

Protocol for Documenting Disturbances, Prioritizing Restoration, and Evaluating Restoration Effectiveness for Vehicle Disturbances in Mojave Desert Uplands

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U.S. GEOLOGICAL SURVEY
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Prepared in Collaboration with

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Abstract

Vehicle disturbances have sharply increased on public lands in the desert Southwest in recent decades, thus challenging resource managers with tracking and mitigating potential negative impacts to soils, hydrology, and vegetation. Federal land management agencies in Clark County, Nevada created the Southern Nevada Restoration Team (SNRT) to manage vehicle disturbances using a single standardized approach. This document, which was compiled by US Geological Survey (USGS) in collaboration with the interagency SNRT partners, represents a protocol for documenting, prioritizing, and restoring vehicle disturbances on federal lands in Clark County. The protocol outlines several steps that will guide managers as they locate new disturbed sites, determine the vulnerability of the sites to vehicle disturbance, choose appropriate restoration treatments, and implement restoration actions. A final step evaluates the treatment implementation and restoration effectiveness, typically within two years and beyond two years of action, respectively. Management objectives presented in the final assessment step represent the minimum objectives to be considered, and the levels that trigger management responses are based on existing knowledge about vehicle impacts to desert shrublands. Periodic refinement of the list of objectives as well as changes in the levels for management responses should only be considered after resource managers and technical experts have the opportunity to review the data gathered using this protocol and as we learn more about the functioning and recovery of desert ecosystems.

Introduction

Four federal agencies – Bureau of Land Management (BLM), National Park Service (NPS), US Forest Service (USFS), and US Fish and Wildlife Service (USFWS) – manage over seven million acres of public land in Clark County, Nevada and collectively host more than 16 million visitors annually. Thousands of acres of these lands need rehabilitation as a result of past surface disturbances and the slow rate of natural recovery in the Mojave Desert (Webb 2002, Abella 2010). Frequent vehicle traffic injures vegetation and compacts soil, and water erosion occurs as a result of decreased soil porosity and infiltration capacity, ineffectiveness of surface stabilizers, and decreased hydraulic resistance to overland flow (Braunack 1986). Mechanical compaction of soil can also reduce seedling establishment and impede root penetration and growth (Bainbridge and Virginia 1990). Invasive annual species are known to colonize areas previously inhabited by native species following soil surface disturbance (Hunter *et al.* 1987). As a result of the multifaceted impacts of disturbances on



soils and vegetation, and with few opportunities for natural regeneration due to low rainfall, desert lands may take decades or centuries to recover without any active intervention (Lovich and Bainbridge 1999, Webb 2002).

Off-road vehicle use in the arid Southwest sharply increased during the period from 1965 to 1982 (Matchett *et al.* 2004), resulting in numerous unauthorized vehicle routes. Understanding the appropriate methods for actively revegetating disturbed areas is necessary for minimizing future disturbances and for defining and directing rehabilitation efforts in resource management plans (Newton 1999, Anderson and Ostler 2002). Recovery of soil stability, and vegetation community composition and structure is typically a function of wetting-drying cycles, freeze-thaw cycles, and bioturbation (Webb 2002) as well as geomorphology (Caldwell *et al.* 2006) and the amount and seasonality of rainfall (Grantz *et al.* 1998a,b). Thus, rehabilitation techniques may be successful in one region of the desert but have little or no effect in others or may entirely fail during periods of low rainfall.

In the short term, public land managers strive to visually obscure decommissioned routes and discourage continued vehicle activity using treatments such as vertical mulch (dead limbs or whole plants positioned upright in the soil), live plantings of greenhouse-raised seedlings, horizontal mulch (dead plant material laid on the soil surface), and natural or artificial barriers that block vehicle access. In the longer term, land managers in the Mojave Desert seek to restore soil and site stability, hydrologic function and biotic integrity, an approach



that is advocated for other arid and semi-arid systems (Herrick *et al.* 2005). Most rehabilitation treatments are designed to improve conditions for natural plant establishment, including soil decompaction (mechanical or manual), directly reducing soil erosion (horizontal mulch, straw bales, barriers), and roughening the surface to capture litter and provide

“safe sites” for seed germination (pitting, horizontal mulch, vertical mulch, rocks). Application of mulches on top of disturbed soil surfaces can reduce evaporation and stabilize soils against wind and water erosion, thereby enhancing seedling establishment (Brammer 1982, Fraser and Wolfe 1982, Walker and Powell 2001). Mulches also trigger detritivore activity that can improve soil conditions for vulnerable seedlings and young plants (Mando *et al.* 1999). Plant establishment can vary among the different vertical and horizontal mulches typically used to reduce water erosion and increase infiltration (Sutherland *et al.* 1998, Walker and Powell 2001), and in some arid regions, mulching has had limited success in revegetating disturbed areas (Winkel *et al.* 1995). Using logs or rocks to roughen the seed bed can increase survival of plants through enhanced soil moisture (Walker and Powell 2001, Petersen *et al.* 2004). Efforts to slow or reverse the

negative impacts of vehicle routes on the landscape through active rehabilitation have occurred throughout the arid Southwest over the past several decades, yet a reliable prescription that recommends which techniques are appropriate and under which conditions has never been developed for deserts. To date, the effectiveness of current methods is uncertain in desert ecosystems, and resources have been expended with little accountability for the success of rehabilitation efforts.

Background of Protocol Development

Four federal land management agencies established the Southern Nevada Restoration Team (SNRT) to foster interagency cooperation and develop common approaches to habitat restoration. While recent efforts have resulted in many successfully completed projects and operations, the effort to restore degraded desert habitat often cannot keep up with the incidence of new vehicle disturbances. Thus, new disturbances need to be quickly documented and the urgency of restoration and other management actions prioritized in order to sustain the ecological function within public lands (Tuttle and Griggs 1987). At the same time, the success and failure of rehabilitation treatments in the Mojave Desert needs to be assessed using an adaptive management approach, so that limited resources



can be used as effectively as possible. US Geological Survey (USGS) and SNRT interagency partners collaboratively developed a protocol that can be used by agency staff to evaluate rehabilitation success across lands administered by the SNRT agencies. We gratefully acknowledge that this protocol reflects several years of deliberation and refinement by agency staff as well as contributed data forms that were adapted for the protocol and photographs that were used for illustration. The result is a common approach to disturbance assessment and restoration monitoring.

Objectives and How to Use the Protocol

Planning for restoration of degraded public lands in Clark County is challenging because the availability of resources needed to implement such projects fluctuates year-to-year and varies among management agencies. A practical approach for restoring routes begins with prioritizing sites and implementing a feasible restoration action that has the highest likelihood of success. This protocol provides SNRT managers and their staff with 1) a standard method to assess and prioritize vehicle disturbances for future restoration, 2) a landscape-scale estimate of site vulnerability, 3) guidance for choosing and implementing restoration treatments, and 4) a monitoring strategy to evaluate the

implementation success and ecological recovery associated with restoration treatments. The protocol was developed particularly for vehicle disturbances located in desert uplands. While the approach of this protocol may be adapted to other disturbances or other desert habitats, appropriate rehabilitation monitoring strategies are available for riparian areas (Prichard 1998, 1999) and forests (<http://www.fia.fs.fed.us/program-features/indicators/>). The monitoring protocol presented here has the following 5 steps:

Step 1: Locate and assess the severity of a disturbance

When a new vehicle disturbance is found, staff can use the Disturbance Assessment Form to generate an index of severity for the disturbance based on soil and vegetation degradation. The assessment form can be found on pages 51-52 (Appendix I - Disturbance Assessment Form), and instructions for completing the form begin on page 8. This section includes a photographic guide to identify and report common weed species (Appendix II, page 53-61).

Step 2: Determine site vulnerability

Some soil types are more vulnerable to disturbance than others and may require immediate intervention. The protocol includes a map that estimates the vulnerability of sites to vehicle disturbance based on soil texture and parent material (page 21). The soil vulnerability map is also provided as a shape file that can be loaded onto a hand-held electronic device (for example, Trimble GPS), allowing the user to determine the soil vulnerability for disturbances while in the field.

Step 3: Determine priority for restoration of new disturbances

Together, the index of disturbance severity (Step 1) and the Soil Vulnerability Map (Step 2) are used to prioritize restoration. A decision tree incorporates both steps to guide restoration actions for new disturbances (page 22-26).

Step 4: Document the restoration actions

Once the restoration action is selected during Step 3, the protocol provides a Restoration Documentation Form for detailing the restoration treatments that are implemented in the field (Appendix III - Restoration Project Documentation Form, pages 62-63); instructions for completing the form begin on page 27.

Step 5: Measure and evaluate treatment effectiveness

Finally, in an effort to meet management goals regarding the success of restoration treatments, the protocol includes a strategy for measuring and evaluating the effectiveness of treatment implementation and ecological recovery. Measurement and evaluation begins within 1 month of implementation by filling out the Effectiveness Monitoring Form (Appendix IV, pages 64-65). Subsequently, a site visit is performed 6 months to 2 years after implementation to evaluate the effectiveness of the initial restoration (that is, are treatments still intact, was restored disturbance trespassed, are

there positive changes on the site). Continued long term effectiveness monitoring should use the same Effectiveness Monitoring Form for subsequent years to evaluate ecological recovery. Instructions for completing this form begin on page 36.

Step 1. Locate and assess a disturbance: completing the Disturbance Assessment Form

This form can be loaded onto a hand-held electronic device (for example, a GPS-enabled device such as a Trimble); but for those that do not have such as device, a written form may be used and later manually entered in the Disturbance Assessment database (Refer to Appendix I - Disturbance Assessment Form on page 51-52).

Disturbance Code: This unique identifier for the disturbance is composed of the Agency acronym, Date and Time, separated with hyphens (for example, BLM-20110607-102515 was recorded on BLM land, June 7, 2011 at 10:25:15 am).

Date: MM/DD/YYYY

Agency: The Federal Land Manager responsible for the administration of the lands where the disturbance occurs. Use the acronym in the Disturbance Code.

BLM – Bureau of Land Management
NPS – National Park Service

USFS – US Forest Service
USFWS – US Fish and Wildlife Service

Region: The area/region of the agency where the disturbance occurs.

- **BLM**

Amargosa Desert E	Amargosa Desert W	Black Mt Area
California Wash	Colorado Valley	Coyote Springs Valley
Crater Flat	Eldorado Valley	Fortymile Canyon
Frenchman Flat	Garnet Valley	Gold Butte Area
Greasewood Basin	Hidden Valley N	Hidden Valley S
Indian Sprgs Valley N	Indian Sprgs Valley S	Ivanpah N
Ivanpah S	Jean Lake Valley	Las Vegas Valley
Meadow V. W. Lower	Meadow V. W. Upper	Mercury Valley
Mesquite Valley	Moapa Valley	Muddy River Springs Area
Pahrump Valley	Piute Valley	Rock Valley
Three Lakes Valley N	Three Lakes Valley S	Tikapoo Valley
Virgin River Valley		

- **NPS**

Boulder City	Callville Bay	Cottonwood Cove
Echo Bay	Gold Butte	Government Wash
Katherine	Lakeshore	Overton Beach
Pearce Ferry	Temple Bar	Willow Beach

- **USFS**

Carpenter Canyon	Charleston Wldns	Clark Canyon
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Cold Creek
Lee Canyon
Rainbow Wilderness
Wallace Canyon

Kyle Canyon
Lovell
Stirling
Wheeler

LaMadre Wilderness
Potosi
Trout Canyon

▪ **USFWS**

Ash Meadows
Moapa

Desert Clark
Pahranagat

Desert Lincoln

Primary Observer: Include first and last names of person filling out the GPS assessment form.

Secondary Observer: Include first and last name of person assisting in the completion of the assessment form.

USGS Quad: A four-letter acronym identifies the USGS 7.5 minute topographic quadrangle map that the disturbance is in. The convention for determining the acronym is as follows: For single word quadrangle names with three letters (not including “, Nevada”), use all letters plus an asterisk (for example, “UTE*” for Ute, Nevada quadrangle). For single word names with four or more letters, use the first four letters (“APEX” and “POTO” for Apex and Potosi, respectively). For quadrangle names with two words, use the first two letters of each word (“GOWA” for Government Wash). Three word quadrangle names use the first letter of the first two words plus the first two letters of the third word (“BCNW” and “CCSP” for Boulder City NW and Corn Creek Springs, respectively). Finally, for four word quadrangle names, use the first letter of each word to generate your code (“CCSN” for Corn Creek Springs NW). Exceptions to this rule apply when names result in duplicate codes. These exceptions and their appropriate codes include: Bird Spring (BIRS) and Bitter Spring (BITS); Hart Peak (HARP), Hayford Peak (HAYP), and Hayford Peak SE (HPSE); Lower Pahranagat Lake SE (LPSE) and Lower Pahranagat Lake SW (LPSW); Mule Deer Ridge NE (MDNE) and Mule Deer Ridge NW (MDNW); Mercury NE (MRNE) and Mesquite NE (MSNE); Moapa Peak (MOAP) and Mount Perkins (MOPE); Mound Spring (MOSP) and Mountain Springs (MTSP); Moapa West (MOAW) and Mormon Well (MOWE); Senator Mountain NE (SMNE) and Spirit Mountain NE (SPNE); and Senator Mountain NW (SMNW) and Spirit Mountain NW (SPNW). Refer to Appendix II (page 53-56) for a list of all possible quad names and abbreviations. If the USGS quadrangle is not known at the time of assessment, assign the USGS Quad code as “*****” so that it can be designated after returning from the field.

GPS File: Name of the GPS file associated with the disturbance.

Photo File(s): File name of the photo or photos of the disturbance, if applicable.

X and Y: Point location of the disturbance (NAD83).

Court Case #: To be filled in, if applicable.

Disturbance Properties

Site Stability: An overall estimate of the severity of the disturbance, Site Stability is based on an on-site, ocular assessment of water/wind erosion, litter/biological crust cover, and vegetation cover. This metric has the potential to be used for rapid assessment of site condition, but it must be rigorously and statistically correlated with the overall index of disturbance severity. This correlation was not sufficient with the limited sites available at the time of protocol development, but should be tested again after at least 100 disturbances that are representative of the variability across Clark County are entered in the database. If this metric continues to fail as a rapid assessment tool, the ocular determination of Site Stability should be discarded.

Unstable – Extensive rilling or gullies due to water erosion resulting in active export of soil and litter away from the disturbance and surrounding areas (Rilling: small, shallow erosional features that are generally linear and whose flow is strongly influenced by gravity, in contrast to natural flow patterns that follow a site's microtopography; Gullies: larger erosional features than rills that generally follow natural drainages but are caused by accelerated water flow after heavy rainfall and the resulting down-cutting of soil). Wind erosion can also occur where wind blows away finer particles of topsoil, often leaving residual gravel, rock, or exposed roots on the soil surface. The soil removed from wind-scoured depressions is redistributed to accumulation areas (for example, eolian deposits), which increase in size and area of coverage as the degree of wind erosion increases. Vegetation cover, litter and soil crusts are virtually absent or so minimal as to have no influence on reducing surface flow of water if heavy rainfall were to occur.

Poor – The disturbance is predominantly bare ground. Exposed mineral or organic soil shows signs of erosion such as soil movement caused by rain drop splash or wind. Rills or gullies may be developed or there is evidence of high-energy surface flows after heavy rainfall. Vegetation cover, litter and soil crusts are minimal, and would have only a minor influence on reducing surface flows.

Moderate – Structural and vegetative damage are occurring on the disturbance due to erosion; some erosion occurring and spots of erosion becoming linked to form larger erosional surfaces. Portions of the soil surface are stabilized by surface incorporated organic matter (litter), soil crusting, vegetation cover, or a combination of these surfaces. Soil crusts can be biological or physical. Biological crusts are made up of algae and cyanobacteria. Physical crusts form in silt, clay and loam soils. Vegetation occurs mainly as a cover of annual grasses and forbs.

Good – Soil surfaces are largely stabilized by surface-incorporated organic matter (litter), soil crusting, vegetation cover, or a combination of these surfaces. The resistance to soil surface erosion is often greater under shrub canopies (if shrubs occur) than in interspaces. Vegetation occurs as a cover of annual grasses and forbs, with some live perennial shrubs and grasses. Rilling is largely absent, although there may be some evidence of minor wind or water erosion.

Stable – All soil surfaces are stabilized by surface incorporated organic matter (litter), soil crusting, vegetation cover, or a combination of these surfaces. Soil crusts can be biological or physical. Vegetation occurs as a continuous cover of annual grasses and forbs, patchy distribution of resprouting or otherwise live perennial shrubs and grasses, or a combination of vegetation cover. Rilling and gullyng is absent; surface litter is intact.

Soil crust: Soil crusts, either biological or physical, hold surface soils in place. Where plant cover is sparse, crusts are important for minimizing wind and water erosion. Record the condition within the disturbance ("*Disturb*") **and** in an adjacent undisturbed area ("*Undist*") that has similar slope and aspect.

No crust: No crust present within the area. Rank = 0.

Alkali crust: Any one of various soils found in arid and semiarid regions, containing an unusual amount of soluble mineral salts which effloresce in the form of a hardened physical crust (usually white). Rank = 1.

Cyanobacteria – patchy: Patchy cyanobacteria coverage over the area. Soils with low cyanobacterial biomass can be difficult to distinguish from soils with no cyanobacteria. If the soil surface looks bare, tap it lightly with a pin flag. If you do not penetrate the soil surface, or if the pin flag goes through the surface leaving a distinct hole, you have either a physical or biological soil crust. Pick up a small piece of surface soil and look for hanging fibers; these are cyanobacteria. Rank = 2.

Cyanobacteria – continuous: A continuous coverage of cyanobacterial crust over the area. In high densities, cyanobacteria make the surface soil appear darker than underlying soils. The soil appears slightly roughened but no lichens or mosses are visible. Rank = 3.

Lichen – patchy: The coverage of lichen crust occurs in patches with intervening areas of bare soil or cyanobacterial crust. Rank = 4.

Lichen – continuous: A continuous coverage of lichen crust over the area. Soils with a lichen crust frequently appear black or brown with white spotting. The soil surface is roughened, with obvious mounding and lichens clearly visible. Rank = 5.

Accessibility: The ability for a crew or the public to access the disturbance.

High: Area is easily accessed via a well-maintained approved route. Access includes paved roads, well-graded dirt roads, or washes not requiring 4×4 driving. Able to drive a large truck, including a dually, with a trailer to site.

Medium: Area is accessed via a maintained approved route. Access includes washes or right-of-way roads requiring a high clearance vehicle and possibly 4×4 driving. Able to drive a large truck, such as an extended cab 2500, to the site with care and experience. May be able to drive a dually and/or trailer to locations near the site, but not to the site itself, **or** able to operate and moor a boat easily to the site.

Low: Area is not easily accessed via a maintained approved route. Access includes ATV/dirt bike only routes, washed out roads, roads requiring an experienced backcountry driver, 4×4 driving with high clearance, and extremely time-consuming drives. Not able to get a large truck or trailer to the site. Access to the site may be via ATV/dirt bike or hiking only. Boating to site may be possible, but mooring is not easy.

Visibility: The ability to see the disturbance from an open or maintained road or an area where visitors of public lands are likely to travel.

High: Disturbance is highly visible from a well-maintained approved route. Access to the disturbance may also be highly visible.

Medium: Disturbance is visible with few natural barriers. These natural barriers may include hillslope, trees and shrubs.

Low: View of the disturbance is largely or completely obscured by natural barriers, including landforms and vegetation.

Recent Use: Was the disturbance recently used?

Yes: Tire treads are still visible. Other signs of recent use include trash that has not blown away from the disturbance or a smoldering camp fire.

No: Tire treads no longer visible. Trash may have blown away from the site and become trapped in surrounding vegetation; camp fire is cold and/or rocks are dispersed.

Frequently Used: Was the disturbance frequently used?

Yes: Repeated vehicle passes blend the separate tire tracks into a linear feature on the landscape. Route is usually well-defined with a compacted surface.



No: Disturbance infrequent, likely the result of 1-2 passes, and separate tire tracks are evident. Full linear nature of route may be hard to detect.



Plant Canopy Damage: Damage to the perennial plant canopy caused by the disturbance (adapted from Hansen and Ostler 2005). The term “perennial plant” refers to shrubs, trees, bunch grasses, cacti and other succulents (See examples of canopy damage on page 15).

Denuded: All perennials within the disturbance are detached from their bases. Rank = 6.

Many with roots exposed or detached: More than half of the number of perennials in the disturbance persist only as root crowns exposed aboveground or are detached from their bases (see example). Rank = 5.

Many highly dissected, roots exposed: At least half of the number of perennials in the disturbance have very high damage (highly dissected, see example); some perennials persist only as root crowns exposed aboveground or are detached from their bases altogether. Rank = 4.

Many dissected, few highly dissected: At least half of the number of perennials in the disturbance have high damage (dissected canopy), **and** at least one-quarter of the perennials have very high damage (highly dissected canopy, see examples). Rank = 3.

Many irregular, few dissected: At least half of the number of perennials in the disturbance have moderate damage (irregular shape), **and** at least one-quarter of the perennials have high (dissected canopy) or very high damage (highly dissected, see examples). Rank = 2.

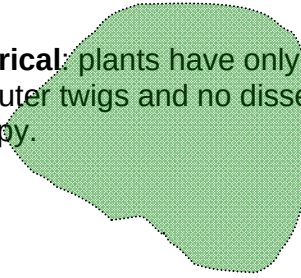
Most symmetrical: More than half of the number of perennials in the disturbance have low damage (symmetrical shape, see following example); more severe damage classes are rare or absent. Rank = 1.

Intact: A very small proportion of perennials in the disturbance have little damage or there is no damage to perennials as a result of the disturbance (for example, vehicle driven while avoiding perennial vegetation). Rank = 0.

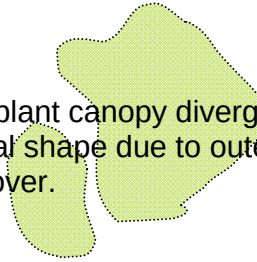
Plant Canopy Damage Examples



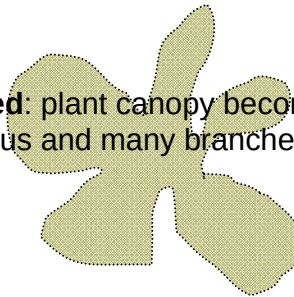
Symmetrical: plants have only few broken outer twigs and no dissection of the canopy.



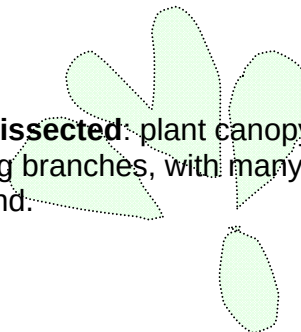
Irregular: plant canopy diverges from the symmetrical shape due to outer branches being run over.



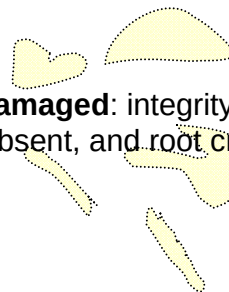
Dissected: plant canopy becomes amorphous and many branches are missing.



Highly dissected: plant canopy has few remaining branches, with many lying on the ground:



Root crown damaged: integrity of plant canopy absent, and root crown often exposed.



Court Case: Number of Plants Damaged

If a court case is ongoing or anticipated, the number of perennial plants damaged should be counted. Record the number of plants damaged by species, if possible (for example, “3/YUBR” denotes three Joshua trees (*Yucca brevifolia*)). Record species, if known, using the USDA plant code (<http://plants.usda.gov>). If you do not know the USDA plant code, write out the full species name. If you do not know the species name, write out the common name. When species cannot be determined due to severe damage, notate by category such as “shrub,” “grass,” “cactus.”

Sensitive Species

Record the presence of any sensitive species as defined by each agency.

Weeds – check all present.

Refer to Appendix III for photos of common weeds that may be encountered during the Disturbance Assessment.

Notify Weed Manager

Particular species may require immediate management action. Are species present that require contacting the weed management team?

Suggest Weed Survey

If weeds of concern are abundant in association with the disturbance, a weed survey will help document the extent of invasion and whether management action is needed. The conditions under which a weed survey would be warranted will need to be determined through consultation with your agency’s weed management team.

Line Disturbance – Description

One-Track: A single trail through the landscape generally caused by a dirt bike. Rank = 1.

Two-Track: Double trail through the landscape with vegetation between the two tracks. Rank = 2.

Random Tracks: Multiple passes which are hard to distinguish as a two-track or a road. Rank = 3.

Road: A fully developed dirt road not approved for use. Rank = 4.

Depth: A measurement of the depth of the ruts of the disturbance into the soil surface.

Broken < 2": The surface of the landscape broken but the depth is not greater than 2 inches (note the pullout from main approved route below). Rank = 1.



Ruts 2" – 4": The surface of the landscape is broken between 2" to 4". Rank = 2.



Ruts 4" – 8": The surface of the landscape is broken between 4" to 8". Rank = 3.



Ruts > 8": The surface of the landscape is broken greater than 8". Rank = 4.



Width: The average distance across the line disturbance, based on the wheel width of the vehicle.

2 ft – Dirt bike: A disturbance 2 feet across likely made by a dirt bike. Rank = 1.

4 ft – ATV: A disturbance 4 feet across likely made by an ATV. Rank = 2.

6 ft – Vehicle: A disturbance 6 feet across likely made by a passenger vehicle. Rank = 3.

Other: A measurement in feet of the disturbance if it is not characterized by the previous categories. Rank = 1 if the width is less than 2 ft and Rank = 4 if the width is greater than 6 ft.

Use: The known or suspected use of the line disturbance can be used to help determine the need for appropriate signage.

Social: Used to get to a location or used for an activity.

Mine: An old road used to access and extract mineral resources.

Utility: An old road used during installation, or maintenance of, power and water transmission lines, including aboveground telephone or belowground cables.

Random/bladed: Unknown use (Note the complete loss of vegetation).



Length: Record the total length of the line disturbance. Select one unit of measurement (feet or meters) and leave the other blank.

Comments: Any additional information regarding the line disturbance.

Point Disturbance – Description

Type: A short and standardized description of the point disturbance.

Dumpsite: A location where debris or garbage was dumped or left illegally.

Fire Ring: Aggregation and placement of stones in a circle to contain a campfire, created illegally and outside of approved camping areas.

Graffiti: Illegal or unauthorized defacing of an object (for example, rock, tree, sign) with spray paint or other markings.



Mine: Excavation in the earth from which ores and minerals are extracted.

Plant Collection: A location where plants were collected illegally and the area was disturbed by this process.

Other: Other disturbances may also include shooting damage to a sign or tree, a structure such as a hunting blind, paintball spatter or damage to a fence. Details of the “Other” point disturbance can be recorded in the “Comments” section.

Area: Record the aerial extent of the point disturbance. Select one unit of measurement (square feet or square meters) and leave the other blank.

Comments: Any additional information regarding the point disturbance.

Polygon Disturbance – Description

Type: A short and standardized description of the polygon disturbance.

Donuts: Created by rotating the rear of the automobile around the front wheels in a continuous motion on the landscape surface. Rank = 1.



Pullouts: Areas where visitors pull off the side of a road to park or turn around. Rank = 2.

Random Track: Multiple passes which are hard to distinguish as a two-track or a road and unable to GPS as lines. Rank = 3.

Denuded Area: An area impacted by widespread and intensive use by off-road vehicles resulting in the loss of perennial vegetation and making the area susceptible to erosion. An area stripped of all vegetative cover after a severe disturbance. Rank = 4.



Scrape: An area scraped using earth-moving equipment or otherwise to remove all vegetation and surface soil. Rank = 5.

Depth: A measurement in inches of how deep the ruts of disturbance are into the surface of the landscape.

Broken < 2": Surface of the landscape broken but the depth is not greater than 2". Rank = 1.

Ruts 2" – 4": Surface of the landscape is broken between 2" to 4". Rank = 2.

Ruts 4" – 8": Surface of the landscape is broken between 4" to 8". Rank = 3.

Ruts > 8": Surface of the landscape is broken greater than 8". Rank = 4.

Area: Recorded the aerial extent of the polygon disturbance. Select one unit of measurement (square meters or square feet) and leave the other blank.

Comments: Any additional information regarding the polygon disturbance.

OVERALL INDEX OF LINE/POLYGON DISTURBANCE SEVERITY: Calculate the disturbance severity index using the scores selected during the disturbance assessment. First, subtract the crust score for the disturbance from the crust score for the undisturbed area to obtain a crust damage score (for example, a rank of 5 for crust cover in the adjacent undisturbed area minus a rank of 2 for crust in the disturbance equals a crust damage score of 3). If this difference is negative (that is, the undisturbed area has a lower score than the disturbance) assign a score of zero for crust damage. The crust damage score is added to the scores for plant damage, disturbance type, depth of track, and width of track to get an overall index. This disturbance severity index is used in conjunction with

the soil surface vulnerability map when choosing a restoration action for the disturbance.

The Drive: Include the number of hours for the entire disturbance assessment, and detail the directions to the site, particularly if straight line of travel using a GPS is inefficient.

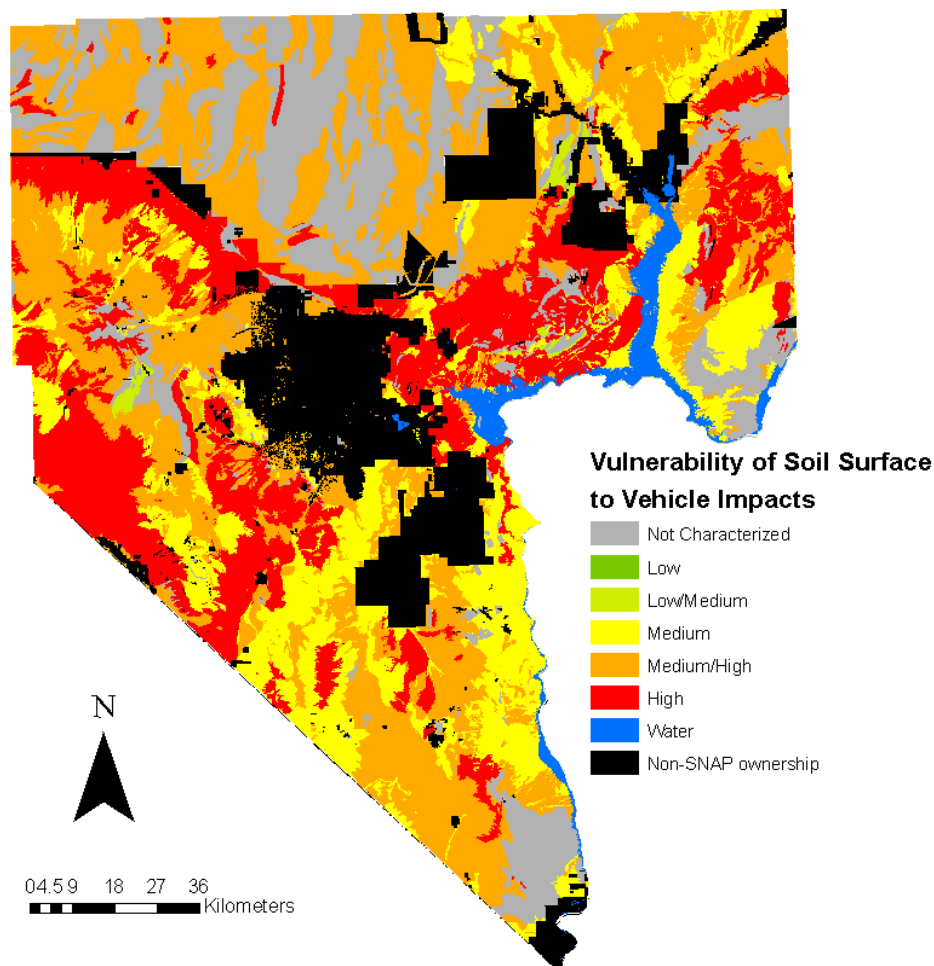
Suggested Restoration Techniques: Include potential barriers that may be effective for protecting restoration areas and potential restoration treatments. These suggestions will be considered before restoration is implemented. Also, indicate the number of signs needed (carsonite or interpretive) and appropriate message to include for public education.

Cultural: Check the box if cultural resources are impacted by the disturbance.

Comments: Any additional information regarding potential restoration techniques or specific recommendations.

Step 2. Determine site vulnerability from the Soil Vulnerability Map

The Soil Vulnerability Map (below) estimates the departure of soil and vegetation attributes (such as litter cover, soil aggregate stability, cryptobiotic crust cover, and bare soil cover; see Belnap (1998)) for disturbances compared with adjacent undisturbed areas based on 50 paired sites evaluated by USGS in Clark County, Nevada (USGS unpublished data). Principal components analysis of these attributes explained 81% of the variability, and the components were used as indicators of vulnerability. Low vulnerability is a difference between disturbed and undisturbed sites of 0% for soil aggregate stability and litter cover, and 0 – 5% difference for crust cover and bare soil. Medium vulnerability is a difference of > 0 – 25% for soil aggregate stability and litter cover, > 5 – 25% difference for crust cover, and > 5 – 50% difference in bare soil. High vulnerability is a difference of > 25% for soil aggregate stability, litter cover, and crust cover, and > 50% difference for bare soil. Estimated vulnerabilities were mapped using surface soil texture (NRCS) and surficial geology data layers (USGS). For areas that were not represented by the 50 sites and therefore could not be characterized (indicated in grey), a conservative estimate of vulnerability (“Medium to High”) should be assumed when determining restoration implementation.



Step 3. Prioritize restoration of new vehicle disturbances: a decision tree for implementing restoration

High priority disturbed sites are those that 1) are severely damaged (for example, sites with well-defined track and denuded of vegetation), and 2) are vulnerable to vehicle disturbance (soil types that compact easily). The following guidelines for restoration actions incorporate damage severity, which is determined based on the Disturbance Assessment Form (Step 1) and site vulnerability, based on quantitative comparisons between unauthorized routes and adjacent undisturbed sites in Clark County (Step 2). Other factors important for determining restoration actions include slope of the site, presence of new weed species, and the accessibility and visibility of the disturbance. The following decision framework provides a guide for restoration actions; however, unique circumstances may require alternative considerations (for example, unauthorized routes through protected rare plant habitat or cultural sites will likely receive high priority regardless of soil vulnerability and damage severity). Begin by determining whether the disturbance is a point (choose I in the key below) or a line/polygon disturbance (choose II), and then determining frequency of use (choose A or B in the key), vulnerability of sites to vehicle impacts (choose 1 or 1'), damage severity (choose c or d), and so on until a restoration guideline is provided. Rationale for the restoration guidelines are provided beginning on page 24.

Decision Tree for Implementing Restoration

I. Point disturbance.....Requires agency-specific action; otherwise, go to II
Point disturbances such as graffiti or fire rings have different priority actions among the agencies; therefore, restoration actions for point disturbances are at the discretion of each agency.

II. Line or polygon disturbance.....choose A, B, C or D

A. Disturbance was created recently and infrequently used choose 1 or 1'
A recently created disturbance with infrequent use is typified as, but not limited to, a location where an ATV created a "donut," an SUV backed off an approved road to turn around, or a motorcycle drove cross-country. The recency and infrequency of these disturbances suggests that they still have sufficient on-site resources for recovery (for example, only minor redistribution of surface litter and topsoil). These disturbances typically require no action, but visual erasure of those that are accessible can discourage further use.

1. Disturbance occurs on low or low/medium vulnerability substrate.....**No action**

1'. Disturbance occurs on medium to high vulnerability substrate.....choose a or b

a. Damage Severity Index is low (Index = 0 – 7; Appendix I).....choose i or ii
Low severity damage is typified as, but not limited to, tracks that are less than 2" deep; alkali crust or a continuous cyanobacterial crust occurring in adjacent undisturbed areas is broken up by vehicle impact in the disturbance, or the adjacent undisturbed soils do not support crusts. Canopy damage to perennial plants is isolated to a small number of individuals in the disturbance so that the visual patterns of vegetation are not different between disturbed and comparable undisturbed areas.

i. Accessibility to and/or visibility of site are low..... **No action**

- ii. Accessibility to and/or visibility of site are medium to high.....**Hand raking**
- b. Damage severity is medium to high (Index = 8 – 22; Appendix I).....**Hand raking**

Medium to high severity damage is typified as, but not limited to, two-track vehicle creates tracks greater than 2" deep; lichen crust in adjacent undisturbed area is broken up or absent in the disturbance. Canopy damage to perennial plants is extensive and occurs among numerous individuals, creating a visible difference in the pattern of vegetation between disturbed and comparable undisturbed areas. Medium to high severity damage is expected to be rare for recent disturbances with infrequent use (for example, a single pass of two-track vehicle up a hill climb when soils were wet causes deep ruts), but visual erasure is important to prevent these disturbances from becoming major thoroughfares for visitor travel.
- B. Disturbance was created recently and used frequently..... choose 2 or 2'

A recently created disturbance with frequent use is typified as, but not limited to, a location where vehicles made multiple passes in a previously undisturbed area, such as where vehicles strayed from an approved race course route or a new social site where vehicle use is localized in a concentrated area. These disturbances may begin to lose on-site resources if they are continually visited (for example, redistribution of surface litter and mounding of topsoil, which may be susceptible to wind and water erosion). Thus, these disturbances should be prioritized for visual erasure, stabilization of soil and vegetation resources and, when the sites are accessible to visitors, for installation of barriers.
- 2. Disturbance occurs on low or low/medium vulnerability substrate.....**Hand raking**
- 2'. Disturbance occurs on medium to high vulnerability substrate.....choose c or d
 - c. Damage severity is low (Index = 0 – 7; Appendix I).....**Hand raking**
 - d. Damage severity is medium to high (Index = 8 – 22; Appendix I)...choose iii or iv

Medium to high severity damage is typified as, but not limited to, two-track vehicle creates tracks greater than 2" deep; lichen crust in adjacent undisturbed area is broken up or absent in the disturbance. Canopy damage to perennial plants is extensive and occurs among numerous individuals, creating a visible difference in the pattern of vegetation between disturbed and comparable undisturbed areas. Visual erasure is important to prevent these disturbances from becoming major thoroughfares for visitor travel or social use.
 - iii. Accessibility to and visibility of site are low.....**Hand raking/Vertical mulch**
 - iv. Accessibility to and visibility of site are medium or high.....

.....**Hand raking/Vertical mulch/Barrier**
- C. Disturbance was not created recently and used infrequently.....choose 3 or 3'

An old disturbance with infrequent use is typified as, but not limited to, a location where a vehicle made one or two passes off an approved route, such as backing off the road to turn around or driving cross-county. These disturbances are usually of lowest priority, depending on their age, but visual erasure may be necessary for these disturbances if new disturbances are occurring nearby.
- 3. Disturbance occurs on low or low/medium vulnerability substrate.....**No action**
- 3'. Disturbance occurs on medium to high vulnerability substrate.....choose e or f
 - e. Damage severity is low (Index = 0 – 7; Appendix I).....**Hand raking**
 - f. Damage severity is medium – high (Index = 8 – 22; Appendix I).....choose v or vi
 - v. Accessibility to and visibility of site are low.....**Surface roughening**
 - vi. Accessibility to and visibility of site are medium or high.....

.....**Surface roughening/Barrier**

D. Disturbance was not created recently but used frequently in the past..choose 4 or 4'
An old disturbance with frequent use is typified as, but not limited to, a location where vehicles parked off an approved route over the course of several years, well-used social routes or old mine or utility roads. Soils are typically compacted within the surface 10 cm (3.9") and perennial vegetation is dramatically diminished. These sites not only require visual erasure but also repair of soil surface condition and re-vegetation.

4. Disturbance occurs on low or low/medium vulnerability substrate.....
**Live planting/Barrier**

4'. Disturbance occurs on medium to high vulnerability substrate.....choose g or h
 g. Damage severity is low (Index = 0 – 7; Appendix).....

.....**Surface roughening/Barrier**
 h. Damage severity is medium – high (Index = 8 – 22; Appendix I).....

.....choose vii or viii
 vii. Accessibility to and visibility of site are low.....

.....**Surface roughening/Vertical Mulch**
 viii. Accessibility to and visibility of site are medium or high

.....**Surface roughening/Vertical mulch/Signage**

Rationale for Restoration Guidance

No action: No action, also known as passive restoration, is suggested for disturbances that occur on low to low/medium vulnerability substrates (*for example*, deep sandy soils and active washes) and medium to high vulnerability sites with low damage severity, visitor accessibility and visibility. Passive restoration may require placement of barriers or signs to prevent continued disturbance. Sites with minimal damage to soils and vegetation are most likely to recover without active intervention, especially if they continue to be obscured from view and difficult to access by the public.

Raking: Hand raking of tracks eliminates the visual indication of a vehicle route. Raking can be effective in instances where naturally sparse or short-statured vegetation does not obscure soil ruts, or on a hill climb where tracks are distinctly visible. Visual erasure of the disturbance is desirable, but raking is itself a disturbance that can enhance establishment of weed species if seed sources are abundant. Therefore, raking should be considered in the context of the presence of aggressive weed species. For sites that are likely to be revisited by the public, more direct action may be necessary for aggressive weed species, as recommended by the Weed Manager or other experts.

Surface roughening: Even on a low vulnerability substrate, roughening of the soil surface (0 - 10 cm (0-4")) may be necessary on older, frequently travelled disturbances. Surface roughening ranges from pitting with hand tools to dragging a harrow across the surface, both of which remove surface compaction and create microsites that capture wind-blown litter and seeds. Shallow harrowing may be more appropriate than surface ripping, which has been prescribed in the past to alleviate highly compacted soils but can severely alter soil hydrologic

properties (Caldwell *et al.* 2006). When surface roughening of the disturbance is important for enhancing infiltration, consideration should be made for establishment of weed species whose abundances can be significantly enhanced with surface roughening. For sites that are likely to be revisited by the public, more direct action may be necessary for aggressive weed species, as recommended by the Weed Manager or other experts. Surface roughening on steep slopes may benefit from surface stabilization such as rolled erosion control systems that cover the soil surface (Ziegler and Sutherland 1998).

Vertical mulch: Vertical mulch refers to dead plant material, generally branches, anchored vertically in the ground to create the structure of shrubs or perennial grass clumps. Vertical mulch implemented along the line-of-sight can minimize the visibility of the route as well as capture windblown litter, nutrients and seeds that are at risk of movement away from the site. Vertical mulch in combination with litter/seed bank transfer, transplanting and/or replanting, and rock placement will aid in visual erasure.

Horizontal Mulch: Horizontal mulch refers to dead plant material or inorganic objects (for example, branches, stumps, or rocks) placed horizontally on the ground surface. Horizontal mulch implemented along the line-of-sight can help minimize the visibility of the route as well as capture windblown litter, nutrients and seeds that are at risk of movement away from the site. Large materials are often available on site and work best, because fine horizontal mulches such as straw or wood chips placed on the soil surface can have a negative influence on re-vegetation success (Anderson and Ostler 2002) through wicking of soil moisture and consequent surface evaporation.

Live planting: Re-seeding has promise, particularly for broad disturbances that are difficult to access or are cost prohibitive to transplant (Abella and Newton 2009); however, techniques need to be refined when significant seed losses by seed harvesting ants and rodents are expected (DeFalco *et al.* 2010) or site conditions are incompatible with available seed mixtures (Walker and Powell 1999). Re-vegetation using topsoil from adjacent intact soils is difficult because heavy equipment typically used to harvest topsoil can dilute seed-rich surface soils with seed-poor subsoils during collection (Scoles-Sciulla and DeFalco 2009). Linear disturbances are more likely to re-seed naturally than polygon disturbances (DeFalco *et al.* 2010); therefore, reseeding may be unnecessary but transplanting or outplanting can help erase the indication of a disturbance. Plants used to re-vegetate small-scale denuded areas, particularly for old, frequently used disturbances, may originate directly from nearby undisturbed areas (for example, transplanting cholla joints to disturbed areas) or indirectly from greenhouse-raised plants (for example, outplanting of creosote bush seedlings equipped with soil moisture supplements such as DriWater). Preference should be for plant material that represents local ecotypes to develop and promote regionally adapted genetic diversity (Johnson *et al.* 2010). For young plants established on disturbances, plastic cones or mesh cages not only protect plants

from herbivores, but plastic cones also buffer the plants from environmental extremes (Grantz *et al.* 1998a, Scoles-Sciulla and DeFalco, unpubl. data). Fertilization is discouraged because it has little influence on successful establishment and strongly encourages weedy species (Anderson and Ostler 2002).

Barriers: Natural barriers including boulders, downed logs or stumps, and dead brush prevent access while blending the recovering disturbance with the surrounding environment. Artificial barriers such as bales of sterile straw, posts, fencing or gates can substantially deter physical access but directly identify the disturbance.

Signage: Monitoring of the disturbance may reveal continued visitor use and the need for signage that indicates the closure of the route (carsonite) or the efforts in place to restore the route (sign with restoration message). Signage may be necessary in especially problematic areas but may only be effective where law enforcement has a frequent presence.

Step 4. Document restoration actions: completing the Restoration Project Documentation Form

As with the Disturbance Assessment Form, this form can be loaded and completed using a hand-held electronic device or a written form may be completed and manually entered in the Restoration Project Documentation database (refer to Appendix III - Restoration Project Documentation Form on page 62-63).

Restoration Code: The unique identifier for the restoration activity. Identical to the Disturbance Code assigned during the initial disturbance assessment (Step 1), unless multiple disturbances are included on a single restoration documentation form.

Disturbance Code: This is the unique identifier for the disturbance and is identical to the Disturbance Code assigned during the initial disturbance assessment (Step 1). If multiple disturbances are included on a single restoration documentation form, list all appropriate Disturbance Codes.

Start Date: Date on which restoration treatments are implemented.
MM/DD/YYYY

End Date: Date on which restoration treatments are completed. May be the same as start date. MM/DD/YYYY

Length Completed: For linear disturbances, record the total length of the disturbance to which restoration treatments were applied. Select one unit of measurement (meters or feet) and leave the other blank.

Area Completed: For polygon disturbances, record the total area of the disturbance to which restoration treatments were applied. Select one unit of measurement (square meters or feet) and leave the other blank.

Project Leader: Include first and last names of the crew leader(s) applying the restoration treatments.

Photo File(s): File name of the photo or photos of the restoration treatment, if applicable.

Treatment GPS File: Once restoration work is completed, take a GPS track of the treated area. At minimum, record a start and end point. Record the name of the GPS file associated with the restoration.

Is there a suitable Control site and Reference site for monitoring treatment success?

A reference site for future monitoring is a nearby undisturbed area with similar slope, aspect and soil type to the treated area. For example, if a disturbance occurred on a bench, a neighboring bench would make a better reference site than a wash, even if the wash were physically closer to the disturbance.

A control site for future monitoring is an untreated portion of the disturbance where further trespass does not occur. The control site must be at least as long as the treated area and occur on a similar slope, aspect and soil type. For linear disturbances, a control site is generally located beyond where active restoration treatments are applied. The comparison of soil and vegetation between the control and reference sites during effectiveness monitoring (see Step 5) indicates recovery from the disturbance without human intervention, sometimes referred to as passive restoration. In contrast, the comparison between control and treated sites indicates the effectiveness of the active restoration treatments applied to the disturbance.

Answer yes only when **both** suitable control and reference sites exist. Answering “yes” flags the restoration site for future in-depth monitoring. Compliance monitoring is not influenced by your answer.

Control GPS File: If a suitable control exists, take a GPS track of the control site. At minimum, record a start and end point. Record the name of the GPS file associated with the control site.

Reference GPS File: If a suitable reference area exists, take a GPS point of the general location. Record the name of the GPS file associated with the reference site or write down the x and y coordinates (NAD83).

Weather

Cloud Cover: The amount of total sky covered by clouds in categories (0-5%, 6-25%, 26-50%, 51-75%, 76-100%).

Precipitation: Record any precipitation that occurred during the restoration project (rain, hail, snow, none, or other (please describe)).

Precip Duration: The duration of the precipitation event.

N/A: Not applicable, no precipitation.

Intermittent: Precipitation is temporary or periodic.

Constant: Continuous precipitation.

Temperature: The average temperature during the restoration project in degrees Fahrenheit.

Restoration Techniques Used

Record the linear or square meters or feet treated for each of the applicable restoration treatments. Use the same unit of measurement as you did to record the total length or area treated.

ATV/chain-drag: Using an ATV to drag chains across the disturbance.

Fill: Adding soil from adjacent areas or from off-site to the disturbance site.

Fire Ring Removal: Physical dismantling and removal of an unapproved fire ring.

Garbage Removal: Physical collection and removal of a large amount of garbage from site.

Graffiti Removal (chemical): Removal of graffiti from any surface using chemical compounds.

Graffiti Removal (chisel/hammer): Removal of graffiti from any surface using hand tools.

Mulch (horizontal): Material such as branches, stumps, straw, or commercial jute matting placed horizontally over the disturbed soil surface primarily to stabilize topsoil but also for capturing seeds and other organic matter and reducing the visual cue of the disturbance (see below).



Mulch (vertical): Dead plant material, generally branches, anchored vertically in the ground to create the structure of shrubs or perennial grass clumps and discourage visitor access (see below).



Outplanting: Planting of seedlings or cuttings grown in a greenhouse or other facility. Plant materials such as seeds or cuttings that are collected in nearby undisturbed areas or from the same ecoregion are preferred over commercial

sources (see Level IV Ecoregion designation by EPA, www.epa.gov/wed/pages/ecoregions). May also include use of tree shelters, wire cages, insect screening, or rodent repellent to protect the plants from herbivores, DriWater packs, PVC pipe, or drip line to irrigate the plants, and mycorrhizae to inoculate plant roots.

Permeon: A simulated desert varnish used to stain soils or rocks.

Pitting: The use of hand tools to create or enhance soil surface roughness for capturing wind-blown seeds and other organic matter.

Raking (McCleod): The use of McCleods or similar heavy tools to reduce rilling and gullying and even the soil surface.

Raking (leaf): The use of a flexible rake to distribute organic matter across the soil surface.

Raking (rock): The use of a rigid metal rake to reduce minor soil compaction and distribute organic matter across the soil surface.

Ripping (Harrowing): A tillage method using heavy equipment to drag metal tines through the soil, decompacting soil to a depth of 6" – 8" (see below).



Rock Replacement: Placing surface rocks collected nearby onto the disturbed area in a pattern and density similar to the surrounding undisturbed area.

Seeding: Hand distributing native seed on the disturbed site. Seeds collected from nearby undisturbed areas or from the same ecoregion are preferred (see Level IV Ecoregion, www.epa.gov/wed/pages/ecoregions); commercial sources that document where seeds were collected may be acceptable. In all cases, the origin of seeds should be documented in the "Additional Restoration Notes" section of the form.

Transplant: Placement of cuttings or whole live plants collected from nearby areas onto the disturbance. The source of plant materials used for transplanting follows similar guidelines as for seeding, and details of origin should be documented in the "Additional Restoration Notes" section of the form.

Weed Removal: Physical or chemical removal of weed species. This treatment is determined by Weed Manager and/or Weed Management team.

Passive Treatment: Any length or area of the disturbance that is not treated using an active technique. This area can serve as a control (if it is at least as large as the active treatment area and comparable in all other respects) in restoration effectiveness monitoring.

Other: Record any other restoration methods utilized. Provide details in the "Additional Restoration Notes" section of the form.

Signs and Barricades

Record the length or quantity of barricades and/or signs used to discourage access.

Carsonite with Sticker or Sign: Posts are built to withstand impacts, extreme weather, corrosive elements and ultra-violet exposure with informational sticker.

Metal Sign: Heavy-duty metal sign affixed to a metal or wooden post.

T-Posts: Generally placed 3 ft apart to prevent further access. Used in areas where trespass is low and there is little time to invest in post and cable. Photo shows T-posts and carsonite with sticker (see below).



T-Post Fence: Used where fencing exists, to cover large areas, or when it's logistically difficult to haul heavier barriers to a site. May not be effective in areas where it can be easily breached, although fence can be easily fixed by one person (see below).



Telephone Posts: Used in backcountry areas where trespass is low and T-posts would not be as effective. Not effective at preventing dirt bike access. Photo shows telephone posts and a metal sign (see below).



Telephone Post & Cable: Used in the backcountry and areas where they are not likely to be burned. Once in the ground they can be extremely effective and very difficult to pull out (see below).



Metal Posts: Metal posts with a piece of rebar or nail in bottom hole for better stability. Similar to telephone posts, but sturdier (see below).



Metal Post & Cable: Metal posts with cable to prevent access between posts. End and corner posts are usually cemented. Used in front country and high trespass areas (see below).



Gate: A movable barrier used when access is needed by authorized personnel (for example, right-of-ways, maintenance, researchers; see below).



Boulders: Used when installing posts is not an option because of soil type (for example, too sandy or volcanic; see below).



Tank Traps: Trenches along the side of a road made using heavy equipment. Used along major roads to cover long distances (2+ miles), or when soil type makes it difficult to install posts (see below).



Material Used

If used during restoration treatments, record the quantity of carsonite posts, DriWater gel packs, DriWater inserts (refills), drip line, graffiti remover, insect screening, jute, mycorrhizae, permeon, PVC pipe, rodent repellent, stakes, straw wattles, tree shelters, and wire cages.

Plant Material

Record any greenhouse-sourced plant materials using during treatments.

#: Record the number of items used.

Species: Record the species of the greenhouse-sourced plant material.

Material Type: Record the type of material used, such as seedling, cutting.

Material Size: Record the size of material used, such as 1 gal pot.

Source: Record material source, such as LAME greenhouse, CSN greenhouse.

Sensitive Plant: Check box if the plant species used is a sensitive species, as defined by the appropriate agency.

Sensitive Host: Check box if the plant species is a host for a sensitive animal species, as defined by the appropriate agency.

Site Collected Material Used

Check all appropriate boxes.

Seeds

Record any seed using during treatments.

Species: Record the species of seed used.

Quantity: Record the quantity of seed used, such as 2 pounds.

Source: Record the source of seed used, such as Granite Seed, area collection.

Seed Lot ID #: For commercial sources of seeds, record the lot ID #.

Seedball Content: If applicable, record the other materials used in seed balls, such as fertilizer, local soil, clay.

Rented Equipment Used

Record any rental equipment used to implement restoration treatments. Also record the number of hours used on the project and the cost per unit (hourly or daily rental).

Maintenance Required

This section will be useful to record restoration actions you consider necessary but were not able to complete during the project due to time, supplies, or other factors. It can also be used during subsequent visits to flag a site as needing additional restoration work due to trespass, soil erosion or other factors.

Additional Barriers: If trespass is occurring or anticipated, additional barriers may be necessary.

Decompaction: In the notes section, indicate if you anticipate hand or mechanical work.

Graffiti Removal: Indicate in the event that graffiti removal supplies are not available during the initial treatment visit or new graffiti is noted during subsequent visits.

Law Enforcement: Where trespass is particularly problematic, and includes destruction of barricades and signs, increased law enforcement presence may help.

Monitoring: When repeated trespass has occurred, you may wish to flag the disturbance for compliance monitoring.

Mulch: Record if original mulch has washed away or you could not find enough local materials to complete the task, and include in the notes section if any additional supplies are needed.

Permeon: Can help visually disguise small areas.

Raking: When subsequent trespass to the initial treatment has occurred, you may wish to remove this visual cue.

Replace Rock: When a disturbance removes surface rocks from an area, it creates a striking visual cue. There may not be enough time or personnel during the initial treatment visit to replace rock.

Replant: Planted materials that die, or are damaged or removed by trespass may be replanted.

Reseed: Future opportunities may arise to collect seed in the area or for commercial seed application.

Re-treat Weeds: Weed species may increase at sites where restoration treatments are applied. Further action may be taken in consultation with the Weed Manager or other expert.

Water Schedule: If outplanted plants are to receive watering, record the frequency in the notes.

Maintenance Notes: Any additional notes related to maintenance requirements.

Additional Restoration Notes

This section provides space to record any additional notes regarding the restoration treatments.

Step 5. Measure and evaluate treatment effectiveness: completing the Restoration Effectiveness Monitoring Form

The effectiveness of restoration is periodically assessed to meet specific management objectives (Table 1). Monitoring has two phases. Implementation monitoring occurs within the first several months to two years and focuses primarily on visitor compliance (for example, trespass), treatment integrity, and to ensure that the initial components of recovery are in place. In contrast, ecological monitoring focuses on the restoration of hydrological function and biotic recovery of the treated disturbance. Indicators of site stability and plant establishment were adapted from Herrick *et al.* (2005) for assessing the effectiveness of restoration efforts. Monitoring should be scheduled for a subset of disturbances as determined by each agency. Implementation monitoring of a subset of disturbances at a prescribed monitoring interval is especially important for documenting the frequency of trespass after restoration implementation (that is, monitoring needs to document both presence **AND** absence of trespass).

Table 1. Suggested management objectives and responses for treated linear and polygon vehicle disturbances on federal lands within Clark County, Nevada

Management Objectives (O)	Management Response (R)
<u>Implementation monitoring (six months to 2 years following treatment)</u>	
O1. Minimize visitor re-use of all disturbances during the first two years after they are treated.	R1. A proportion of visitor re-use of more than 0.20 within a specified region (for example, 20 re-used for every 100 restored disturbances monitored) will prompt an analysis to identify problem areas and implement law enforcement or barriers and signage to prohibit vehicle access in these areas.
O2. Allow no more than 30% loss of restoration structure from implementation up to two years after disturbance is treated.	R2. A greater than 30% decrease in frequency of restoration structure between initial restoration and subsequent monitoring will result in re-treating a disturbance.
O3. Allow an increase in weed frequency of no more than 30%.	R3. Any treated disturbance with an increase greater than 30% in non-native annual plant frequency for treated route over untreated control will trigger notification of Weed Manager and/or appropriate weed removal.
O4. Minimize erosion channels to 10-20%.	R4. A frequency greater than 20% for erosion channels that are ≤ 5 cm deep or wide, or 10% for those > 5 cm deep or wide will identify the need for erosion abatement measures.
O5. Initiate site recovery by enhancing frequency of litter and reducing bare soil cover.	R5. On treated disturbance, litter cover less than 20% or bare mineral soil greater than 20% compared with untreated control will require re-treatment.

Table 1 (cont.) Suggested management objectives and responses for treated linear and polygon vehicle disturbances on federal lands within Clark County, Nevada

Management Objectives (O)	Management Response (R)
<u>Ecological monitoring (approximately every 5 years following treatment)</u>	
O6. Determine site recovery through ecological monitoring of soil compaction, soil erosion, soil stability, and vegetation.	R6a. Average compaction at each depth that is more than 10% of the reference site will continue to be monitored for compaction at 5 year interval. R6b. An average surface and subsurface soil aggregate stability that is more than one stability class less than the reference will continue to be monitored for soil aggregate stability at 5 year interval. R6c. Only for disturbances where undisturbed reference areas have soil crust, average soil crust count that is less than 25% of the reference site will continue to be monitored for soil crust at 5 year interval. R6d. A greater than 10% difference in the frequency of perennial plants (Herb Per, Per Grass, Woody Per, Suc Per) between treated disturbance and reference will indicate continued monitoring at 5 year interval.

Data collected on hand-held electronic devices and downloaded to an electronic spreadsheet such as Microsoft Excel (refer to Appendix IV on page 64-65) will greatly facilitate analysis of the restoration effectiveness to determine whether management objectives have been met. The values presented as guidance measures for management response are based on best existing knowledge, and should be re-evaluated periodically as new information becomes available in the adaptive management framework. The protocol for determining management responses is meant to be a guide only, and participation of experts in monitoring design and statistical analyses is essential and highly recommended.

Instructions for completing the Restoration Effectiveness Monitoring Form (Appendix IV)

Restoration Code: The unique identifier for the treated disturbance. This code was assigned during restoration treatment documentation of the disturbance (see Step 4).

Observers: Include first and last names of all individuals participating in monitoring.

Date: Date on which the monitoring is completed. MM/DD/YYYY

Select One: Check the appropriate box to which the data sheet applies, Treated Disturbance, Untreated Control, or Undisturbed Reference. All measurements must be completed for each of these three areas, or the data will not be usable.

A reference site for monitoring is a nearby undisturbed area with similar slope, aspect and soil type to the treated area. For example, if a disturbance occurred on a bench, a neighboring bench would make a better reference site than a wash, even if the wash was physically closer to the disturbance.

A control site for monitoring is an untreated portion of the disturbance where further trespass does not occur. The control site must be at least as large as the treated area and occur on a similar slope, aspect and soil type. For linear disturbances such as an unauthorized route, a control site is generally located beyond where active restoration treatments are applied. The comparison of soil and vegetation between the control and reference sites during effectiveness monitoring indicates recovery from the disturbance without human intervention, sometimes referred to as passive restoration. Passive restoration is typically the most cost-effective solution for mitigating damage associated with disturbance but may take many years to achieve. In contrast, the comparison between control and treated sites indicates the effectiveness of the treatments applied to the disturbance.

GPS File: Take a GPS track of the Treated Disturbance, Untreated Control, or Undisturbed Reference monitored. At minimum, record a start and end point. Record the name of the GPS file associated with this data sheet.

Photo File(s): Record the file name of the photo or photos of the monitoring area, if applicable.

Purpose of Site Visit: Document trespass or Effectiveness monitoring. If the purpose is to document a trespass, record details in the Additional Monitoring Notes section. At a minimum, record damage to barricades, signs and restoration treatments. If the visit is to conduct effectiveness monitoring, either short-term

implementation monitoring or long-term ecological monitoring, complete the rest of the sheet. You may select both options.

Line-Point and Belt Transect Measurements

Line-point and belt transects within disturbances are a rapid technique for detecting changes associated with restoration treatments. For a treated linear disturbance (check "Treated Disturbance"), run a transect line down the middle of the treated route, starting at least 5 m (approx. 16') from the beginning of the treated area and ending at least 5 m from the end of the treated area to avoid edge effects. The treated area must be long enough to accommodate a transect 50 meters (approx. 164') long, as indicated on the data sheet. Overlay a belt transect one-half the width of the treated route segment, using the line-point transect as the center of the belt. If the entire treated route is 1 meter wide, for example, the belt transect will be 0.5 meters wide with its center being the line transect already established. Record the width of the belt transect on the data sheet. Starting at the end closest to the main designated route, lower a thin rod, wooden dowel or pin perpendicular to the soil surface, or use a laser point sampler, every 1 m along the transect. It is important to always stand on the same side of the transect tape to avoid bias in the readings. At each point, record only the surface that the rod or pin lands directly on. Also search the belt carefully for all plants, including small seedlings, in 1-meter long intervals and check the appropriate boxes for each plant functional group found. For the reference area, lay out the belt transect at a width equivalent to that used for the treated disturbance and untreated control. For monitoring treated polygon disturbances, the procedure is the same, but a minimum of three transects should be distributed across the treated area to represent the disturbance as a whole, and the belt transects should be 2 meters wide. In all cases, comparable untreated and undisturbed areas are needed for comparison (fill out separate forms and check "Untreated Control" or "Undisturbed Reference").

Surface: Soil surface characteristic. Record as the following categories:

BR: Bedrock

R: Rock fragment greater than ¼ inch (0.6 cm) in diameter

M: Moss

LC: Lichen crust

L: Litter. Litter is defined as any detached dead plant material that is lying directly on or partly incorporated into the soil (for example, dead annuals, leaves, stems, branches, stumps).

V: Vegetation. Only a direct hit on the basal area of a plant is recorded as vegetation. Hits on vegetative material are recorded as litter if the vegetation is detached, or as appropriately represents the soil surface under vegetative material not in direct contact with the surface, such as an overhanging branch.

S: Bare mineral soil

Erosion Feature

Record in centimeters the width and depth of any erosion channels, rills, or ruts that cross an imaginary line running perpendicular to the transect line across the entire width of the disturbed area. For the reference area, use a width equivalent to the average width of the disturbance.

Vegetation and Restoration Structure

Check the appropriate boxes for all of the following that are present anywhere within the belt transect in the interval between points. For example, you would record the presence of any plant group present across the width of the belt transect from >1 - 2 meters on the data line labeled 1-2.

N Ann: Native annuals

NN Ann: Non-native annuals (common examples include Sahara mustard, red brome, cheat grass, Chilean chess, red-stem filaree, African mustard, Indian hedgemustard; see Appendix II).

Herb Per: Herbaceous perennials. This category includes non-woody perennial forbs.

Per Grass: Perennial grasses.

Woody Per: Woody perennials. This category includes trees and shrubs.

Suc Per: Succulent perennials. This category includes cacti, yuccas, and agaves.

Rest. Structure: Restoration structure originally placed during restoration treatment. This category includes, but is not limited to, vertical mulch, tree shelters, horizontal mulch and boulders. Restoration structure not only reduces the visual cue of the disturbance, but also provides the means for seeds and nutrient-rich organic matter to be trapped on the disturbance and promote recovery.

Soil Stability Class

Every 5 meters along the line transect, measure soil stability. Record the stability class for both surface and subsurface soils. Sample approximately 5 cm away from the transect line on the side selected as the "no trample" zone. Methods are detailed by Jeff Herrick, but a brief synopsis is included here.

Use the wide end of the sampling scoop to excavate a small trench (1-1.5 cm deep) in front of the sampling area. Use the small end of the sampling scoop to lift out a surface soil fragment. If soil crust is present, include the crust in the sample. The ideal size of fragment is 3 mm thick and 6-8 mm in diameter.

Carefully place sample on a dry sieve and place in appropriate cell of a dry box. Collect the subsurface sample directly below the surface sample. Place sample on a dry sieve and place in appropriate cell.

Once you have collected all 18 samples from the transect (9 surface and 9 subsurface samples), fill the second empty box with deionized or distilled water. Lower the first sieve, with sample, into the respective water-filled compartment. Start the time when the first sample touches the water. Every 15 or 30 seconds

put the next sample in the water (beginners should use 30 seconds). Watch the sample for the first 5 seconds to determine if sample is in class 1. Check sample after 30 seconds to determine if the sample is in class 2. After a sample has been in the water for 300 seconds (5 minutes), raise the sieve completely out of the water and then lower it to the bottom without touching the bottom. Repeat dipping 5 times. Proceed with the dipping cycle even if you have already rated the sample a 1, 2, or 3. You should change the rating if after dipping, >10% remains on the sieve. Rate hydrophobic samples as 6 and circle the classification.

Stability classes

- 1: 50% of structural integrity lost (melts) within 5 seconds of immersion in water, **or** soil too unstable to sample (falls through sieve).
- 2: 50% of structural integrity lost (melts) 5-30 seconds after immersion.
- 3: 50% of structural integrity lost (melts) 30-300 seconds after immersion, **or** < 10% of soil remains on the sieve after five dipping cycles.
- 4: 10–25% of soil remains on the sieve after five dipping cycles.
- 5: 25–75% of soil remains on the sieve after five dipping cycles.
- 6: 75–100% of soil remains on the sieve after five dipping cycles.

Compaction

Measure soil compaction every 5 meters along the line transect,. A dynamic cone penetrometer, such as that described by Herrick and Jones (2002) is recommended, as the measurements obtained are more consistent among observers than with static cone penetrometers, where extreme care must be taken to maintain a constant velocity. Before beginning, record the parameters used with the penetrometer: mass in grams and drop height in meters. Record the number of drops needed to drive the penetrometer into the soil to 5 cm, 10 cm, 15 cm, and 20 cm depth. These depth intervals are marked on the penetrometer by permanent incisions around the shaft. Sample away from the transect line on the side selected as the “no trample” zone, taking the measurement near, but not in, the hole left by soil stability sampling. At all times, take care to keep the penetrometer vertical or readings will be inaccurate.

Biological Soil Crusts

Adapted from protocols developed by Jayne Belnap (Photo credit: Jayne Belnap, USGS). See Belnap *et al.* (2001), an excellent reference for ecology and management of crusts.

Every 5 meters along the line-intercept transect, measure biological soil crusts. To quantify biological soil crusts, frequency counts using the point intercept method work best. Use a 25 cm × 25 cm quadrant frame fitted with crosswires every 5 cm, resulting in 36 points per quadrant. At each sampling point along the transect, place the sampling quadrant on the ground approximately 0.5 m away from the vegetation line on the side selected as the “no trample” zone, taking care to avoid the disturbance caused by soil stability and compaction

measurements. Record the frequencies of crustal organisms at each of the points within the quadrat.

Biological soil crusts are composed of cyanobacteria, lichens, mosses, and occasionally liverworts. There are a wide variety of lichens and mosses, and it can take a lot of training to identify lichen and mosses to species. Strong relationships exist between morphology of biological crust organism and their ecological functioning in relation to landscape processes and disturbance (Eldridge and Rosentreter 1999). Therefore, classification of biological soil crusts can occur on a general morphological level. There are 3 nitrogen fixing lichens (*Collema*, *Placidium*, and *Psora*) that are easily identified and should be counted separate from the rest of the lichens due to their influence on nitrogen levels. Groupings appropriate for Mojave Desert uplands are Cyanobacteria, *Collema*, *Placidium*, *Psora*, Other Lichen, Short Moss, Litter, Rock, and Bare. Specimens of crust organisms can be collected from outside the sampling area for further identification by experts.

***Collema* species**

Gelatinous lichen with a blackish color. Jelly-like when moist, doubles in size when wet.



***Placidium* species**

Squamulose lichen with brownish color and black reproductive structures. Scale-like appearance.



***Psora* species**

Squamulose lichen with white scale-like appearance and black reproductive structures.



Short moss

When rehydrated, the resulting green color distinguishes mosses from lichens.



Additional Monitoring Notes: Any additional information regarding monitoring.

Determining Responses to Management Objectives

1. Minimize visitor re-use of disturbances during the first two years after treatment.

The recurrence of vehicle disturbances is likely to be detected within several months to two years following implementation of restoration treatments. There are at least two perspectives for this monitoring: 1) determine the pattern of re-use of restored disturbances (for example, a BLM manager wants to know the proportion of restored areas within ACECs that were re-used) or 2) determine whether re-use of disturbances is associated with particular treatments (for example, a restoration specialist wants to determine if vertical mulch is more effective at discouraging re-use of vehicle disturbances during the first two years of treatment implementation compared with horizontal mulch). The first perspective focuses primarily on requirements for annual administrative reporting: the proportion of restored disturbances that are re-used is calculated as the total number of disturbances with documented vehicle re-use (noted as “Document Trespass” on Implementation Monitoring Form) divided by the total number of forms completed for disturbances monitored after restoration. This calculation can also be expressed on a restored area basis. When re-use of these restored disturbances exceeds a proportion of 0.20, mapping the spatial pattern of restored disturbances and their re-use triggers specific management responses. For example, if a cluster of restored disturbances that are repeatedly re-used occur adjacent to a social area, a management response may include increased law enforcement, educational signage, or constructing physical barriers. This spatial analysis requires a large sample and a broad distribution of restored disturbances (> 50 restored disturbances).

The second perspective focuses specifically on the effectiveness of particular restoration treatments and can be analyzed statistically. A 2×2 contingency table (referring to two outcomes – presence or absence of trespass during a specified time period – for two route treatments – those routes receiving the treatment of interest versus those that received passive treatment) tests the null hypothesis that the proportion of restored routes that are re-used is the same as the proportion for passively restored routes. Rejection of the null hypothesis supports the alternative that the restoration treatments deterred the re-use of the treated disturbance. This contingency table approach may be extended to a $2 \times p$ contingency table to reflect p additional treatments (horizontal mulch, barriers, raking, surface roughening). Refer to Elzinga *et al.* (2001) and statistics texts for a thorough description of the background and execution of a contingency table analysis.

2. Allow no more than 30% loss of restoration structure from implementation to up to two years after disturbance is treated.

Restoration treatments that do not remain intact during extreme rainfall events or due to vandalism require repeated maintenance. Treatment structures such as horizontal and vertical mulches, boulders and rock placement, are expected to remain intact until the disturbance recovers over the course of many years. However, disturbances whose restoration structures are reduced within the first two years may need supplemental treatment; particularly for disturbances that are visible to the public, occur on steep inclines, or those with persistent erosion channels that move surface sediment and restoration structures off the restored area. For each disturbance where restoration structure was added, count the number of 1-meter belt intervals along the transect that noted restoration structure and divide by the total number of intervals surveyed on the Effectiveness Monitoring Form (note: disturbances that are treated with passive restoration or hand raked only are excluded from this management objective). Treated disturbances with more than 30% loss of restoration structure from the initial monitoring to the time of follow-up monitoring within 6 months to 2 years may require re-treatment. Selection of treatment should be based on site-specific conditions (for example, straw bales for disturbances with steep slopes and high surface flow during rain events).

3. Allow an increase in weed frequency of no more than 30%.

Restoration treatments can initially favor establishment of aggressive non-native annual species after implementation, especially for treatments that roughen the soil surface or enhance nutrient availability. Count the number of 1-meter belt intervals with non-native annuals ("NN Ann") for the Treated Disturbance and the Untreated Control and divide each by the total number of belt intervals surveyed to calculate frequencies. A 30% higher weed frequency on treated disturbance compared to the untreated control may require consultation with the Weed Manager. This comparison should be made with every evaluation that is conducted on restoration sites.

4. Minimize erosion by 10-20%.

Count the number of points with erosion features that are ≤ 5 cm deep or wide and those that are > 5 cm deep or wide; divide these counts by the total number of points surveyed on the Line-Point Measurements from the Effectiveness Monitoring Form to calculate frequency. A frequency that is greater than 20% for erosion channels that are ≤ 5 cm deep or wide, or 10% for those > 5 cm deep or wide, will prioritize these disturbances for re-treating with additional erosion control measures.

5. Initiate site recovery by enhancing frequency of litter and reducing bare soil cover.

Successful restoration should be quantifiable using some basic criteria to show site improvement based on management objectives. For example, litter cover is highly correlated with the abundance of native seeds in the seed

bank in highly degraded Mojave Desert shrublands (DeFalco et al. 2009). Count the frequency of surface points recorded as litter (*L*) divided by the total number of points surveyed for both treated disturbance and untreated control (note: remove points recorded as bedrock (*BR*)). The same procedure is conducted for bare mineral soil (*S*). A <20% difference on treated disturbance compared to untreated control will help identify which treatments are performing poorly with regard to litter cover and bare mineral soil. Treatments that augment litter cover and decrease bare mineral soil, such as horizontal mulch and rock placement should be considered for re-treatment.

6. Detect site recovery by monitoring soil compaction, soil erosion, soil stability and vegetation.

The ecological recovery of a treated disturbance may take years to decades to detect. This management objective aims to determine the point at which monitoring is no longer needed and the site can be considered “restored.” Average across the nine sampling points the number of drops to reach each depth during compaction measurements for the Treated Disturbance and the Undisturbed Reference. A difference in drops of more than 10% for any of the four soil depths indicates continued monitoring for compaction again in 5 years. Similarly, average the surface and subsurface soil stability classes; a difference of more than one stability class of the Treated Disturbance from the Undisturbed Reference indicates continued monitoring for soil stability again in 5 years. For biological soil crusts, calculate the average of the combined counts of cyanobacteria, *Collema*, *Placidium*, *Psora*, other lichens and short moss for both Treated Disturbance and the Undisturbed Reference. An average soil crust count less than 25% of the reference site will indicate continued monitoring for crust organisms again in the next 5 years. Finally, count the number of 1-m belt intervals for each of the vegetation growth forms (N Ann, NN Ann, Herb Per, Per Grs, Woody Per, and Suc Per) for the Treated Disturbance and Undisturbed Reference. Annuals are expected to recover more rapidly than herbaceous perennials and perennial grasses, followed by woody perennials and succulent perennials. A difference between Treated Disturbance and Undisturbed Reference greater than 10% for each plant functional group will indicate continued monitoring for that group at the next 5 year interval.

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Appendices

Appendix I. Disturbance Assessment Form

Disturbance Assessment Form

Disturbance Code _____ Date _____
Agency _____ Region _____ Location _____
Observer / Assessing Party _____ USGS Quad _____

GPS

GPS File _____ Photo File # _____
X _____ Y _____ Court Case # _____

Disturbance - Properties (check one box per property)

Site Stability

☐ Unstable ☐ Poor ☐ Moderate ☐ Good ☐ Stable

Soil Crust

Disturb- ☐ No Crust ☐ Alkali ☐ Cyano-patchy ☐ Cyano-continuous ☐ Lichen-patchy ☐ Lichen-continuous
Undist- ☐ No Crust ☐ Alkali ☐ Cyano-patchy ☐ Cyano-continuous ☐ Lichen-patchy ☐ Lichen-continuous

Accessibility ☐ High ☐ Medium ☐ Low Visibility ☐ High ☐ Medium ☐ Low

Recent use ☐ Yes ☐ No Frequently used ☐ Yes ☐ No

Plant Canopy Damage

☐ Denuded ☐ Many with roots exposed or detached ☐ Many highly dissected, roots exposed
☐ Many dissected, few highly dissected ☐ Many irregular, few dissected ☐ Most symmetrical ☐ Intact

Court Case Number of Plants Damaged

Actual Count (/ species): _____ / _____
Actual Count (/ species): _____ / _____
Actual Count (/ species): _____ / _____

Sensitive Species (write in the species)

☐ _____ ☐ _____ ☐ _____ ☐ _____ ☐ _____ ☐ _____

Weeds (check all present)

Notify Weed Manager	☐ Yes ☐ No	Suggest Weed Survey?	☐ Yes ☐ No
☐ Acreptilon repens	☐ Convolvulus arvensis	☐ Nerium oleander	☐ Sorghum halepense
☐ Brassica tournefortii	☐ Elaeagnus angustifolia	☐ Nicotiana glauca	☐ Tamarix aphylla
☐ Bromus inermis	☐ Erodium cicutarium	☐ Pennisetum cetaceum	☐ Tamarix ramosissima
☐ Bromus rubens	☐ Hordeum vulgare	☐ Phragmites australis	☐ Taraxacum officinale
☐ Bromus tectorum	☐ Kochia spp.	☐ Rhaponticum repens	☐ Tribulus terrestris
☐ Bromus tritici	☐ Lepidium latifolium	☐ Salsola tragus	☐ Typha angustifolia
☐ Cardaria draba	☐ Lolium perenne	☐ Sisymbrium orientale	☐ Verbascum thapsus
☐ Ceratocephala testiculata	☐ Malcomia africana	☐ Solanum elaeagnifolium	☐ Xanthium spp.
☐ Other _____	☐ Other _____	☐ Other _____	☐ Other _____

Line Disturbance - Description (only check one box for each)

Type ☐ One-Track ☐ Two-Track ☐ Random Tracks ☐ Road
Depth ☐ Broken < 2" ☐ Ruts 2" - 4" ☐ Ruts 4" - 8" ☐ Ruts > 8"
Width ☐ 2 ft - Dirt Bike ☐ 4 ft - ATV ☐ 6 ft - Vehicle ☒ Other _____ (width in feet)
Use ☐ Social ☐ Mine ☐ Old utility ☐ Random/Bladed
Length (m) _____ Length (ft) _____

Comments

Appendix I. Disturbance Assessment Form (cont.)

Point Disturbance - Description (only check one)

Type ☐ Dumpsite ☐ Fire Ring ☐ Graffiti ☐ Mine
☐ Plant Collection ☐ Other _____

Area (square m) _____ **Area (square ft)** _____

Comments _____

Polygon Disturbance - Description (only check one)

Type ☐ Donuts ☐ Pullouts ☐ Random Track ☐ Denuded Area ☐ Scrape
Depth ☐ Broken < 2" ☐ Ruts 2" - 4" ☐ Ruts 4" - 8" ☐ Ruts > 8"

Area (square m) _____ **Area (square ft)** _____

Comments _____

OVERALL INDEX OF LINE/POLYGON DISTURBANCE SEVERITY:

(Undist-Disturb) + () + () + () + () = _____
 Crust damage Plant damage Type Depth Width Overall Index

The Drive

Documentation Time _____ hours (include prep time, travel time one way, and time to GPS site)

Directions to Site _____

Suggested Restoration Techniques (Check all that apply)

Barriers

☐ Boulders ☐ Gate ☐ Metal Post ☐ Metal Post & Cable
☐ T-Post ☐ T-Post Fence ☐ Tank Traps ☐ Telephone Posts
☐ Telephone Posts & Cable ☐ _____ ☐ _____ ☐ _____

Restoration

☐ ATV/chain-drag ☐ Dump Removal ☐ Graffiti (chisel/hammer) ☐ Graffiti (chem. remover)
☐ Fill ☐ Mulch (Horizontal) ☐ Mulch (Vertical) ☐ Permeon
☐ Pitting ☐ Raking/Hand Tools ☐ Replanting ☐ Rock Replacement
☐ Seeding ☐ Transplant ☐ Weed Removal ☐ Fire Ring Removal
☐ Litter/seed bank transfer ☐ Natural Recovery ☐ Other _____

Signs	Quantity	Message(s)
Carsonite	_____	_____
Sign	_____	_____

Cultural

☐ Cultural _____

Comments _____

Appendix II. Photo Gallery of Weeds

Pictures of commonly-encountered weed species are used with each photographer's permission. No license is given or implied to utilize these images for any purpose outside of this document.

- ***Acrotilon repens* (*Rhaponticum repens*, Russian knapweed)**



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- ***Brassica tournefortii* (Sahara mustard)**



© 2004 James M. Andre



© 2009 Thomas Stoughton

- ***Bromus inermis*
(smooth brome)**



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- ***Bromus rubens*
(red brome)**



USGS, Lesley DeFalco

- ***Bromus tectorum*
(cheat grass)**



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Appendix II. Photo Gallery of Weeds (cont.)

▪ *Bromus trinii* (Chilean chess)



© 2006 Steve Matson



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▪ *Cardaria draba* (whitetop, hoary cress)



© 2009 Barry Breckling



© 2001 CA Dept. of Food & Agriculture

▪ *Ceratocephala testiculata* (curvseed butterwort; flowering and senescing)



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Appendix II. Photo Gallery of Weeds (cont.)

- *Convolvulus arvensis* (bindweed)



© 2008 Dr. Amadej Trnkoczy



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- *Elaeagnus angustifolia* (oleaster, Russian olive)



© 2008 Louis-M. Landry



© 1995 John Randall, Ph.D



© 1998 John Randall, Ph.D

- *Erodium cicutarium* (red-stem filaree, storksbill)



© 2010 Neal Kramer



USGS, Lesley DeFalco

Appendix II. Photo Gallery of Weeds (cont.)

- *Hordeum vulgare* (common barley)



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- *Kochia* species (kochia, burning bush, smotherweed)



© 2001 CA Dept. of Food & Agriculture

- *Lepidium latifolium* (broad-leaved pepperweed)



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© 2008 Jorg Fleige

- *Lolium perenne* (perennial ryegrass)



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- *Malcolmia africana* (African mustard)



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Appendix II. Photo Gallery of Weeds (cont.)

- ***Nerium oleander* (oleander)**



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© 2007 Louis-M. Landry

- ***Nicotiana glauca* (tree tobacco)**



© 2005 Steven Perkins



© 2009 Thomas Stoughton

- ***Pennisetum setaceum* (fountaingrass)**



© 2010 Michael O'Brien



© 1995 Br. Alfred Brousseau, Saint Mary's College

Appendix II. Photo Gallery of Weeds (cont.)

- *Phragmites australis* (common reed)



© 2009 Robert Sivinski



© 2005 Luigi Rignanese

- *Sisymbrium orientale* (Indian hedgemustard)



© 2009 Phil Pullen



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- *Salsola tragus* (prickly Russian thistle) *Solanum elaeagnifolium*
(silverleaf nightshade)



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Appendix II. Photo Gallery of Weeds (cont.)

- *Sorghum halepense* (Johnsongrass)



© 2001 CA Dept. of Food & Agriculture



© 2009 Barry Rice

- *Tamarix aphylla* (athel tamarix)



© 2010 Neal Kramer



© 2009 Neal Kramer

- *Tamarix ramosissima* (saltcedar)



© 2000 Joe DiTomaso



© 2005 Steven Perkins

- *Taraxacum officinale* (common dandelion)



© 1995 Br. Alfred Brousseau, Saint Mary's College

Appendix II. Photo Gallery of Weeds (cont.)

- ***Tribulus terrestris* (puncturevine)**



© 2001 Steven Thorsted



© 2005 James M. Andre



© 2008 John Dittes

- ***Typha angustifolia* (narrowleaf cattail)**



© 2005 Louis-M. Landry



© 2008 Neal Kramer

- ***Verbascum thapsus* (common mullein)**



© 1995 Br. Alfred Brousseau, Saint Mary's College

Appendix II. Photo Gallery of Weeds (cont.)

- *Xanthium* species (cocklebur)



© 2006 Kai Palenscar



© 2003 George W. Hartwell

Appendix III. Restoration Project Documentation Form

Restoration Project Documentation

Restoration Code _____ Start Date _____

Disturbance Code(s) _____ End Date _____

Length Completed (m) _____ Length Completed (ft) _____
Area Completed (square m) _____ Area Completed (square ft) _____

Project Leader _____ Photo File(s) _____

Treatment GPS File _____

Are there a suitable Control and Reference for monitoring treatment success? ☐ yes ☐ no

If Yes:

Control GPS File _____

Reference GPS File _____

Weather

Cloud Cover ☐ 0-5% ☐ 6-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%
Precipitation ☐ none ☐ rain ☐ hail ☐ snow ☐ other: _____
Precip Duration ☐ N/A ☐ intermittent ☐ constant Temperature _____

Restoration Techniques Used (Fill in all that apply with # of Linear or Square meters or feet)

_____ ATV/chain-drag	_____ Mulch (horizontal)	_____ Raking (leaf)	_____ Weed Removal
_____ Fill	_____ Mulch (vertical)	_____ Raking (rock)	_____ Passive
_____ Fire Ring Removal	_____ Outplanting	_____ Ripping	_____ Treatment
_____ Garbage Removal	_____ Permeon	_____ Rock Replacement	
_____ Graffiti Removal (chem)	_____ Pitting	_____ Seeding	_____ Other
_____ Graffiti Removal (chisel)	_____ Raking (McCleod)	_____ Transplant	(_____)

Signs and Barricades (Fill in all that apply)

☐ Carsonite	Quantity: _____	Message: _____		
☐ Metal Sign	Quantity: _____	Message: _____		
☐ T-Posts	Quantity: _____	☐ T-Post Fence	Quantity: _____	
☐ Telephone Posts	Quantity: _____	☐ Telephone Post & Cable	Quantity: _____	
☐ Metal Posts	Quantity: _____	☐ Metal Post & Cable	Quantity: _____	
☐ Gate	☐ Boulders	Quantity: _____	☐ Tank Trap	Length: _____

Material Used (Check all that apply)

Material	Quantity/Unit	Material	Quantity/Unit
☐ Carsonite Post	_____	☐ Permeon	_____
☐ Dri-Water Gel Packs	_____	☐ PVC Pipe	_____
☐ DriWater Inserts	_____	☐ Rodent Repellent	_____
☐ Drip Line	_____	☐ Stakes	_____
☐ Graffiti Remover	_____	☐ Straw Wattles	_____
☐ Insect Screening	_____	☐ Tree Shelters	_____
☐ Jute	_____	☐ Wire Cages	_____
☐ Mycorrhizae	_____		

Appendix III. Restoration Project Documentation Form (cont.)

Plant Material		Material Type	Material Size	Source	Sensitive	Sensitive
#	Species				Plant	Host
					☐	☐
					☐	☐
					☐	☐
					☐	☐
					☐	☐

Site Collected Material Used

☐ Boulders
 ☐ Cacti
 ☐ Dead/Downed
 ☐ Plant Material
 ☐ Rocks

Seeds

Species	Quantity	Source	Seed Lot ID #	Seedball Content (if applicable)

Rented Equipment Used

Equipment Name	Hours Used	Cost per Unit

Maintenance Required (Check all that apply)

☐ Additional Barriers
 ☐ Law Enforcement
 ☐ Permeon
 ☐ Replant
 ☐ Water Schedule
☐ Decompaction
 ☐ Monitoring
 ☐ Raking
 ☐ Reseed
☐ Graffiti Removal
 ☐ Mulch
 ☐ Replace Rock
 ☐ Retreat Weeds

Maintenance Notes:

Additional Restoration Notes:

Appendix IV. Restoration Effectiveness Monitoring Form

Restoration Effectiveness Monitoring Form

Restoration Code _____

Observers _____

Date _____

Select One:

☐ Treated Disturbance

☐ Untreated Control

☐ Undisturbed Reference

GPS File _____

Photo File(s) _____

Purpose of Site Visit: ☐ Document trespass ☐ Effectiveness Monitoring (Implementation or Ecological)

Line-Point Measurements

Belt Transect Measurements

Width: _____ m

Point	At Point			Interval	Across width of Disturbance (check all that are present)						
	Surface	Width	Depth		N Ann	NN Ann	Herb Per	Per Grass	Woody Per	Suc Per	Rest. Structure
1				0-1	☐	☐	☐	☐	☐	☐	☐
2				1-2	☐	☐	☐	☐	☐	☐	☐
3				2-3	☐	☐	☐	☐	☐	☐	☐
4				3-4	☐	☐	☐	☐	☐	☐	☐
5				4-5	☐	☐	☐	☐	☐	☐	☐
6				5-6	☐	☐	☐	☐	☐	☐	☐
7				6-7	☐	☐	☐	☐	☐	☐	☐
8				7-8	☐	☐	☐	☐	☐	☐	☐
9				8-9	☐	☐	☐	☐	☐	☐	☐
10				9-10	☐	☐	☐	☐	☐	☐	☐
11				10-11	☐	☐	☐	☐	☐	☐	☐
12				11-12	☐	☐	☐	☐	☐	☐	☐
13				12-13	☐	☐	☐	☐	☐	☐	☐
14				13-14	☐	☐	☐	☐	☐	☐	☐
15				14-15	☐	☐	☐	☐	☐	☐	☐
16				15-16	☐	☐	☐	☐	☐	☐	☐
17				16-17	☐	☐	☐	☐	☐	☐	☐
18				17-18	☐	☐	☐	☐	☐	☐	☐
19				18-19	☐	☐	☐	☐	☐	☐	☐
20				19-20	☐	☐	☐	☐	☐	☐	☐
21				20-21	☐	☐	☐	☐	☐	☐	☐
22				21-22	☐	☐	☐	☐	☐	☐	☐
23				22-23	☐	☐	☐	☐	☐	☐	☐
24				23-24	☐	☐	☐	☐	☐	☐	☐
25				24-25	☐	☐	☐	☐	☐	☐	☐
26				25-26	☐	☐	☐	☐	☐	☐	☐
27				26-27	☐	☐	☐	☐	☐	☐	☐
28				27-28	☐	☐	☐	☐	☐	☐	☐
29				28-29	☐	☐	☐	☐	☐	☐	☐
30				29-30	☐	☐	☐	☐	☐	☐	☐
31				30-31	☐	☐	☐	☐	☐	☐	☐
32				31-32	☐	☐	☐	☐	☐	☐	☐
33				32-33	☐	☐	☐	☐	☐	☐	☐
34				33-34	☐	☐	☐	☐	☐	☐	☐
35				34-35	☐	☐	☐	☐	☐	☐	☐
36				35-36	☐	☐	☐	☐	☐	☐	☐
37				36-37	☐	☐	☐	☐	☐	☐	☐
38				37-38	☐	☐	☐	☐	☐	☐	☐
39				38-39	☐	☐	☐	☐	☐	☐	☐
40				39-40	☐	☐	☐	☐	☐	☐	☐
41				40-41	☐	☐	☐	☐	☐	☐	☐
42				41-42	☐	☐	☐	☐	☐	☐	☐
43				42-43	☐	☐	☐	☐	☐	☐	☐
44				43-44	☐	☐	☐	☐	☐	☐	☐
45				44-45	☐	☐	☐	☐	☐	☐	☐
46				45-46	☐	☐	☐	☐	☐	☐	☐
47				46-47	☐	☐	☐	☐	☐	☐	☐
48				47-48	☐	☐	☐	☐	☐	☐	☐
49				48-49	☐	☐	☐	☐	☐	☐	☐
50				49-50	☐	☐	☐	☐	☐	☐	☐

Soil Measurements

	Soil Stability Class		Compaction (# of drops to depth)			
Point	Surface	SubSurface	5 cm	10 cm	15 cm	20 cm
5						
10						
15						
20						
25						
30						
35						
40						
45						

[illegible]

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. The paper has a slight shadow on its right side, suggesting it's resting on a surface.