C would be limited in application to "non-sensitive" areas. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, cumulative impacts to farmlands and subsistence uses throughout most of the canyon floor environments would be similar to the no-action alternative. Moderate, long-term, adverse effects to socioeconomic conditions would occur in the canyon-bottom environments.

Cumulative Impacts. Implementation of alternative C would not mitigate other human-related disturbances that currently impact socioeconomic conditions related to the canyon floor. Under alternative C, some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, but these benefits would be jeopardized by potential re-sprouting of tamarisk and Russian olive from remaining root systems. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits under alternative C would be less likely to assist in facilitating integrated management strategies for

developing sustainable agriculture and improved socioeconomic conditions at Canyon de Chelly National Monument.

Conclusion. Limited long-term, negligible to minor, beneficial effects would occur in treated locations. The socioeconomic conditions associated with canyon-bottom environments would incur long-term adverse impacts, or moderate intensity, as identified under the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative C.

Effects of Alternative D (whole tree removal above and below ground):

Analysis. Alternative D would use heavy equipment to remove both above and below-ground portions of Tamarisk and Russian olive. No herbicide would be used under alternative D. Short-term, minor to moderate, adverse impacts would occur in treated locations as a result of increased lateral channel erosion as stream channels attempt to stabilize. Negligible to minor, long-term benefits may occur in treated areas once channel erosion stabilizes. Actions under alternative D would be limited in application to "non-sensitive" areas. Tamarisk and Russian olive would continue to spread from non-treated locations. Long-term, impacts to socioeconomic conditions throughout most of the canyon-bottom environments would be similar to the no-action alternative.

Cumulative Impacts. Implementation of alternative D would not mitigate other human-related disturbances that currently impact unique farmlands and socioeconomic conditions of the canyon-bottom environments. Some longer-term, negligible to minor, beneficial effects could be realized in treatment locations, however, tamarisk and Russian olive would continue to spread from non-treated locations. Long-term effects would remain adverse and of moderate intensity throughout most of the canyon floor. The lack of visual improvement and measurable benefits would result in alternative D being less likely to assist in facilitating integrated management strategies for developing sustainable agriculture and improved socioeconomic conditions at Canyon de Chelly National Monument.

Conclusion. Under alternative D, limited long-term, negligible to minor, beneficial effects would occur in treated locations. Socioeconomic conditions, however, would continue to degrade as tamarisk and Russian olive continue to spread. Long-term adverse impacts to socioeconomic conditions would be of moderate intensity and similar to those identified for the no-action alternative.

Impairment Determination. Since there would be no major, adverse impacts to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Canyon de Chelly National Monument; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant National Park Service planning documents, within the foreseeable future there would be no impairment of the park's resources or values under alternative D.

5 Consultation and Coordination

5.1 Agencies, Tribes, Organizations Contacted

U.S. Fish and Wildlife Service
Navajo Nation Department of Fish and Wildlife
Navajo Nation

5.2 Preparers

Pamela Benjamin, Vegetation Ecologist, Intermountain Regional Office – Denver, National Park Service. B.S. and M.S. Biology. 15 years NPS. Document lead - responsible for natural and cultural resource research, impact evaluations and document preparation.

Heather Germaine, National Natural Landmarks Coordinator, Intermountain Regional Office – Denver, National Park Service. Responsible for coordination of informal consultations with USFWS and Navajo Nation NHP and evaluation of impacts to species of special concern.

Jennifer Lavris-Vanishing Treasures Archeologist, Canyon de Chelly National Monument. Contributor-Cultural Resource text and analysis.

Elaine Leslie, Assistant Superintendent, Canyon de Chelly National Monument, National Park Service, Department of the Interior. Final Review and submission. USFWS and NNFW Consultation.

Michael Rees, Natural Resource Specialist, Denver Service Center – Denver, National Park Service. Responsible for natural resource research and impact evaluations.

Larissa Read, Natural Resources / Biological Technician, Intermountain Regional Office - Denver, National Park Service. B.A. Biology, M.S. Environmental Sciences. 2 years NPS. Responsible for document formatting and technical review.

Scott Travis, Superintendent, Canyon de Chelly National Monument, National Park Service – Chinle Arizona. Responsible for scoping, cultural resource research, impact evaluations, and technical review.

6 List of Recipients

Navajo Nation
BIA
US Fish and Wildlife Service
NRCS-Flagstaff and Chinle Units
Canyon Residents List
IHS

References

Andrews, T.J. 1990. "Navajo Land Use and Settlement Patterns in Canyon de Chelly and Canyon del Muerto." Report prepared for Canyon de Chelly National Monument. On file at park headquarters.

Burgess, T.L. 1973. "Mammals of the Canyon de Chelly Region, Apache County, Arizona." Journal of the Arizona Academy of Science:21-25.

Cook, K.E. 1994. "The Desert Plateau and Canyon Floor – Contrasting the Plant Communities of Canyon de Chelly." Report prepared by Department of Biology, Western Washington University.

Cooper, D.J., D.C. Andersen, R.A. Chimner. 2003. Multiple pathways for woody plant establishment on floodplains at local to regional scales. *Journal of Ecology* 91: 182-196.

Cooper, D.J. and Ellen Wohl. 2003. Developing concepts for stream channel and floodplain restoration at Canyon de Chelly National Monument, Arizona: An adaptive management approach. 2004 NPS Fee Demonstration Program study proposal. 19pp.

Dennis, A.E. 1975. "The Natural Vegetation of Canyon de Chelly National Monument." The Kiva 41(1):15-21.

Dolan, M.T. 1993. Canyon del Muerto Archeological Reconnaissance Survey, Canyon de Chelly National Monument – Quaternary Geomorphic History of Canyon del Muerto.

Halse, R.R. 1973. "The Flora of Canyon de Chelly National Monument." M.S. Thesis, University of Arizona.

Harlan, A. and A.E. Dennis. 1976. A Preliminary Plant Geography of Canyon de Chelly National Monument. *Journal of the Arizona Academy of Science* 69-78.

Hasty, G.M. and D.P. Fletcher. 1998. "A Checklist of Wildlife of Canyon de Chelly National Monument." Southwest Parks and Monuments Association, Tucson, Arizona.

McDonald, J.A. 1976. "An Archeological Assessment of Canyon de Chelly National Monument". Publications in Anthropology, #5. Western Archeological Center. Tucson, AZ.

Morris, D.P. 1986. "Archeological Investigations at Antelope House." NPS. Washington D.C.

National Park Service. 2004. Trip Report for October 2003 Canyon de Chelly National Monument. 20pp.

National Park Service Air Resources Division (NPS-ARD). 2003. AirWeb: Protecting Air Quality. 7/17/2003: http://www2.nature.nps.gov/ard/.

National Park Service. 1999. "Baseline Water Quality Data Inventory and Analysis – Canyon de Chelly National Monument." Technical Report NPS/NR/WRD/NRTR-99/228. Water Resources Division, Fort Collins, Colorado.

National Park Service (NPS). 2000. Management Policies 2001. Publication D1416. U.S. Department of the Interior, 137pp.

National Park Service. 1989. Canyon de Chelly National Monument - Resources Management Plan. 45pp.

National Park Service. 1986b. "Canyon de Chelly Statement for Management." On file at park headquarters.

National Park Service. 1987. Canyon de Chelly National Monument - Statement for Management. 31pp.

Remley, A.R. 1993. "The Canyon de Chelly Interpretive Ranger's Manual." 1st Draft. Funded by Canyon de Chelly National Monument and Southwest Parks and Monuments Association, Tucson, Arizona. On file at park headquarters.

Rinks, G. 2003. 'Vascular Flora of Canyon de Chelly National Monument, Apache County, Arizona." M.S. Thesis. Northern Arizona University, Flagstaff, Arizona.

USDA, Natural Resources Conservation Service. 2000. Natural Resource Plan – Canyon del Muerto/Tsaile Creek Watershed. Chinle, Arizona, 76 pp.

7 Appendices

Appendix 1. US Fish and Wildlife Service Letter of Concurrence with NPS Determination of Impacts to Threatened and Endangered Species.

AESO/SE
02-21-04-I-0224

May 7, 2004

Memorandum

To: Wildlife Biologist, Intermountain Regional Office, National Park Service, Denver, Colorado (Attn: Cay Ogden)

From: Field Supervisor

Subject: Canyon de Chelly National Monument Tamarisk and Russian Olive Removal Species List

Thank you for your correspondence of April 2, 2004. This memorandum responds to your request for our concurrence with your initial determinations for sensitive species and suitable habitat for the subject proposed action. The action is the removal of tamarisk (*Tamarix ramosissima, T. chinensis* and their hybrids) and Russian olive (*Elaeagnus angustifolia*), and restoration with native plants, primarily willows. Work would occur in Canyon de Chelly National Monument (Monument) along Chinle Wash east of the Monument's visitors' center and upstream in Canyons de Chelly and del Muerto, Apache County, Arizona. Our comments are presented by species in the order they occur in your letter.

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Recovery Plan (U.S. Fish and Wildlife Service, 2002) contains recommendations for the management of exotic plant species (see Recovery Action 1.1.3.2 and Appendix H). In summary, the plan advises determining and evaluating the root causes and associated conditions that facilitate the spread of exotics. These conditions could include decreased water table, increased soil salinity, and alterations in disturbance regimes, both natural (e.g., flood flows) and introduced (e.g., livestock grazing). If it is unclear what the causes are, it can be useful to determine whether there were past actions (e.g., different grazing regime) that precipitated the invasion and spread of exotics. After the root causes have been evaluated, a plan should be developed to (1) reduce the conditions that have allowed the exotics to be successful and (2) re-establish a functional semblance of the conditions that allow native plants to thrive. We advise incorporating these recommendations early in your planning, independent of southwestern willow flycatcher considerations, because if the root causes for the presence of exotics is not addressed then the symptoms (thriving tamarisk and Russian olive) will likely persist. The potential for erosion, and to "release" other exotics, such as camelthorn (*Alhagi pseudalhagi*), once the tamarisk and Russian olive have been removed, should also be considered. The description of the environment in your letter mentions that conditions necessary to support native riparian communities

appear to be present in Chinle Wash, with various age classes of cottonwoods and abundant willows present, but that Russian olive and tamarisk have spread dramatically upstream in the canyons. Based on this information it appears the riparian conditions within the Monument are complex. We recommend a study of fluvial-geomorphic processes and riparian dynamics to gain a better understanding of these conditions and determine an effective strategy to address them.

The means of addressing the Mexican Spotted Owl (*Strix occidentalis lucida*) (spotted owl) presented in your letter is avoidance, and the project area depicted on enclosed maps ends where spotted owl suitable habitat begins. The presence of restricted areas, per the Recovery Plan for the Mexican Spotted Owl (USDI Fish and Wildlife Service, 1995), within the project area does not preclude management that maintains or enhances owl habitat. Nesting and roosting habitat may be present on steep slopes or within canyons. If spotted owls are found then avoidance, particularly during the breeding season, is advised. However, even within a protected activity center, a limited amount of certain management actions (e.g., to reduce the risk for fire) is allowable. With respect to surveys we recommend clarifying the circumstances under which surveys will be conducted. In your Initial Determination table, the term "*reasonable probability* of supporting…owls", used to determine areas where surveys will be conducted, should be defined or replaced with "areas where…owls *may be present*". This comment also applies to the southwestern willow flycatcher.

Suitable habitat for both the southwestern willow flycatcher and spotted owl is in the process of being re-designated. The final rule designating suitable habitat for the spotted owl should be published by August 20, 2004. The draft suitable habitat proposal for the willow flycatcher should be released this fall.

Your determination states that the California condor (*Gymnogyps californianus*) (condor) has not been found as far east as the project area. As of 2002, condor movements have been documented 140 miles or more from the release site at Vermillion Cliffs on five occasions. The most eastward movement was in the general area of Grand Mesa, Colorado, 275 miles from the release site. Canyon de Chelly is about 130 miles from the release site. For the Monument's General Management Plan (GMP) we have recommended that the National Park Service develop a plan of action if condors are documented in the vicinity of the Monument. Further action at this time, for either the GMP or the subject action, is at the discretion of the Park Service.

Navajo sedge (*Carex specuicola*) is typically found in hanging gardens on sandstone cliffs, but may occur at the base of cliffs if suitably moist soil conditions (e.g., a seep) are present. It appears that the subject action will take place a significant distance from any cliffs. This fact should be clarified to support your determination.

Your determination for several species is that they will not be further evaluated based on the lack of habitat. Your evaluation may be enhanced by also including information about the known distribution of these species. For example, Chiricahua leopard frog (*Rana chiricahuensis*) habitat also includes livestock tanks, which may be present in the

action area. However, the current distribution for this species is about 130 miles from the monument. Conversely, the determination for the Zuni fleabane should be based not only on the known elevational range for this species but also on the presence of suitable habitat (i.e., detrital clay soils).

In summary, we concur with the species you are evaluating for the subject action and recommend that you consider the above comments in your initial determinations. Should you require further assistance or if you have any questions, please contact John Nystedt (x104) or Brenda Smith (x101) of our Flagstaff Suboffice at (928) 226-0614. In future correspondence, please refer to file number 02-21-04-I-0224. Thank you for your continued efforts to conserve endangered species.

/s/ Steven L. Spangle

cc: Director, Navajo Nation Department of Fish and Wildlife, Window Rock, AZ
NEPA Coordinator, Navajo Region, Bureau of Indian Affairs, Gallup, NM

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Appendix 2. Garlon 3A Herbicide

Material Safety Data Sheet
Date: Thursday, April 22, 2004
Last Revised Date: 11/19/03
SECTION 1 - CHEMICAL PRODUCT and COMPANY IDENTIFICATION
Catalog Number: PS-417
Description: Triclopyr
Other Name(s): 3.5.6-Trichloro-2-pyridinyloxyacetic acid/Crossbow(TM)/Garlon(TM)
Supplied by CHEM SERVICE, Inc. PO BOX 599, WEST CHESTER, PA 19381 (610)-692-3026
EMERGENCY PHONE: 1-610-692-3026
SECTION 2 - COMPOSITION, INFORMATION ON INGREDIENTS
CAS No.: 55335-06-3
Description: Triclopyr
EINECS No.: Not Available
Hazard Symbols: Not Available
SECTION 3 - HAZARDS IDENTIFICATION
Contact lenses should not be worn in the laboratory.All chemicals should be considered hazardous -
Avoid direct physical contact!
May be harmful by inhalation, ingestion, or skin absorption. Can cause eye irritation. Can cause skin irritation. Dust and/or vapors can cause irritation to respiratory tract. Can be irritating to mucous membranes.
SECTION 4 - FIRST AID MEASURES
An antidote is a substance intended to counteract the effect of a poison. It should be administered only by a physician or trained emergency personnel. Medical advice can be obtained from a POISON CONTROL CENTER. In case of contact: Flush eyes continuously with water for 15-20 minutes. Flush skin with water for 15-20 minutes. If no burns have occurred-use soap and water to cleanse skin. If inhaled remove patient to fresh air. Administer oxygen if patient is having difficulty breathing. If patient has stopped breathing administer artificial respirations. If patient is in cardiac arrest administer CPR. Continue life supporting measures until medical assistance has arrived. If patient is exhibiting signs of shock - Keep warm and quiet. Contact Poison Control Center immediately if necessary. Do not administer liquids or induce vomiting to an unconscious or convulsing person. If patient is vomiting-watch closely to make sure airway does not become obstructed by vomit. If swallowed, rinse out mouth with water, providing the person is conscious. Get medical attention if necessary. Remove and wash contaminated clothing.
SECTION 5 - FIRE AND EXPLOSION DATA
Flash Point: Not Available
Extinguishing Media: Carbon dioxide, dry chemical powder or spray.
Upper Explosion Limit: Not Available
Lower Explosion Limit: Not Available
Autoignition Temperature: Not Available
NFPA Hazard Rating: Not Available

SECTION 6 - ACCIENTAL RELEASE MEASURES
Spills or leaks: Evacuate area. Wear appropriate OSHA regulated equipment. Ventilate area. Sweep up and place in an appropriate container. Hold for disposal.
Wash contaminated surfaces to remove any residues. Remove contaminated clothing and wash before reuse.
SECTION 7 - HANDLING AND STORAGE
Handling:
This chemical should be handled only in a hood. Eye shields should be worn.
Use appropriate OSHA/MSHA approved safety equipment.
Avoid contact with skin, eyes and clothing. Avoid ingestion and inhalation
Wash thoroughly after handling.
Storage:
Store in a cool dry place. Store only with compatible chemicals.
Keep tightly closed.
SECTION 8 - EXPOSURE CONTROLS/PERSONAL PROTECTION
OSHA PEL (TWA): Not Available
ACGIH TLV (TWA): Not Available
ACGIH TLV (STEL): Not Available
Personal Protective Equipment
Eyes: Wear Safety Glasses.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to minimize contact with skin.
Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 requirements must be followed whenever workplace conditions warrant a respirator's use.
SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES
Color: colorless
Phase: Crystalline solid
Melting Point: 148-150 C
Boiling Point: Not Available
Specific Gravity: Not Available
Vapor Density: 1.26E-6mm@
Vapor Preasure: Not Available
Solubility in Water: Very slightly soluble
Odor: Not Available
Evaporation Rate (Butyl acetate=1): Not Available
Molecular Weight: 256.47
Molecular Formula: C7H4Cl3NO3
SECTION 10 - STABILITY AND REACTIVITY
Sensitive to light - dark color does not affect purity. Readily absorbed and retained on clothing and/or shoes.
SECTION 11 - TOXICOLOGY INFORMATION
RTECS: AJ9000000
Oral Rat or Mouse LD50: 713mg/kg
Dermal Rat or Mouse LD50: Not Available
Rat or Mouse LC50 : Not Available
Carcinogenicity

OSHA: No
IARC: No
NTP: No
ACGIH: No
NIOSH: No
Other: No

SECTION 12 - ECOLOGICAL INFORMATION

Ecotoxicity: Not Available
Environmental Fate: Not Available

SECTION 13 - DISPOSAL CONSIDERATIONS

DISPOSAL: Burn in a chemicals incinerator equipped with an afterburner and scrubber.

SECTION 14 - TRANSPORTATION INFORMATION

UN Number: UN2811
Class: 6.1
Packing Group: III
Proper Shipping Name: Toxic Solid, Organic, nos *

SECTION 15 - REGULATORY INFORMATION

European Labeling in Accordance with EC Directives
Hazard Symbols: Not Available
Risk Phrases: Not Available
Safety Phrase: Not Available

SECTION 16 - OTHER INFORMATION

The above information is believed to be correct on the date it was last revised and must not be considered all inclusive. The information has been obtained only by a search of available literature and is only a guide for handling the chemicals. OSHA regulations require that if other hazards become evident, an upgraded MSDS must be made available to the employee within three months. RESPONSIBILITY for updates lies with the employer and not with CHEM SERVICE, Inc.
Persons not specifically and properly trained should not handle this chemical or its container.

Garlon References

Garlon 3A. *Specimen Label*. Dow AgroSciences.
Garlon 3A. *Material Safety Data Sheet*. Dow AgroSciences.
Gardener, S.C., et al. “Single Species Algal (*Ankistrdesmus*) Toxicity Tests with Rodeo and Garlon 3A.”
1997. *Bulletin of Environmental and Contamination Toxicology*. 59:492-499.
Triclopyr. EPA R.E.D. Facts. 1998. United States Environmental Protection Agency. EPA-738-F-98-007.
Vogue, P.A., et al. *OSU Extension Pesticide Properties Database*. 1994 http://ace.orst.edu/info/nptn/ppdmove.htm (2/2/01).
Triclopyr. Extension Toxicology Network. 1996. http://ace.orst.edu/info/extoxnet/pips/triclopy.htm (2/2/01).
Solomon, K.R., “Persistence of Hexazinone (Velpar), triclopyr (Garlon), and 2,4,-D in a Northern Ontario

Aquatic Environment." 1988. *Journal of Agricultural Food Chemistry* 36:1314-1318.
Stephenson, G.R., et al. "Persistence, Leachability, and Lateral Movement of Triclopyr (Garlon) in Selected Canadian Forestry Soils." 1990. *Journal of Agricultural Food Chemistry* 38:584-588.
USDA. Risk Assessment for Herbicide Use in Forest Service Regions 1, 2, 3, 4, and 10 and on Bonneville Power Administration Sites. 1992. *Contract number 53-3187-9-30.*
Wan, M.T., et al. "Acute Toxicity to Juvenile Pacific Salmonids of Garlon 3A, Garlon 4, Triclopyr, Triclopyr Ester, and Their Transformation Products: 3,5,6-Trichloro-2-pyridinol and 2-Methoxy-3,5,6- trichloropyridine." 1987. *Bulletin of Environmental and Contamination Toxicology* 39:721-728.
Please refer to Specimen Labels and Material Safety Data Sheets for Garlon 3a

Appendix 3. Remedy® Herbicide Specimen Label

MSDS Document
Product Remedy
1. Chemical Product and Company Identification
Trade Name of this Product Remedy
MSDS ID DA7040
Manufacturer
Drummond American
600 Corporate Woods Parkway
Vernon Hills, IL 60061
Contact Name
Corporate Compliance Team
Phone Number
(847) 913-9313
Emergency Phone
(888) 426-4851
Revision Date 04/27/2004
Reactivity:
Specific
2. Composition and Information on Ingredients
Ingredient CAS Number Weight % ACGIH TLV PEL STEL
LIQUIFIED
PETROLEUM GAS
68476-85-7 1% - 10% 1000 ppm 1000 ppm ND
D-LIMONENE 5989-27-5 1% - 5% NE NE NE
PROPRIETARY
EMULSIFIER
N/Ap N/Av % ND ND ND
SODIUM
METASILICATE
6834-92-0 N/Av % ND ND ND
WATER 7732-18-5 N/Av % ND ND ND
3. Hazard Identification
Route(s) of Entry
Eyes. Skin. Ingestion. Inhalation.
Eyes
May cause irritation.
Print Date 12/01/2004
MSDS ID DA7040
Remedy
Skin
Direct contact may cause the following effects: Redness.

Inhalation
May cause the following effects: Dizziness. Sore throat. Drowsiness.
Ingestion
No information available.
Medical Conditions Aggravated by Exposure
Pre-existing skin conditions may be aggravated by exposure to this product. Pre-existing respiratory conditions may be aggravated by exposure to this product. Pre-existing eye conditions may be aggravated by exposure to this product.
4. First Aid Information
Skin
Flush skin with water. Immediately wash skin with soap and plenty of water. Remove contaminated clothing. Get medical attention if symptoms occur. Wash clothing before reuse.
Inhalation
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Eye
Hold eyelids apart and flush eyes with plenty of water for at least 15 minutes. Seek medical attention if irritation persists.
Ingestion
Seek medical attention.
5. Fire Fighting Measures
Flash Point >100°F (>37°C)
FP Method N/Av
LEL 1.8
UEL 9.2
Extinguishing Media
Carbon dioxide. Foam. Dry chemical.
Fire and Explosion Hazards
Product is nonflammable and nonexplosive under normal conditions of use. This product has been tested in accordance with the method described in 16 CFR 1500 and found to be not flammable. Containers may vent or burst under extreme or prolonged fire conditions.
Special Fire Fighting Procedures
Keep containers cool. Use shielding to protect against bursting or venting containers. Water should be used to cool closed containers to prevent pressure build-up and possible

Remedy autoignition or explosion when exposed to extreme heat.
6. Accidental Release Measures
Small Spill
Eliminate all sources of ignition. Ventilate area to maintain exposure below permissible exposure limits. Soak up with noncombustible inert absorbent material. Collect and contain for disposal. Dispose of absorbent in accordance with local, state and federal regulations.
Large Spill

Follow procedures for small spill.

7. Handling and Storage

Handling

Avoid breathing vapors. Use with adequate ventilation. Do not puncture or incinerate. Use only according to label directions.

Storage

Do not store in direct sunlight. Keep away from heat and flame. Store in temperatures below 130 degrees F (53°C).

NFPA Storage Codes

Store as Level 1 Aerosol (NFPA 30B).

8. Exposure Controls and Personal Protection

Eye Protection

ANSI approved safety glasses are recommended to prevent accidental eye contact.

Protective Gloves

The following glove(s) are recommended: Chemical resistant gloves. Consult glove manufacturer to determine the proper type for a specific operation.

Ventilation

Local: recommended. Mechanical: optional.

Respiratory Protection

If the exposure limits are exceeded, a NIOSH/MSHA approved respirator is recommended.

Seek professional advise prior to respirator selection and use.

Other Protective Clothing

Impermeable clothing should be worn.

9. Physical and Chemical Properties

Physical State Aerosol

Specific Gravity 0.9517

Color/Appearance Coarse white mist

Remedy

Odor Citrus

pH N/Ap

Boiling/Cond. Point N/Av

Melting/Freezing Point N/Av

Solubility Almost complete

Evaporation Rate <1 (Ether = 1)

VOC % 7.8 by weight

Percent Volatile N/Av

Viscosity N/Av

Vapor Density >1 (Air = 1)

Vapor Pressure 126psig @130°F

10. Stability and Reactivity

Stability

Stable.

Hazardous Polymerization
Will not occur.
Incompatibility
Strong oxidizing agents.
Hazardous Decomposition Products
Toxic chemicals. Carbon dioxide. Carbon monoxide.
Conditions to Avoid
Avoid direct sunlight. Avoid heat. Avoid open flames. Avoid sparks. Do not store above 130 degrees F (53°C). Dropping of containers may cause bursting.
11. Toxicological Information
Carcinogenicity
None of the components are listed by NTP, IARC, or OSHA as carcinogenic.
12. Ecological Information
Ecological Information
No information available.
13. Disposal Considerations
Waste Disposal Method
Do not puncture or incinerate. When contents are depleted, depress button until all gas is expelled. Dispose in accordance with federal, state, and local regulations.
14. Transportation Information
Proper Shipping Name
Aerosol, flammable Consumer Commodity (ORM-D)

Print Date 12/01/2004
MSDS ID DA7040
Remedy
DOT Class
ORM-D.
IATA Class
2.1 (Flammable Gas)
ID Number
UN1950
15. Regulatory Information
CPR Certification
This product has been classified in accordance with the hazard criteria of the Controlled Product Regulations and the MSDS contains all of the information required by the Controlled Product Regulations.
TSCA Certification
All chemicals in this product are listed, or are exempt from listing on the TSCA inventory.
S.A.R.A. Title III, Section 313
This product contains no listed chemicals subject to reporting.
16. Other Information
Disclaimer
The information accumulated herein is believed to be accurate but is not warranted to be

whether originating with the company or not. Recipients are advised to confirm in advanceof need that the information is current, applicable, and suitable to their circumstances.