

HISTORIC STRUCTURES—VEGETATION CONTROL
FORT LARAMIE NATIONAL HISTORIC SITE

MANAGEMENT PLAN

COOPERATIVE ECOSYSTEM STUDIES UNIT GRANT (CA-1200-99-007)

MARCH 31, 2005

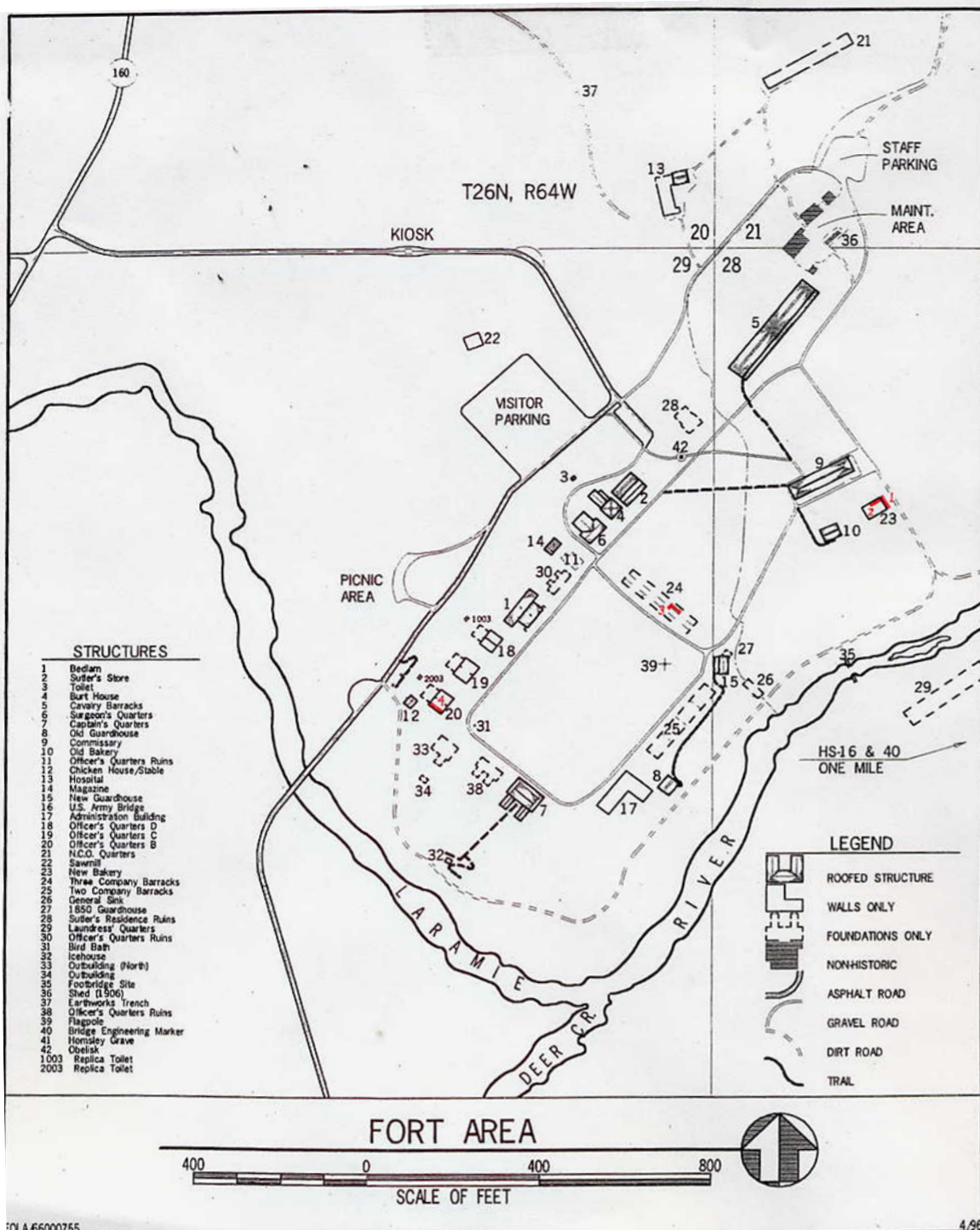


Figure 1. Sites 1-4 for experiment.
 Map reprinted from *Lime Concrete and Plaster Preservation Project, Phase I: History of Stabilization and Maintenance and Conditions Assessment, Fort Laramie National Historic Site, Fort Laramie, Wyoming.*

Historic Structures—Vegetation Control

Description of Methodology

Objectives and Schedule

The principal objectives were the assessment of the effects of two herbicides and manual removal on unwanted vegetation and on lime concrete, which comprises a significant amount of the historic fabric of the architecture and ruins at Fort Laramie National Historic Site. The experiment was initiated on May 18, 2004, and continued through September 3, 2004, as vegetation tends to flourish during this period.

Test Sites and Plots

Four sites (Figure 1) were chosen to represent visible, variable exposures to sunlight, wind, and moisture and some variety in the vegetation; composition of the soil was not considered in the selection of these sites. Each of the four sites contained four plots, which measured four feet by four feet and which were labeled Plot A through D and arranged linearly in the ruins of the historic architecture. In all four sites, Plots A and B were separated by a distance of approximately eight feet, with an additional, similar interval between Plots B and C; this separation served as a buffer, because Plots A and B were reserved for the application of the herbicides. Plots C and D were immediately adjacent at all four sites.

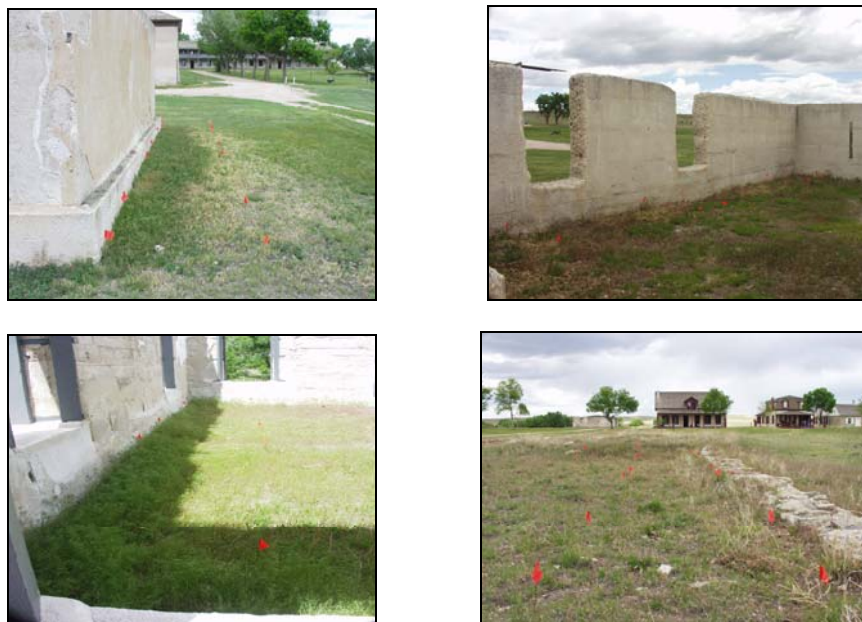


Figure 2. Clockwise from upper left, Sites 1-4. May 27, 2004.
Photographs by Joshua F. Moro.

Site 1 was located along the exterior of the northeast wall of Historic Structure 23 (New Bakery), and the four plots stretched along its length. Site 2 was located inside Historic Structure 23 along the northwest wall, with Plot D at the interior northeast corner. Site 3 was located among the ruins of the foundation of Historic Structure 24 (Old Barracks), and the plots were aligned in a northwesterly direction with Plot D jutting southward to form an L; this arrangement occurred due to the terrain at this site and the limitations of space. Site 4 rested inside Historic Structure 20 (Officer's Quarters B) along the southwest wall, with Plot C in the southwest corner of the ruin and Plot D against the northwest wall; this configuration was again the result of the confined space of the ruin.

Application of Herbicides and Manual Removal of Vegetation

The herbicide Garlon* 4 (triclopyr) was applied on Plot A in the four sites. Roundup Weed & Grass Killer (glyphosate) was applied in Plot B. Plot C served as the plot for observation or the control, as no treatment occurred in this plot. In Plot D, vegetation was either removed entirely manually or the weeds and grasses were trimmed to a height approximately two inches above the ground.

Application of the herbicides was accomplished with a hand-pumped sprayer: for the application of Roundup Weed & Grass Killer, a multi-purpose one-gallon sprayer—the Mainstays Garden Model 1201GBB—was used; for the application of Garlon* 4, a unit carried in a backpack—SP Systems Model SP1 with a Swissmex nozzle—was used. Only enough herbicide to cover the vegetation completely was applied. Because this method required only limited amounts of herbicide, the manufacturer's formula for dilution was followed. Care was taken to ensure that all plots received the same amount of herbicide. Each individual plot required less than one minute to spray, and a large sheet of cardboard shielded the historic fabric during the application.

The first application of herbicides occurred on June 2 between 1:00 P.M. and 2:00 P.M. The remainder of the Garlon* 4 from an earlier treatment by the Northern Great Plains Exotic Plant Management Team was applied; this batch had been tinted with a green dye that served to identify the herbicide after application. The second application occurred on July 15 around 9:00 A.M. A new solution of Garlon* 4 without the dye was applied. Both days had light winds and moderate heat.

Two or three applications were determined to be sufficient for this experiment. Previously, crews applied Roundup Weed & Grass Killer near the bases of the walls two or three times during the season—a procedure that proved successful in the abatement of vegetation. The process involved the use of a Femco sprayer mounted on a mini-truck; a member of the crew sprayed the vegetation as the truck traveled around the perimeters of the ruins and buildings.

Manual removal of vegetation in Plot D occurred twice—on June 17, approximately two weeks after the first application of herbicides, and on July 18, three days after the second application. The procedure consisted of removal or trimming of vegetation by hand within the plots to a distance between twelve and eighteen inches from the walls; beyond that distance, equipment, such as mowers and weed whackers, could be used with a reduced risk of damage to the historic fabric. Most of the vegetation was removed with this procedure, as the ground was very dry, allowing the plants to be easily extracted. (Note that, when removed manually, vegetation occasionally breaks at or near the surface, leaving the roots from which the plants regenerate.) The exception in this procedure was Plot 3D, which lay approximately four feet from any historic fabric and in which removal was limited to trimming the vegetation to an approximate height of two inches.

Exposure of Samples of Lime Concrete, Mortar, and Plaster

In Plots A and B throughout the four sites, samples of lime concrete, mortar, and plaster were placed for observation of any effects of the applications of the herbicides. The samples were debris from the nearby historic structures, which were collected and distributed randomly in the plots.

Preliminary Results

The manual control of vegetation in the small plots at these sites did not require intensive labor, but on a district-wide scale, this maintenance would pose challenges. Moreover, manual removal of vegetation embedded in the ruins creates the risk of damage to the historic fabric, as does the operation of mowers and weed whackers near the walls and the ruins of the foundations.

Garlon* 4 had the most visible impact on the vegetation. At all sites nearly 100% of the vegetation died, including the fragile pricklypear cactus (*Opuntia fragilis*) in Site 3. The amount of cover remained unchanged, however, because the dead vegetation still clung to the surface of the sites. (With annual treatments the dead vegetation would deteriorate until the soil was exposed.) After the first application of this herbicide tinted with the dye, the color of the lime concrete and the vegetation was altered. A greenish hue lasted until July 10, although minute specks of color were observed afterwards. A strong odor was detected as well, which was attributed to the methylated seed oil used as a surfactant in Garlon* 4.



Figure 3. Clockwise from upper left, Sites 1-4. July 18, 2004.
Photographs by Joshua F. Moro.

Roundup Weed & Grass Killer was almost equally detrimental to vegetation. Although rogue shoots of grass emerged a few weeks after its application, the effect on vegetation was similar at all four sites. Neither residue on the samples nor odors were evident after the applications.

Of chief concern were the effects of these two herbicides on lime concrete. Observations on the site revealed that, aside from the temporary discoloration from the dye, the herbicides seemingly never visibly affected the composition or color of the samples of lime concrete. To supplement this procedure and investigate the reactions at the microscopic level, samples of lime concrete were treated with solutions of Roundup Weed & Grass Killer. Each sample was exposed to 12 ml of solutions with 2% glyphosate, 1% glyphosate, and 0.84% glyphosate with diquat for two hours and monitored for the evolution of carbon dioxide at intervals of 5, 30, and 120 minutes; this reaction was anticipated, because lime concrete is alkaline and the pH of this herbicide is 4. No evolution of gas was observed with the methodology employed; however, small quantities could have been undetected—an observation that would not preclude occurrence of gradual erosion of the historic fabric after repeated exposure to this herbicide.¹ Experimentation with solutions of Garlon* 4 to determine reactions at the microscopic level proved to be a challenge: the composition of the lime concrete itself prevented any preparation of samples for analysis of reactions at this level. However, experimentation with samples of lime concrete and Garlon* 4 in the facilities of the University of Wyoming College of Engineering, which involved prolonged exposure to the herbicide, revealed no visible effect on composition and the eventual dissipation of discoloration.

While the preliminary results from the experiment with Roundup Weed & Grass Killer indicated no immediately detectable reaction with lime concrete and while the experiment with Garlon* 4 at the University of Wyoming College of Engineering indicated no visible effect on the composition of lime concrete, the long-term effect of the exposure of the historic fabric to these two herbicides has not been fully determined, as the experiment on the site spanned only a single season and as the experiments in the Scientific Research and Analytical Support Laboratory of the National Park Service yielded only partial, rather than conclusive, evidence of the lack of an immediate effect. Although a longitudinal analysis of the effects of the applications of these herbicides should be considered, the effects of the exposure of the lime concrete to the harsh climate at Fort Laramie National Historic Site could eventually be more deleterious than the infrequent exposure to the levels of herbicides in these applications.

¹The account of this procedure has been excerpted from the unpublished data of J. J. Bischoff and J. K. Herrmann, Scientific Research and Analytical Support Laboratory, National Park Service, with the permission of its authors.

Purpose and Need

Background

Fort Laramie National Historic Site occupies 832.85 acres on the banks of the Laramie River near its confluence with the North Platte River in Goshen County, Wyoming. In 1938 President Franklin D. Roosevelt designated the area as Fort Laramie National Monument under Proclamation Number 2292. Some of the relevant purposes included the observations that “the lands and structures are of great historic interest and constitute a historical landmark, and . . . it appears that it would be in the public interest to reserve such lands and structures.” After extensive restoration during the 1940s and 1950s, the monument was designated a National Historic Site in 1960. In 1966 the site was added to the National Register of Historic Places. Twenty years later, a review of the nomination for the National Register of Historic Places reduced the boundary of the historic district to include only the structures of the fort itself and the iron bridge that spans the North Platte River.

The significance of Fort Laramie National Historic Site lies in its key contributions to the National Park Service’s theme of westward expansion, including the migration of immigrants and the warfare between the indigenous peoples and the United States Army. The evolution of the site reflects that history. From 1834 to 1848, this locale featured a post pivotal in the trade in furs. In 1849 the post and the adjacent site were acquired by the government, and a garrison was established and operated until 1890. Several historic trails, including the Oregon Trail, and the route of the Pony Express passed near Fort Laramie, which witnessed the journey of nearly 400,000 immigrants during the Great Western Migration.

The importance of the site likewise lies in its existence “as a premier example of historic preservation,” according to the *Fort Laramie National Historic Site Cultural Landscape Report*. The most prominent features are the thirty-six historic structures, which include sixteen intact historic buildings, eleven standing ruins, and nine ruins of foundations. All of these features are described in both the *Cultural Landscape Report* and the *General Management Plan*. Other contributions to the cultural landscape are the site’s vast vistas and its unobstructed views.

Fort Laramie National Historic Site itself lies in a transitional zone that contains vegetation common to the arid Rocky Mountain West, as well as vegetation found farther east on the Great Plains. All terrain within the National Historic Site has been classified as the Historic Zone. There are three subzones, which include the Development Subzone, which contains the historic structures, the Natural Environment Subzone, and the Special Use Subzone and which comprise 203 acres. The remainder of the site is composed of former agricultural land and natural landscape now managed as prairie grassland.

Purpose

Fort Laramie National Historic Site has a variety of native and exotic vegetation. Previous management of these species has included the reintroduction of native species, the application of herbicides, the sterilization of the soil, grazing, mowing, biological control, and fire. Most of the documented measures and experiments occurred outside of the Development Subzone. (Two key studies of the management of the vegetation—*A Vegetation Management Plan for Fort Laramie National Historic Site* and *Vegetation*

Analysis and Management for Fort Laramie National Historic Site—focused wholly on the areas outside of the Development Subzone.) However, fire was used to control weeds within the ruins during the 1950s.² More recent efforts have included the broadcast of pellets to sterilize the soil around the perimeters of buildings and within the ruins, the application of Roundup Weed & Grass Killer in those areas, and the reliance on equipment, such as mowers and weed whackers. This latter method ceased shortly before the initiation of this project.

In accordance with the goals outlined in the *General Management Plan* to “protect and preserve the historic integrity of the buildings, ruins, structures, . . . assuring their survival, for the benefit of the public, in perpetuity” and to “protect, to the fullest extent possible, the integrity of the historic scene of the park,” this Management Plan directs attention to the immediate effects and potential problems caused by the methods of the abatement of the vegetation—past and present—around the perimeters of the historic architecture and ruins. Among the objectives are the development of recommendations for the preservation of the integrity of these structures and the maintenance of the historic authenticity of the cultural landscape and the Development Subzone, as presented in both the *Cultural Landscape Report* and the *General Management Plan*.

Need

The historic fabric has been subjected to the effects of weather and the intrusion of vegetation. Another contribution to its deterioration has been the damage inadvertently inflicted during routine maintenance with equipment, such as mowers and weed whackers. This latter effect has been identified by the crews and other members of the staff, which led to the cessation of this practice.

Among the considerations in the development of a strategy are (1) the allowance of vegetation in some areas, particularly where removal poses enormous challenges or where its presence would enhance the experience of the encounter with the ruins, and (2) the eradication of vegetation where it intrudes upon the historic fabric, reduces the visual appeal of the site, or interferes with patterns of traffic by visitors.

Scope

The staff of Fort Laramie National Historic Site and specialists and members of the faculty at the University of Wyoming, assisted by students in the Program in American Studies, conducted inquiries to define further the scope of the project. Issues raised during these investigations included

- the impact of uncontrolled vegetation in and around the historic structures on the lime concrete
- the creation of a hazard from fire due to the effects of the drought and the presence of uncontrolled vegetation
- the decrease in visitors' access and the impact on safety by uncontrolled vegetation
- the alteration of the cultural landscape and the scenic vistas by uncontrolled or overly controlled vegetation and
- the damage to the historic fabric with the removal of vegetation by mechanical equipment or by hand.

Yet another issue was consideration of strategies elsewhere. Consultation with the staff of the San Antonio Missions National Historical Park was conducted via electronic mail with Mr. Vekasy, the Supervisory Facility Operations Specialist, in July 2004. That site contains many historic walls and ruins

²American Heritage Center, Fort Laramie Collection, Box 1, Folder 10.

with lime-based mortar, and the control of vegetation has likewise presented many of the same challenges, particularly with the employment of equipment, such as mowers and weed whackers. An effective remedy has been provided by the application of Roundup Weed & Grass Killer in a reduced concentration of 2.5-4.0 ounces per gallon of water twice annually. Precautions have included any avoidance of contact between the herbicide and the historic fabric during the application to create a buffer one foot wide between walls and turf.

Relationship of the Proposed Action to Previous Planning Efforts

Control of the vegetation in and around the historic structures in a manner that best preserves their integrity and contributes to and maintains the cultural landscape of Fort Laramie National Historic Site is consistent with the recommendations of the *General Management Plan* and its Amendment, the *Statement for Management*, *A Vegetation Management Plan*, and the *Cultural Landscape Report*.

Impact Topics

Members of the staff at Fort Laramie National Historic Site—including the superintendent, rangers, and personnel charged with maintenance—and members of the faculty and specialists at the University of Wyoming identified issues concerning this proposal; no additional issues were identified outside of this scope. A few distinct topics were derived from this process in order to facilitate the analysis of environmental consequences. The topics analyzed in this Management Plan include public access and safety and the protection of vegetation and natural and cultural resources. Each of these topics is addressed in the section for proposed alternatives.

Impact Topics Dismissed from Further Consideration

The National Environmental Policy Act and Commission on Environmental Quality instruct federal agencies to “avoid useless bulk . . . and concentrate effort and attention on important issues.”³ Therefore, impact topics addressed for other proposed actions have been determined to be unaffected by any of the alternatives for abatement considered in this Management Plan. These topics have been listed below, and an explanation of their exclusion from further review has been provided.

Transportation: None of the alternatives would affect transportation by highway, railroad, water, or air in and around Fort Laramie National Historic Site. Therefore, this topic has been excluded from further analysis.

Noise: Extreme, constant noise would not be a threat under any of these alternatives. Presently mowers, carts and similar vehicles, tools, trucks, and simulated discharges from artillery and small arms generate the noise at Fort Laramie National Historic Site. None of the alternatives would create a disturbance beyond the current level, and, therefore, this topic has been excluded from further analysis.

Utilities: Telephone, electrical, natural gas, water, and sewer systems will not be affected by the alternatives. Therefore, this topic has been excluded from further analysis.

Socioeconomics: The National Environmental Policy Act mandates an overview of impacts on the human environment that includes economic, social, and demographic elements in the affected area. The proposed action includes the purchase of herbicides like Roundup Weed & Grass Killer and Garlon* 4.

³40 CFR 1502.15.

These purchases will be infrequent in accordance with National Park Service regulations: "Pesticides must not be stockpiled. No pesticides may be purchased unless they are authorized and expected to be used within one year from the date of purchase." On July 7, 2004, both herbicides were purchased from the Goshen County Weed and Pest District, an agency of the State of Wyoming. Roundup Weed & Grass Killer costs \$1.58 per gallon. A mixture of 3 parts methylated seed oil and 1 part Garlon* 4 costs \$33.12 per gallon. No significant change in the amount of labor will be required. Therefore, the socioeconomic aspects will not be addressed as a topic.

Prime and Unique Farmlands: Prime farmland is defined as soil that produces crops, such as common foods, forage, fiber, and seed. Unique farmland produces specialty crops, such as fruits, vegetables, and nuts. No soils in the Development Subzone are classified as prime or unique. A small living history garden is present in the subzone, but this feature will not receive any impact from the alternatives. Therefore, this topic has been excluded from further analysis.

Indian Trust Resources: Indian Trust Resources are assets owned by Native Americans but held in trust by the government of the United States of America. Because there are no such trusts at Fort Laramie National Historic Site, this topic has been excluded from further analysis.

Land Use: Historic structures and the facilities for visitors and for the administration and maintenance of Fort Laramie National Historic Site are located within the Development Subzone. Uses within the subzone, other than those which occur during routine maintenance and irrigation, will not be affected. Although residential, industrial, commercial, and agricultural uses occur in the vicinity, no changes should occur as a result of the implementation of the alternatives. Therefore, this topic has been excluded from further analysis.

Environmental Justice: Executive Order 12898, "General Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires that all federal agencies incorporate environmental justice into their missions by identifying and addressing disproportionately high and adverse effects of their actions or policies on the health and the environment of minorities and low-income populations and communities. These alternatives create no such effects, and, therefore, this topic has been excluded from further analysis.

Resource Conservation: The National Park Service's *Guiding Principles of Sustainable Design* provides a basis for achievement of sustainability in planning and design, emphasizes the importance of biodiversity, and encourages responsible decisions. None of the alternatives would significantly increase or minimize the conservation of resources or the prevention of pollution enough to be considered as a topic.

Wildlife and Endangered Species: The United States Fish and Wildlife Service has identified five endangered or threatened species or species that are candidates for these designations in or near Fort Laramie National Historic Site. The endangered species is the black-footed ferret; the threatened species include the bald eagle, Preble's meadow jumping mouse, and Ute ladies-tresses; the mountain plover is the species proposed for inclusion in the previous categories. Bald eagles have been spotted at Fort Laramie National Historic Site, but the other species are not known to exist within the site presently. Because of the eagle's tendency to avoid directly the immediate areas occupied by humans (the Development Subzone on this site), no mitigation is necessary. In October 2003 botanist Bonnie Heidel of the University of Wyoming's Wyoming Natural Diversity Database determined that Fort Laramie National Historic Site did not have Ute ladies-tresses (*Spiranthes diluvialis*) and ruled out the site as a potential habitat. Should the other species of wildlife and plants be spotted within the Development Subzone, further review and assessment of the impact of these alternatives should occur.

Air Pollution: The potential for pollution caused by the occasional application of these herbicides and the periodic use of mowers and weed whackers in a remote, rural area seems modest. Therefore, this topic has been excluded from further analysis.

Waste Management: Neither of these two herbicides is listed in the category for restricted use. As noted in the section on socioeconomics, regulations prohibit extended storage, since they stipulate authorized purchase of amounts to be consumed within a year of the date of purchase. Disposal or recycling of empty containers is compatible with the treatment of other household and commercial waste. Therefore, this topic has been excluded from further analysis.

Alternatives Considered

Alternative A — No Action

Under this alternative, the prohibition of the use of equipment would continue indefinitely. This practice would allow all vegetation, including weeds, shrubs, and trees, to grow in and around the structures and ruins. While this strategy would prevent any damage caused by mowers and weed whackers, it would eventually contribute to the deterioration of the historic fabric and the alteration of the appearance of the landscape.

Alternative B — Use of Mechanical Devices Only

This alternative would promote a continuation of the current measures for control of vegetation, including irrigation of the parade ground and its vicinity, mowing selected areas within the Development Subzone, and the use of weed whackers in areas inaccessible to mowers. (Although no weed whackers or mowers were used within the plots for the experiments, they were utilized within and near the perimeters of the historic structures and ruins during the summer of 2004.) Without the assistance of herbicides, the abatement of unwanted vegetation could require more labor and would pose the risk of damage to the historic fabric from contact with the equipment.

Alternative C — Application of the Herbicide Garlon* 4 and the Use of Mechanical Devices

This alternative would resemble Preferred Alternative D, except that only a single herbicide would be prescribed. Because the application of Garlon* 4 would control all vegetation, this alternative would relieve crews from the task of application of two separate herbicides. Whereas the labor would be less intensive, the expense would be greater, however, as Garlon* 4 costs considerably more than Roundup Weed & Grass Killer.

Preferred Alternative D — Application of the Herbicides Roundup Weed & Grass Killer and Garlon* 4 and the Use of Mechanical Devices

This alternative would provide the most efficient control of vegetation around the historic structures in the Development Subzone without apparent damage to the lime concrete and with low levels of socioeconomic and environmental impact. The preservation of the cultural landscape and scenery would likewise be promoted.

This alternative would entail the application of Roundup Weed & Grass Killer in a twelve-inch swath at the perimeters of the historic structures and inside the ruins. This application would effectively control grasses and weeds and create a boundary beyond which equipment could be safely employed to control vegetation. Elsewhere, crews would employ mechanical devices, such as mowers and weed whackers, when vegetation reached a height and thickness that would threaten the condition of the historic fabric or

create a lack of access for visitors. In areas where the big root cactus (*Opuntia macrorhiza*) and plains pricklypear cactus (*Opuntia polyacantha*) are present, Garlon* 4 would be sprayed directly on the cacti.

Applications of the herbicides would be accomplished with a manually operated unit and would follow the current schedule of three applications per season. Formulas for dilution would follow the manufacturers' recommendations for the lowest rates of concentration. (A rate of 3 parts methylated seed oil to 1 part Garlon* 4 has been recommended for that herbicide by Mr. Prosser, Exotic Plant Management Specialist, Northern Great Plains Region.)

Both herbicides proved effective in the abatement of vegetation, although the results varied slightly. Garlon* 4 had the most visible impact on the vegetation. At all sites nearly all of the vegetation was exterminated, including the cactus in Site 3. The amount of cover remained unchanged, however, because the dead vegetation clung to the surface of the sites. As noted in the section on preliminary results, two immediate effects included the presence of residue from a dye in the first batch, which was detected for several weeks after the application, and an odor due to the reliance on a surfactant, which lingered briefly. Roundup Weed & Grass Killer was almost equally detrimental to the vegetation, being somewhat less effective with the abatement of cactus. Although rogue shoots of grass emerged a few weeks after application, the effect on vegetation was similar at all four sites. Neither noticeable residue on the samples nor lingering odors in the days following application of this herbicide were evident.

Other Alternatives Considered

Alternative E would have proposed manual removal of vegetation along the perimeters of the historic structures, relying on labor provided by the crews, seasonal employees, or prisoners at jails and other correctional institutions. Because of the risk of damage to the historic fabric, as well as the challenges posed by the number of structures and by the development of a schedule for maintenance, this alternative was abandoned.

Alternative F would have introduced goats to control vegetation among the historic structures. These animals are notorious for their control of the growth of most vegetation, including cactus. However, no evidence of their presence during the period of significance has been uncovered, and their appearance could contribute to a misperception about activities at Fort Laramie. Not only would their daily management impose additional burdens on the staff, but they could also accidentally damage the historic fabric. This alternative was discarded, therefore.

Mitigation Requirements for Alternatives

Alternative A — No Action

Mitigation associated with this alternative would address public safety. To ensure visitors' safety, rangers and other members of the staff would discourage entry into the ruins when the vegetation would be most concentrated. No mitigation of other vegetation or resources, such as water, would be required.

Alternative B — Use of Mechanical Devices Only

Mitigation associated with this alternative would prohibit the use of equipment, such as mowers and weed whackers, within twelve inches of any historic fabric. This strategy would require manual removal of the vegetation from the ground near the perimeters of the structures and within the ruins; no removal of the vegetation within the historic fabric itself would be permitted.

Alternative C — Application of the Herbicide Garlon* 4 and the Use of Mechanical Devices

Mitigation associated with this alternative would follow the procedures outlined for Alternative B and the precautions noted on the Material Safety Data Sheet for Garlon* 4. Adherence to the recommendations should prevent adverse effects, according to the manufacturer.

Application of the herbicide would not occur whenever the probability of rain increased or on windy days to avoid drift. To protect the historic fabric itself during application, a shield should be inserted between the source of the spray and the lime concrete of the walls. Such protection would be impossible to achieve during eradication of vegetation within the ruins of the foundations. However, the preliminary results indicated no visible effect on the composition or color of lime concrete after exposure to Garlon* 4, other than temporary discoloration after contact with the surfactant.

Obviously the members of the crew should focus on their tasks and exercise caution during application of the herbicide and operation of the equipment. Other mitigation would be provided by the availability of kits in the event of accidents, such as spills of the herbicide.

Preferred Alternative D — Application of the Herbicides Roundup Weed & Grass Killer and Garlon* 4 and the Use of Mechanical Devices

Mitigation associated with this alternative would follow the procedures outlined for Alternative C with the additional precaution of adherence to the recommendations by the manufacturer of Roundup Weed & Grass Killer. As the preliminary results indicated, exposure to Roundup Weed & Grass Killer created no visible effects on the composition or color of lime concrete and caused no detectable impact at the microscopic level. Careful application of Roundup Weed & Grass Killer to vegetation within the ruins of the foundations would provide a remedy without an apparent adverse effect on the historic fabric.

Summary of Costs

No formal cost analysis has been formulated for these alternatives. Information about the herbicides was easily obtained, however. On July 7, 2004, both herbicides were purchased from the Goshen County Weed and Pest District; Roundup Weed & Grass Killer cost \$1.58 per gallon, and a mixture of 3 parts methylated seed oil and 1 part Garlon* 4 cost \$33.12 per gallon. Rates of dilution for each herbicide are similar, although they can be altered to adjust potency and conserve resources.

The several alternatives offer a range of solutions for control of the vegetation. They likewise create degrees of impact on the historic fabric.

- **Alternative A — No Action**
Although no expense for labor or materials would be generated with this alternative, the harmful impact on the historic fabric would be immediate with the intrusion of unwanted vegetation and its contribution to the deterioration of the lime concrete.
- **Alternative B — Use of Mechanical Devices Only**
Aside from the expenses of labor and fuel, the chief expense would occur with damage to the historic fabric from contact with the equipment. Such accidents would incur the expense of the conservation of the damaged historic fabric.

- Alternative C — Application of the Herbicide Garlon* 4 and the Use of Mechanical Devices
In addition to the expenses outlined in the previous entry, adoption of this alternative would entail the expense of the herbicide.
- Preferred Alternative D — Application of the Herbicides Roundup Weed & Grass Killer and Garlon* 4 and the Use of Mechanical Devices
In addition to the expenses outlined for Alternative C, adoption of this alternative would entail the expense of another herbicide. Although the most expensive of the alternatives to implement, this alternative would provide the most effective control of the vegetation, because of the effect of Garlon* 4 on cactus.