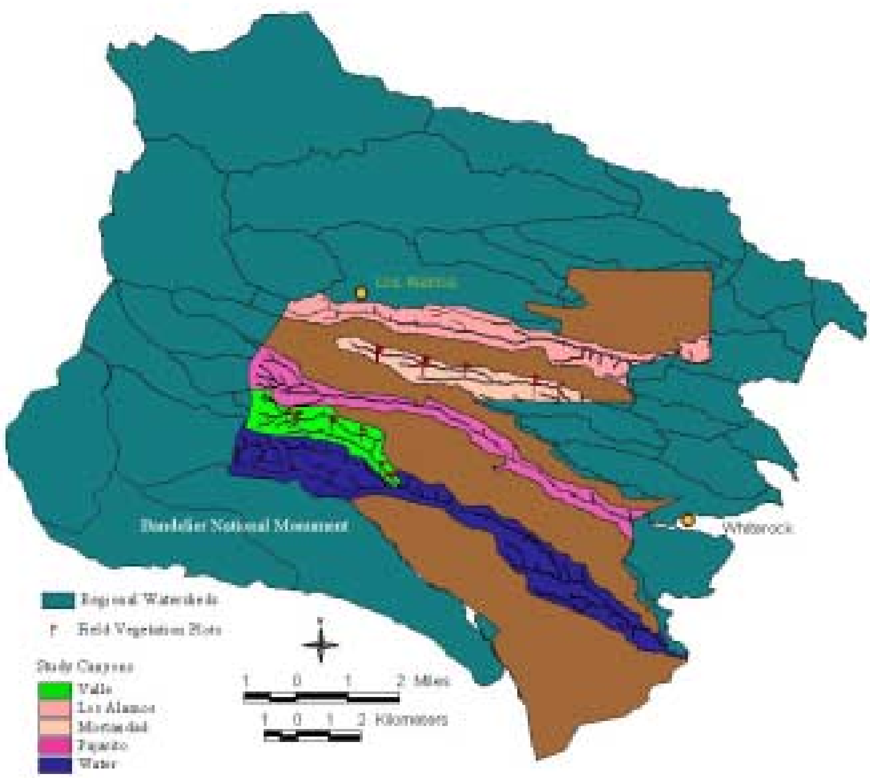
Ecology-Based Biodiversity Evaluation



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Ecology-Based Biodiversity Evaluation for Los Alamos National Laboratory
An Integrated GIS Spatial Analysis and Field Assessment Approach
Final Report[1]

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Summary

An ecology-based biodiversity assessment protocol was developed to support the Los Alamos National Laboratory (LANL) Threatened and Endangered Species Habitat Management Plan (HMP) and for general long-term biological resources management. The protocol relies on a combination of field assessments and GIS spatial analysis, and was developed using a pair of representative canyons on LANL. Field assessment consisted of systematically sampling the vegetation communities (community element occurrences) in each canyon with respect to species composition and a suite of site characteristics. The spatial analysis used the available GIS layers for land cover, roads, and various facilities to analyze the degree of impact and fragmentation in each canyon. Both the field data and spatial analysis results were used to evaluate each vegetation community with respect to sets of condition, landscape and size factors using a weighted ranking procedure. This results in quality ranks for each element occurrence in each canyon, and an overall rank for sites that can be used to compare biodiversity values among canyons. For example, among our two reference canyons, the less impacted Canon de Valle ranked higher (at 3.3 or "B") than Mortandad (2.9 or "C+") with its considerable disturbance in the upper portion of the watershed. Further, GIS analysis of four additional canyons provided information for the delineation of provisional Biodiversity Conservation Areas (BCA) based on contiguous unfragmented natural area. We suggest that BCAs in combination with Areas of Environmental Interest (AEI) developed under the HMP can be used to develop sound biological resource management strategies in the future which can serve to protect LANL's unique biological heritage, while at the same time avoiding conflict with LANL's other mission objectives.

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Introduction

The establishment of Los Alamos National Laboratory (LANL) in 1943, and the subsequent restricted use of its lands has created the unique opportunity for LANL to play a significant role in the conservation and sustainability of biodiversity and other natural resources. While some of this role has been obligated by compliance with federal regulatory mechanisms such as the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA), much also comes from the DOE's stated goal of "using thoughtful planning to sustain the natural systems for which we are stewards."[3] Over the years LANL has moved from a passive natural resources management strategy to a more proactive one. This has most recently resulted in the development of a Threatened and Endangered Species Habitat Management Plan (HMP) to address the specific needs of species of concern (SOCs, federally listed rare and endangered species, candidate species, and other identified sensitive species). The HMP led to the delineation of specific sites with habitat suitable for the maintenance and sustainability of SOCs. These sites are termed Areas of Environmental Interest (AEIs), and they address the protection of target species, but not necessarily the management of the wider complement of biota that occupy laboratory lands.

To expand the scope of biological management other national labs, such as Oak Ridge Reservation, have embarked on comprehensive assessments of biodiversity that not only look at SOCs, but also at the distribution and status of all ecosystem components on their lands. Accordingly, at Oak Ridge, the DOE recognized the need to identify development/conservation alternatives, and in 1994 began what became known as the "Common Ground Process." As part of the process they enlisted The Nature Conservancy (TNC), the international Natural Heritage Network and the state of Tennessee's Natural Heritage Program in an inventory and assessment of the overall biodiversity of the reservation, and the mapping of sites based on biodiversity conservation value. Oak Ridge was viewed as a continuing opportunity to conserve a biologically significant and relatively intact portion of Tennessee's Southern Ridge and Valley province that was compatible with the DOE's mission and stewardship goals (The Nature Conservancy 1995).

LANL recognized a similar need for an alternative, landscape and ecology-based approach to biodiversity evaluation that would be complementary to the species-specific management embodied in AEIs, and also amenable to the general biological management of the lab's mission. Such an approach would help to efficiently address long-term stewardship goals of the natural systems of the laboratory, while also providing a support tool for long-range installation planning that would avoid the bottlenecks and pitfalls inherent in statute-driven biological management. To help meet this goal, a pilot project was initiated as a cooperative effort between LANL ESH-20 and the New Mexico Natural Heritage Program (NMNHP) at the University of New Mexico to develop a comprehensive protocol for biodiversity evaluation that would combine ecological field studies and geographic information system (GIS) based landscape analysis. The protocols would draw upon the Oak Ridge experience and the standards established by the international Natural Heritage Network and The Nature Conservancy for effective biodiversity assessment. In addition, it would take

[3]Threatened and Endangered Species Habitat Management Plant Overview, Los Alamos National Laboratory, 1998.

advantage of new GIS technologies that enable efficient and precise analysis of landscapes—a factor that adds significant breadth and scope to the evaluation process.

The immediate goal of this project is to develop the protocol using a small target set of LANL canyons as sites for biodiversity evaluation. The field studies focus on just one pair of canyons (Mortandad and Canon de Valle) that are known to have significantly different land use histories. GIS-based analysis covers three additional canyons, Pajarito, Los Alamos and Water, that allows for more detailed multi-site comparisons and evaluation of the techniques. An overall approach is outlined that identifies areas of significant biodiversity concentration and landscapes of high ecological functionality which can be used to support effective biological management unit design in the context of LANL's mission.

The Ecology-Based Biodiversity Evaluation Approach

The ecology-based biodiversity approach is outlined in Figure 1. Any site-based biodiversity evaluation begins with the definition and delineation of what constitutes a site, or set of sites, for consideration. A "site" can have several operational definitions, be they biologically based on species distributions or community patterns, or physically based on soils patterns, geology, watersheds, or some other spatially delineated environmental information. In the case of LANL, we took the previously defined canyon watersheds based on first-order streams as our operational sites. These may or may not be the final desired biological units, but they serve as a starting point in the assessment process, and are generally understood by most people since they are already being used in planning and management of the lab. For this pilot project, five target canyons were chosen that represent a wide range of sizes and environments on the lab (Figure 2).

Once sites are defined they are evaluated with respect to their biotic composition and landscape context through a detailed ranking procedure that addresses each biological element of interest in a site. A biological element may be a plant or animal species or plant community, and an *element occurrence* (EO) is either a plant or animal *population*, or a stand(s) of a plant community element. As with sites, EOs can be defined in different biological and physical ways, but for our purposes here, EOs are site or-watershed-defined, i.e., there can only be one occurrence of a biological element in any given site. The ecology-based evaluation process focuses on plant community elements because communities have measurable properties such as species diversity, structure, productivity, and landscape pattern and process, that are good indicators of ecosystem function and sustainability. Plant communities provide an index of the overall biodiversity wealth of a site, and their status or "health" is a reflection of the long-term viability of the constituent elements of the ecosystem, both seen and unseen.

The next step in the process is to rank the quality of each plant community EO within a site, based upon a methodology developed by the international Natural Heritage Network (NHN) and The Nature Conservancy (TNC) over the last 20 years[4]. This involves both field studies to directly determine the condition of an element in terms of species composition, structure, and physical attributes of the environment, plus a GIS-based landscape analysis to

[4] Element Occurrence Data Standard; Working Draft Part 1. 1997. The Nature Conservancy.

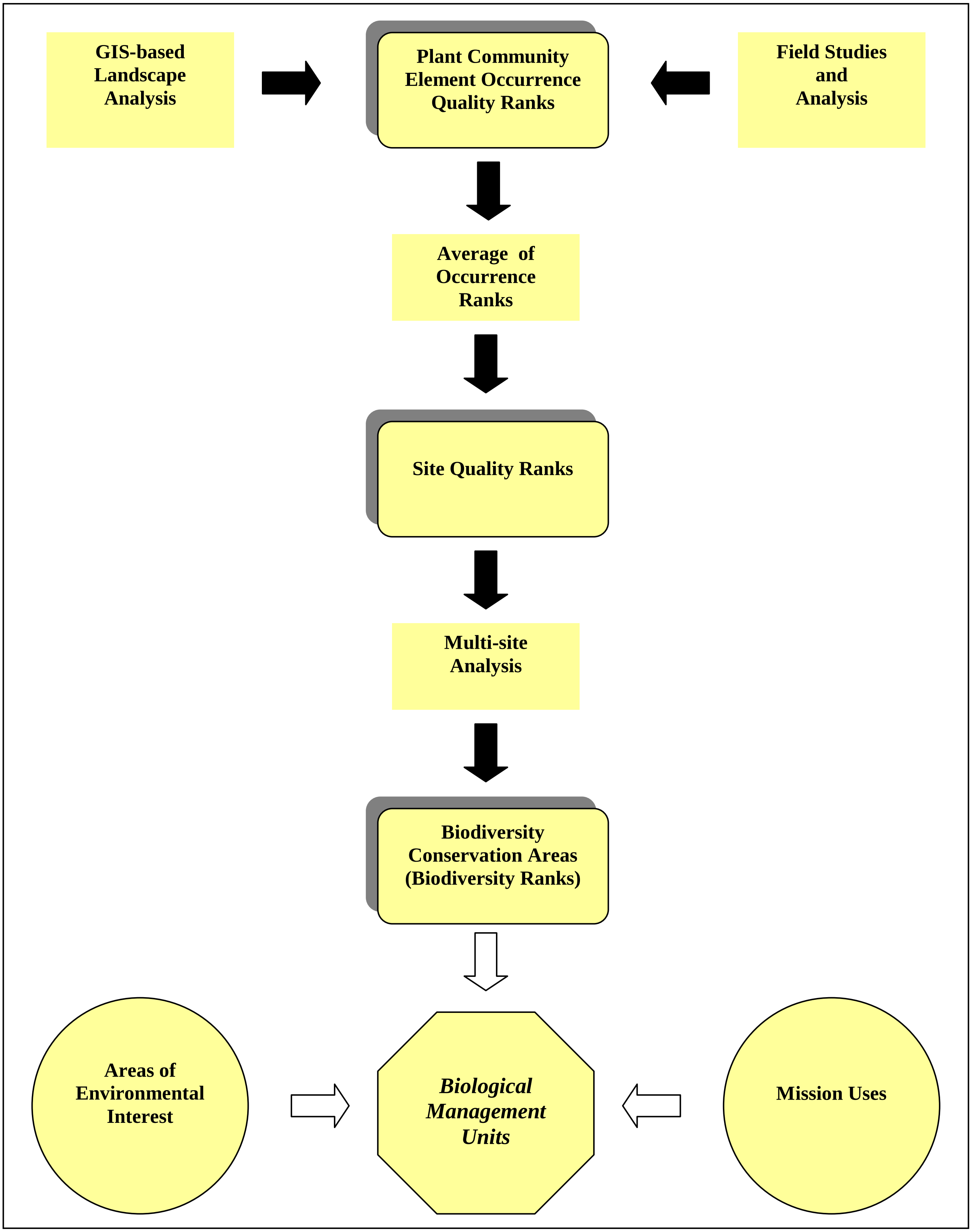

Figure 1. The process for the determination of ranks for element occurrences within sites, overall site ranks, and the delineation of Biodiversity Conservation Areas as input into the design of biological management units, along with Areas of Environmental Interest and mission uses.

Study Canyons

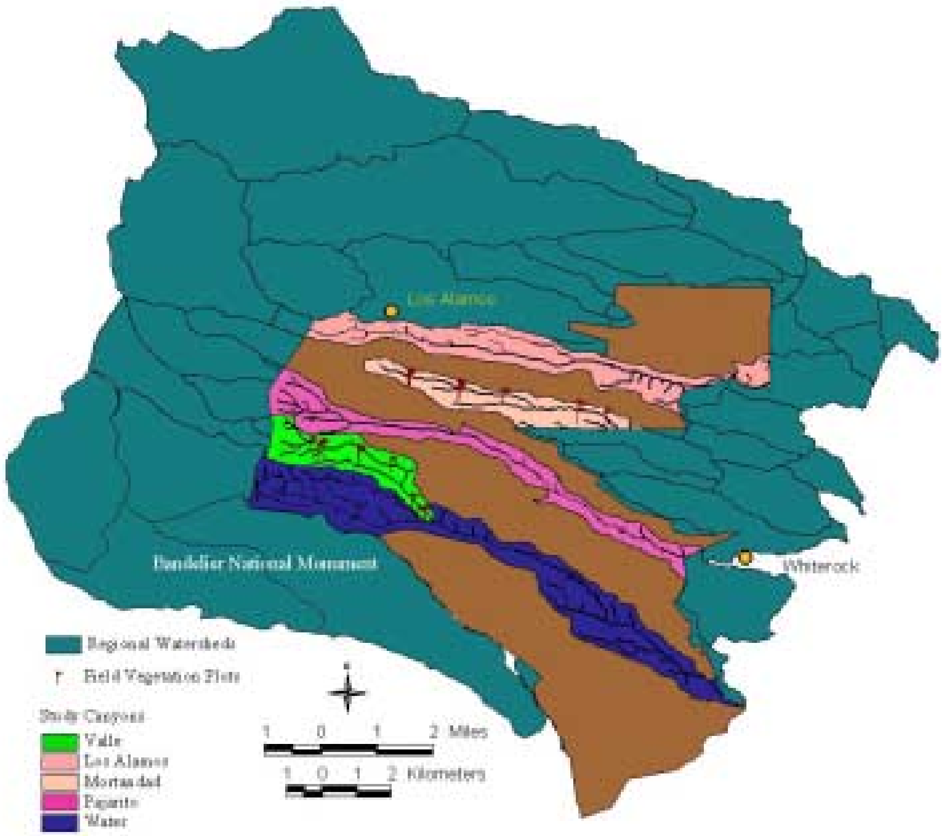

Figure 2. The five canyons selected for the LANL provisional biodiversity evaluation. Drainages were developed in a GIS slope model based on a 30 square meter resolution Digital Elevational Model. Vegetation plots were sampled by New Mexico Natural Heritage Program staff.

determine the ecological context of an element, emphasizing landscape-level processes and patterns that may affect an element's long-term viability. For example, field studies may provide information on exotic species incursion and landscape analysis the degree of fragmentation of habitat that has occurred (this aspect of the process is described in detail in succeeding sections). In the analysis an element is numerically ranked on a wide array of weighted variables resulting in scores between 1.0 and 4.0, where 1.0 represents highly degraded occurrences with low viability or biodiversity value, and 4.0 represents nearly pristine stands with high biodiversity values and viability. The EO ranks for elements of a site are then averaged to arrive at an overall site rank.

Remembering that our sites are operationally defined by watershed boundaries, we then take the next step to reevaluate the landscapes through a multi-site analysis to define areas that are the foci of conservation value; we call these *Biodiversity Conservation Areas* (BCA). These areas represent high ecological integrity as measured by "intactness" and low-utilization impacts, and they may lie entirely within one watershed or stretch across two or more. The BCAs are then also rated on their biodiversity value using the original occurrence and site ranks. Following the guidelines of The Nature Conservancy, BCAs are assigned Biodiversity Ranks based not only on EO quality, but also on the global rareness of community and other biological elements such as threatened plants or animals. This provides a more regional and global perspective on the biological value of an area. As part of this pilot project we provide a sample design of a BCA.

Biodiversity Conservation Areas are fundamentally ecology based; rareness or endangerdness are additional factors that enter into the assessment only in the final stages. They represent independent evaluations of biodiversity value, separate from species-focused delineations such as Areas of Environmental Interest (AEI). We see BCAs as complimentary to AEIs. The combination of BCAs and AEIs can be used with LANL mission directives to inform the development of more multi-purpose biological management units as part of a comprehensive biological management planning process.

Study Area

Of the approximately 15 canyons, two were chosen for intensive analysis for this pilot project: Canyon de Valle (Valle) and Mortandad (Figure 2). These two canyons were subject to both intensive field studies and GIS-based landscape analysis. Three additional canyons, Los Alamos, Pajarito and Water, were later added to the landscape analysis as an initial step in their evaluation, to be followed by future fieldwork.

Methods

Element Occurrence and Site Ranking Criteria

The ranking of a plant community element occurrence (EO) within a site focuses on three sets of factors: condition, landscape, and size (Table 1). These are based on concepts

Table 1. Element Occurrence Ranking Specifications for LANL Ecological Assessment (10/98). A vegetation community occurrence is evaluated on each factor where information is available, then scored by multiplying the numerical point value (pt) of a rank by the weighting factor (W). Next, a rank for each Factor (Condition, Landscape Context and Size) is computed as Sum of the Scores/Sum the Weights.

	Condition Factors	**W**	**A Rank (4 pt)**	**B Rank (3 pt)**	**C Rank (2 pt)**	**D Rank (1 pt)**
C1	*Exotics versus Natives Canopy.* rees, shrubs, or herbs)	5	Natives dominate the highest structural layer; exotic species poorly represented or absent; <5% of the cover in the same structural layer.	Natives dominate, but exotics compose between 5% and 15% of the cover in the same structural layer.	Natives still dominate, but exotics may co-dominate with 15-50% of the cover in the highest structural layer.	Exotics dominate more than 50% of the cover in the highest structural layer.
C2	*Undergrowth Exotics*	5	Exotics <10% of undergrowth cover.	Exotics between 10% and 50% of the cover.	Exotics between 50% and 75% of the cover.	Exotics >75% of the vegetative cover.
C3	*Structural Diversity and Cover* Presence of expected structural layers, i.e. trees, shrubs, and herbaceous layers and their measured loss due to utilization (grazing, fuelwood removals, logging, human-caused fire, etc.).	10	All expected structural layers present; human-induced impacts have reduced potential cover by less than 5%.	All expected structural layers present, but impacts have reduced cover in one or more layers by 5-25% of potential.	One of the expected structural layers significantly reduced in potential cover (50-75%), or two or more layers have lost up to 50% of their potential cover.	One or more expected structural layers reduced by more than 75% of potential cover. Other layers cover reduced by more than 50% of potential.
C4	*Species Richness* Common associates or characteristic species, or loss of, due to unnatural disturbances.	10	Very high species richness; >90% of expected native species associates present. Grazing indicators and weedy species minima1 (<5% of the cover).	High species richness; 75-90% of expected native species associates present. Limited amounts of grazing indicators or weedy species (5-15% of the cover).	Moderate species richness; 50-75% of many expected native species present. Grazing indicators or weedy species may be prevalent (15-50% of the cover).	Low species richness; <50% of the expected native species are present. Grazing indicators and/or weedy species abundant and dominant (>50% of total cover).
C5	*Fire Fuel loads*	5	Light fuel loads; little or no fire potential.	Greater than normal fuel loads; possible fire potential.	Moderate fuel loads representing a definite fire potential.	Excessive fuel loads, catastrophic element-removing fire likely.
C6	*Erosion*	5	Natural erosion conditions for soil type (usually mostly sheet and small rill).	Slight erosion, some indications of more than normally expected for the soil type (still mostly sheet and rill).	Moderate erosion, significantly more than normally expected for the soil type (some gully formation may be occurring).	Severe erosion, highly accelerated erosion than normally expected for the soil type.
C7	*Streambank Conditions*	1	Streambanks well-vegetated and stable.	Streambanks mostly vegetated and stable.	Many streambanks unstable and poorly vegetated.	Most streambanks unstable and poorly-vegetated.
C8	*Parasites and Disease*	2	No detrimental parasitic species or evidence of disease.	Few scattered parasites, limited disease indications.	Moderate parasite infestation or disease indications.	Intense parasite infestation or disease indications

Table 1 (Continued). Element Occurrence Ranking Specifications.

	Landscape Factors	W	A Rank (4 pt)	B Rank (3 pt)	C Rank (2 pt)	D Rank (1 pt)
L1	*Hydrological Regime -- Stream Flow*	10	Intact; no irrigation ditches, no dams upstream, or dams are small and far enough upstream that stream flow through the year is more or less normal, reflecting long-term historical conditions. Flooding and normal groundwater levels act to rejuvenate and sustain wetland/riparian communities.	Light Impacts. Small diversions such as irrigation ditches or acequias may be present and may reduce stream flow or ground water near the sites; dams are absent or small and far enough upstream that stream flow through the year is more or less normal, reflecting long-term historical conditions. Flood peaks and base flows may be reduced somewhat, but rejuvenation and maintenance of wetland/riparian communities can occur with minimal intervention.	Moderate Impacts. Diversions and dams have modified stream flow such that peak flood flows are dampened, but natural seasonal fluctuations still occur to some degree. Sites that once flooded historically no longer do, but minimum flows are still adequate to sustain current wetland/riparian vegetation. Community rejuvenation is unlikely without significant intervention.	Heavy Impacts. Diversions and dams have modified stream flow such that peak flood flows are dampened, and natural seasonal fluctuations are distorted or absent. Sites that once flooded historically no longer do, and minimum flows may not be adequate to sustain current wetland/riparian vegetation.
L2	*Hydrological Regime -- Lateral Stream Movement*	10	Lateral stream movement is associated with natural sinuosity (no channelization or flood plain barriers levees, riprap, jetty jacks, etc.). New sites for community reproduction continually being created.	Minor modifications that alter lateral stream movement in a few places, but still an overall natural sinuosity pattern. New sites for community reproduction still common.	Major modifications such as channelization and levees that significantly restrict the floodplain and limit lateral stream movement. New sites for community reproduction are limited.	Modifications such as channelization, levees, riprap, jetty jacks, etc., severely restrict the floodplain and more or less eliminate lateral movement of the stream. New sites for community reproduction rare.
L3	*Hydrological Regime-- Channel Conditions*	5	Channel width, depth, and gradient are in equilibrium with landscape setting, reflecting excellent watershed conditions with normal erosional processes. System is vertically stable and sediment loads normal, and there is no net loss of vegetated wetland/riparian area.	Limited disequilibrium reflecting good watershed conditions with more or less normal erosional processes. Minor channel morphology changes; some downcutting or light sedimentation occurring. Small losses of vegetated wetland/riparian area occurring.	Moderate disequilibrium reflecting only fair watershed conditions. Stream is either degrading with noticeable downcutting, or stream channel is unnaturally aggrading from excessive deposition. Moderate losses of vegetated wetland/riparian area occurring.	Extreme disequilibrium reflecting poor watershed conditions. Stream is strongly degrading with extensive downcutting and entrenchment leading to accelerated terracing, or stream channel is unnaturally aggrading from excessive deposition and is becoming braided. Large losses of vegetated wetland/riparian area occurring.
L4	*Fire Regime -- Size*	5	Fire patch size normal, and little changed from early historic pattern.	Fire patch size increased up to 25% over historical levels.	Fire patch size has increased 25% -75% over historical levels.	Fire patch size increased >75% over historic levels.
L5	*Fire Regime -- Frequency*	5	Natural fire regime compatible with long-term sustainability of occurrence; natural ignitions not suppressed, but human-caused ones are.	Somewhat modified natural fire regime; fire frequency has been modified up to 25% of historical rates, with associated short-term risks, but long-term sustainability of occurrence still expected.	Modified natural fire regime with fire frequencies modified to between 25% and 50% of historical rates. Long-term sustainability of occurrence is questionable.	Highly modified natural fire regime with >75% modification of fire frequencies over historical rates. Long-term sustainability of occurrence unlikely.

Table 1 (Continued). Element Occurrence Ranking Specifications.

	Landscape Factors	W	A Rank (4 pt)	B Rank (3 pt)	C Rank (2 pt)	D Rank (1 pt)
L6	*Landscape Impacts/ Fragmentation* Percent of landscape converted to exotic-dominated communities, agricultural lands, or disturbed ground (buildings, roads, dumping and other human impacts).	10	Intact; occurrence imbedded in a natural landscape mosaic whose pattern is driven by natural processes. >5% of the area converted.	Mostly Intact; some modification due to human activities has occurred where between 5% and 25% of the natural vegetation has been converted.	Moderately Fragmented; occurrence imbedded in a mixed landscape mosaic where 25% to 75% of the natural vegetation has been converted (some corridors may still exist, and distances between patches of natural vegetation is not excessive).	Highly Fragmented. Occurrence is isolated in a landscape where >75% of the natural vegetation has been converted.
L7	*Landscape Community Diversity and Function*	10	Occurrence surrounded by a wide variety of community types representing early, mid, and late successional stages in approximately equal proportions, indicating a functional ecosystem.	One community type and successional stage is more prevalent that the others (50-66% of the vegetation), but a wide range of expected community types are still present, suggesting limited ecosystem dysfunction.	The landscape is strongly dominated by one community type and successional stage (66-90% of the vegetation); one expected community type and successional stage is significantly reduced (<5% of the vegetation), indicating moderate ecosystem dysfunction.	One community type or successional stage dominates to the near exclusion of all others (>90% of the vegetation), indicting excessive ecosystem dysfunction.

	Size Factor	W	A Rank (4 pt)	B Rank (3 pt)	C Rank (2 pt)	D Rank (1 pt)
S1	*Size*	1	Very Large; patch size meets or exceeds that expected for the landscape under natural processes. Buffering more than adequate against catastrophic disturbance events or weedy or exotic incursions, and edge effects are minimal.	Large; patch size smaller than potentially possible in the landscape under natural processes, but only minor reductions in stand size due to impacts. Adequate buffering against catastrophic disturbance events or weedy or exotic incursions, but some edge effects may be apparent.	Moderate; patch size significantly reduced below potential for the landscape under natural processes. Limited buffering against catastrophic disturbance events or weedy or exotic incursions and edge effects are readily apparent.	Small; patch size reduced well below the potential for the landscape under natural processes. Little or no buffering against catastrophic disturbance events or weedy or exotic incursions and edge effects dominate the character of the occurrence.

originally developed by the Natural Heritage Network and The Nature Conservancy, and derived from protocols developed by the New Mexico Natural Heritage Program as part of its state-wide wetland/riparian assessment project (Bradley et al.,1998). All factors are weighted based on their importance for evaluating ecosystem function and biodiversity value. These weights vary depending on the type of ecosystem being considered, e.g., riparian communities are weighted strongly on hydrological regime, whereas upland communities may receive more emphasis on fire regime. For the pilot project, weighting specifications were developed for upland plant community occurrences. Where information was lacking for any given variable it was not considered in the ranking process. The overall intent was to create a set of consistent criteria for each element that can be used universally to compare occurrences not just at the local level, but the regional and national as well.

Condition Factors

There are eight condition factors that relate directly to the status of a given element occurrence (Table 1); these factors are usually based on direct field measurements of representative stands within a site. Exotic encroachments are considered to be very important indicators of ecosystem health in riparian systems (10 weight) and moderate indicators in uplands (5 weight). There are separate categories for exotics in the canopy versus the understory because of their differing effects on ecosystem structure and function. Structural diversity and cover reflect changes to the expected natural expression of a community as a function of utilization, e.g., logging and fuelwood removals, grazing, etc. Similarly, species richness is a measure of departure from the norm as a result of disturbance. The measurement of fuel loads speaks to the possibility that a given EO might be adversely affected or catastrophically removed due to human-induced fire hazards (fuel loads might be weighted higher in a non-fire-adapted riparian system than in a fire-adapted upland one). Erosion, although a natural process, can also be accelerated as function of disturbance, but the effect of disturbance will vary from community to community. Streambank conditions apply to wetland/riparian occurrence only. Lastly, parasites and infestations (insect, fungal or microbial) are perhaps some of our best measures of ecosystem health.

Landscape Context Factors

Beyond immediate impacts, an element occurrence is also subject to landscape-level processes that affect its condition and perhaps more importantly its long-term sustainability. Accordingly, there are seven landscape-level parameters considered in the ranking process that can be evaluated through a combination of field studies, historical inquiry and GIS-based map analysis. The first three center on the hydrologic regime and pertain primarily to wetland/riparian community assessment. Stream flow changes, lateral stream movement, and channel condition are best addressed through analysis of historical records, monitoring, and field assessment. Analogously, fire patch size and fire frequency can be addressed by a reconstruction of the past record through tree-ring fire-scar evidence and historical photography, as well as current stand structures as they might reflect fire history.

The last two parameters, landscape impact/fragmentation and landscape community diversity and function, can be evaluated to some degree through field studies. However, GIS-based map analysis can be a powerful evaluation tool because it can reveal the pattern and underlying structure of a site and the relationship of any given element to the landscape. This type of analysis requires detailed and accurate spatial information, e.g., good vegetation maps, road and impact coverages, high-resolution digital elevation models, etc. For this project high-quality GIS layers were available that had originally been made for LANL general planning purposes. The manipulation of these GIS layers for biodiversity evaluation is described below in detail.

Size Factor

Because of its importance in ecological assessment, size is considered independently of condition and landscape context. Greater size implies greater buffering against impacts and hence greater stability and long-term viability within the context of the natural dynamics of the ecosystem.

Field Studies and Analysis

Field studies were required to evaluate the various ranking factors and to identify the actual elements to be considered. Sampling was confined to two target canyons, Mortandad and Valle, and was systematically structured to cover the range of variation in community types within each canyon. Four transects were established in each canyon, evenly distributed from the head of the canyon to the lower end. The transects extend across the canyons from rim to rim, and 400-sq.-meter vegetation plots were established along the transects in stands of homogeneous vegetation representing the major community types of the site.

Plot sampling followed NMNHP standard protocols, specified in Appendix A. In general, information was gathered on species composition and abundance; site factors such as slope, aspect and landform; stand structure where there were trees; and the field ranking of condition, landscape and size factors where possible (see Appendix A for field forms). A summary description of each stand and documentary photographs were also taken.

Plot data were entered in the NMNHP community element database (Microsoft Access), duplicated, and quality controlled for accuracy. Plots were classified into plant associations using the National Vegetation Classification System (Grossman et al. 1998). Each plant association represents an element occurrence subject to quality ranking.

GIS-Based Landscape Analysis

For the GIS-based analysis, all spatial coverages for LANL with a bearing on landscape condition were imported into ArcInfo 7.1.2 and processed using ArcInfo and ArcView 3.1. The analysis focused on building spatial themes that contrast direct human impacts as a function of development with a relatively natural area (Figure 3). In the layers representing direct impacts such as roads, telephone lines or buildings, a ten-meter buffer was created around the impacts to represent the minimum influence on the immediate landscape. The buffered coverages were then merged with the LANL land cover map developed class to create an All Impacts layer. The Natural Area layer was defined by merging all natural vegetation classes from the LANL land cover map, then subtracting the

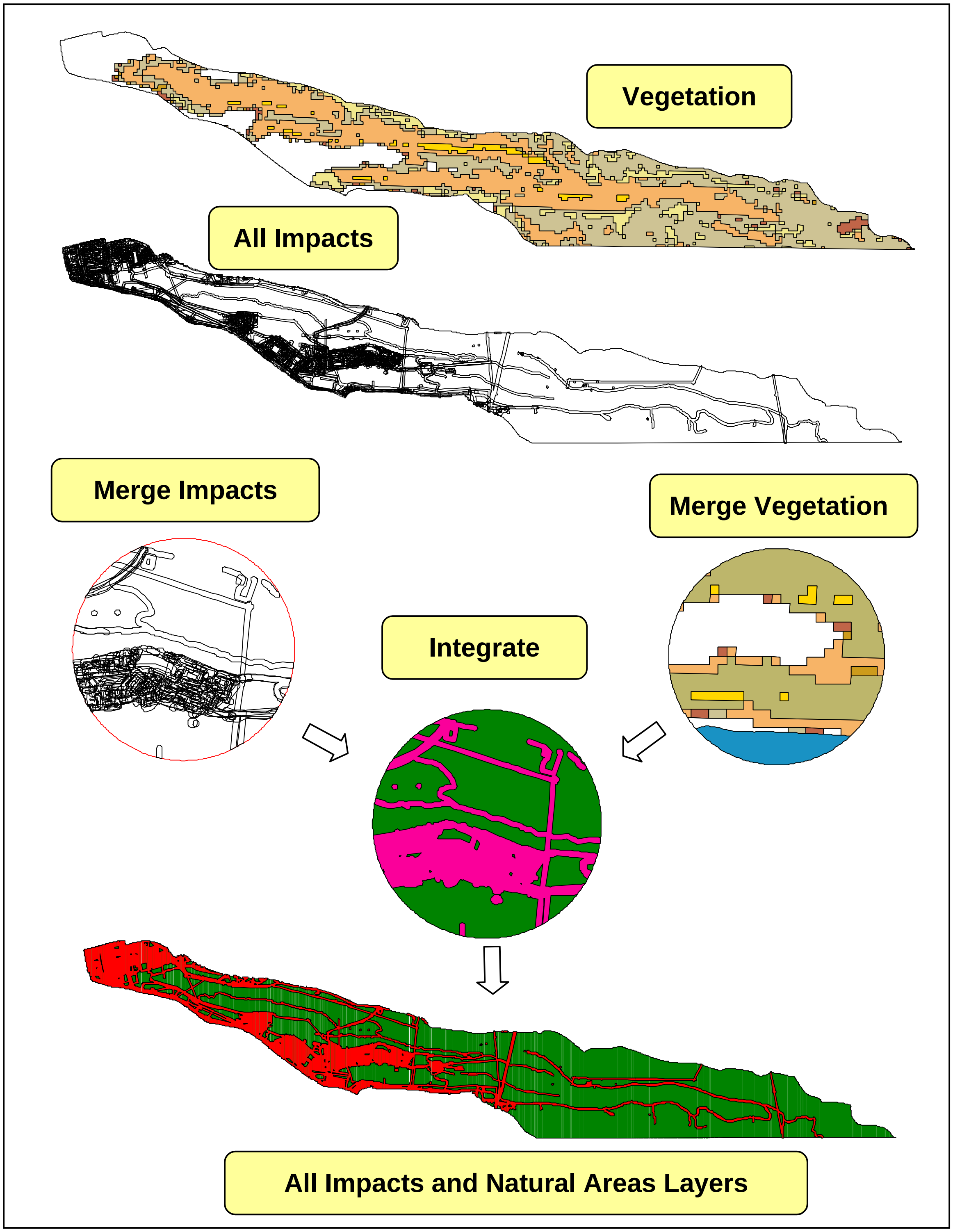

Figure 3. The GIS process for developing All Impacts and Natural Area layers. The All Impacts layer begins with multiple impact layers such as roads, buildings, outfalls, etc. which are then buffered and merged with the LANL land cover map developed class. The Natural Area layer begins with the LANL land cover map and all natural vegetation types are merged. The All Impacts layer is then used as a template and the Natural Area layer cut to it, creating mutually exclusive coverages

All Impacts layer from it to form two mutually exclusive layers. An additional vegetation layer was created to support the analysis of individual vegetation types in relation to impacts and fragmentation. Very small vegetation patches (< 0.25 hectares) were GIS artifacts or deemed non-viable and excluded from most analysis calculations. It should be remembered that the LANL land cover map was originally developed from Thematic Mapper satellite imagery and has inherent limits on resolution and accuracy when used at this scale of analysis; however, it represents the best available spatial data on vegetation community distribution.

The All Impacts and Natural Area layers form the foundation for spatial analysis. From them, various measures of landscape structure and pattern can be derived, such as natural area patch size and degree of fragmentation, the degree of canyon disturbance, and distances from impacts that can have a bearing on animal movements and plant distributions. In addition to the All Impacts and Natural Area layers, digital elevation models (DEMs) and topographic maps (DRGs) were used to generate a landform map for evaluating the distribution of natural vegetation and impacts by major landform characteristics (mesa top, slopes, and canyon bottoms)[5].

Ranking Procedures

Element Occurrence Ranks

Using the information gathered from the field studies and GIS-based landscape analysis, each element occurrence within a site is scored on the various factors. The 1.0 to 4.0 numerical rank for each factor that is evaluated is entered into a spreadsheet along with the associated weights (Table 1) and comments on why the element was scored the way it was. A weighted score is then computed by multiplying the points by the weights and summing them over all measured factors for each set. The sum of weighted scores is then divided by the sum of the weights to arrive at a weighted average for rank for each set of factors (Condition, Landscape and Size). The final Element Occurrence Rank is the average of the Condition, Landscape and Size factors. The numerical rank is assigned a letter grade from A to D, representing excellent to poor quality, respectively.

Site Ranks

The overall Site Rank is determined by averaging all Element Occurrence Ranks within a site. The final rankings are also assigned letter grades, which reflect the best estimate of the quality and degree of human impacts on the ecosystem and the potential for recovery. The site ranks are summarized as follows:

- "A" Excellent (>3.5). The site supports a diverse mosaic of natural vegetation community occurrences that are nearly undisturbed by humans, or have recovered from early human disturbance. Community occurrences are of the highest quality and condition with respect

[5] The various GIS coverages and derivative themes used in the analysis are provided, along with this report, on the compact disk with accompanying technical notes on their development.

to species diversity and community structure, and ecological processes are fully functional. Stand sizes are relatively large and well-buffered. Long-term viability is expected.

- "B" Good (2.75-3.5). The site supports a diverse mosaic of natural vegetation community occurrences that are still recovering from early human disturbance or have been subjected to current or recent light disturbance. The vegetation expression and ecosystem processes may have been slightly modified. In particular, some exotic species encroachment and/or reversible, small modifications to the hydrological regime may have occurred. The stand may recover to A-grade with minimal management intervention. Stand sizes are moderate and the buffer areas adequate. Long-term viability is likely assuming no further environmental degradation.

- "C" Fair (1.75-2.75). The site supports vegetation community occurrences in early stages of recovery or that have been significantly altered by moderate disturbance, resulting in a mixed mosaic of natural vegetation communities and tracts converted to human use (agriculture, structures, roads, etc.). Vegetation expression and ecosystem processes have been significantly modified and may be declining. In particular, exotic encroachment may be significant, and/or permanent small-scale modifications to the hydrological regime may have occurred. Stand recovery to at least B-grade is still possible with proper management intervention. Size of the stand may be relatively small and/or the buffer significantly compromised. Long-term viability is questionable unless declines are stopped and actively reversed.

- "D" Poor (<1.75). The site supports highly fragmented landscapes and/or vegetation community occurrences that are severely disturbed. Species composition and structure have been greatly altered, and natural recovery is not expected. Exotics probably dominate and/or large, irreversible modifications to the hydrological regime may have occurred. Restoration and sustainability are unlikely without intensive management and/or major landscape-level manipulations.

Multi-Site Analysis and Biodiversity Conservation Area Design

To develop Biodiversity Conservation Areas (BCA) that are not constrained by the arbitrary boundaries of watershed sites requires a multi-site analysis in a GIS framework that is informed by field information and principles of conservation design. Within the context of this pilot project we have focused on the GIS application as the first step in this design process. The All Impacts and Natural Area layers from all canyons are merged so the boundaries between adjacent canyons are dissolved within each layer. The result is that adjacent patches of the same type (impact or natural area) are now joined into larger patches. The larger more contiguous natural areas now become candidates for BCA designation. A primary site boundary is delineated which takes into account impinging impacts and captures significant elements of biodiversity in a manner that ensures long-term sustainability. The significance of a BCA is reflected in a site Biodiversity Rank which incorporates not only the quality ranks of constituent elements, but also their rarity from a global perspective.

Secondary boundaries are also defined that specify buffer areas where management might be modified to enhance BCA sustainability. Primary and secondary boundaries that are developed with this GIS process must be reviewed in the context of ancillary information on actual site condition and modified accordingly. For this pilot project, such ancillary information is mostly lacking and, hence, we show only an example of the GIS process that can be put in place for a later, more comprehensive analysis.

Results

Plant Community Elements

A total of 21 vegetation plots were established, 12 in Mortandad and 9 in Valle. The detailed plot records are provided in Appendix B. The classification of each plot according to the National Classification System of Grossman et al. (1998) is summarized in Table 2. Mortandad Canyon had a higher diversity of plant communities, with eight community elements identified ranging from forest to woodlands and grasslands. In contrast, Valle had only six community elements, which were restricted to forest and woodlands; lower elevation pinyon-juniper and grassland elements were missing. This is in keeping with the LANL land cover map, which shows Valle as predominantly Mixed Conifer and Ponderosa, and Mortandad as a broader mixture of Mixed Conifer, Ponderosa, Pinyon-Juniper, Savanna and Grasslands.

From the perspective of global rarity, Valle contains two community elements that are considered very rare and possibly imperiled (Global Rank G2 on Table 2): the *Abies concolor/Jamesia americana* Plant Association (PA), which is known elsewhere only from isolated occurrences in southern Arizona, and the *Pinus ponderosa/Schizachyrium scoparium* PA (G2?), which has been sporadically reported from isolated mountain ranges and breaks in the short grass steppe of New Mexico, Colorado, and further northward. Both types may be more common than current data suggest.

The *Pinus ponderosa/Schizachyrium scoparium* PA also occurs in Mortandad and is more abundant there than in Valle. Mortandad also has a significant riparian zone characterized by forested wetlands of *Acer negundo/Prunus virens* PA (G2?) and shrub wetlands of *Salix exigua/Juncus Balticus* PA (G4?). In general, riparian zone communities are considered imperiled in New Mexico, and these communities, while only provisionally ranked pending further information, should be considered very important elements of diversity in Mortandad and on LANL overall.

Landscape Analysis

The landscape analysis for the five selected canyons focuses on the degree of impact in each canyon, and how that impact is spatially distributed (Figure 4 and Table 3). When all five canyons are compared (Figure 5), Los Alamos has the largest amount of impact area, but because of its size it also has a high amount of natural vegetation (second only to Water and

Table 2. Plant Community Element Occurrences for Canon de Valle and Mortandad classified according to the National Vegetation Classification System along with reference plots. Global rarity ranks are also given based on the Natural Heritage Network criteria and database. G1—Critically imperiled, G2—Imperiled, G3—Vulnerable, G4—Apparently secure and G5—Secure. G#? are communities either not yet ranked or provisionally ranked, pending additional data.

Site, Classification and Acronym	**Plant Community Element (Plant Association)**	**Common Name**	**Plots**	**Global Rank**
CANON DE VALLE				
Conical Crowned Temperate Needle-leaved Evergreen Forests				
PSEMEN/QUEGAM	*Pseudotsuga menziesii/Quercus gambelii*	Douglas-fir/Gambel Oak	97SY003, 97SY004, 97SY005, 97SY020	G5
ABICON/SPARSE	*Abies concolor/*Sparse	White Fir/Sparse Vegetation	97SY005	G5
ABICON/JAMAME	*Abies concolor/Jamesia americana*	White Fir/Cliffbush	97SY002	G2
Rounded Crowned Temperate Needle-leaved Evergreen Woodlands				
PINPON/QUEGAM/MUHMON	*Pinus ponderosa/Quercus gambelii/Muhlenbergia montana*	Ponderosa Pine/Gambel Oak/Mountain Muhly	97SY001	G5
PINPON/SCHSCO	*Pinus ponderosa/Schizachyrium scoparium*	Ponderosa Pine/Little Bluestem	97SY021	G2?
MORTANDAD CANYON				
Conical Crowned Temperate Needle-leaved Evergreen Forests				
PSEMEN/QUEGAM	*Pseudotsuga menziesii/Quecus gambelii*	Douglas-fir/Gambel Oak	97SY012	G5
PSEMEN/ACEGLA	*Pseudotsuga menziesii/Acer glabrum*	Douglas-fir/Rocky Mountain Maple	97SY014	G4?
Rounded Crowned Temperate Needle-leaved Evergreen Woodlands				
JUNMON/QUEPAU	*Juniperus monosperma/Quercus pauciflora*	One-seeded Juniper/Wavyleaf Oak	97SY009	G5
PINPON/SCHSCO	*Pinus ponderosa/Schizachyrium scoparium*	Ponderosa Pine/Little Bluestem	97SY008, 97SY013, 97SY015, 97SY016	G2?
PINPON/MUHMON	*Pinus ponderosa/Muhlenbergia montana*	Ponderosa Pine/Mountain Muhly	97SY017	G5
Intermittently Flooded Cold-deciduous Forest				
ACENEG/PRUVIR	*Acer negundo/Prunus virens*	Box Elder/Choke Cherry	97SY010	G2?
Intermittently Flooded Cold-deciduous Shrubland				
SALEXI/JUNBAL	*Salix exigua/Juncus Balticus*	Sandbar Willow/Baltic rush	97SY018	G3?
Temperate Grassland				
STICOM-SPOFLE	*Stipa comata-Sporobolus flexulosus*	Needle and Threadgrass-Mesa Dropseed	97SY007	G4?

Impacts on Study Canyons

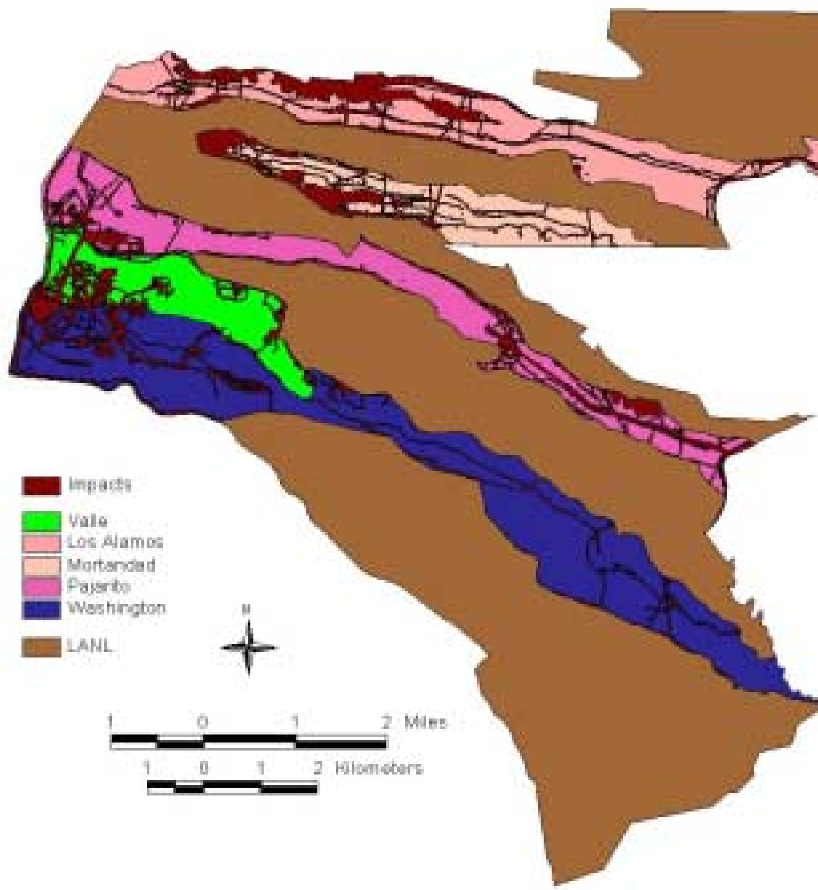

Figure 4. All Impacts layer for all five LANL study canyons. Impacts consist of buffered infrastructure coverages plus the LANL landcover map developed class.

Table 3. Area in hectares of modified LANL land cover types by canyon with percentage allocation within (W) and across (A) canyons.

Canyon	**Valle**			**Los Alamos**			**Mortandad**			**Pajarito**			**Water**			**TOTAL**	
Land Cover (code)	Ha	W %	A (%)	Ha	W %	A (%)	Ha	W %	A (%)	Ha	W %	A (%)	Ha	W %	A (%)	Ha	%
Total Impacts (40)	114.6	24.7	(11.5)	285.9	30.0	(28.6)	169.6	33.5	(17.0)	215.7	25.9	(21.6)	214.7	14.4	(21.5)	**1000.6**	**23.6**
Shadows (9)	0.0	0.0	(0.0)	2.2	0.2	(23.1)	0.0	0.0	(0.0)	0.0	0.0	(0.0)	7.5	0.5	(76.9)	**9.7**	**0.2**
Barren (11)	1.3	0.3	(1.1)	63.6	6.7	(55.9)	2.7	0.5	(2.4)	0.5	0.1	(0.5)	45.5	3.1	(40.1)	**113.7**	**2.7**
Mixed Conifer (21)	39.9	8.6	(15.9)	86.1	9.0	(34.3)	8.4	1.7	(3.4)	81.1	9.7	(32.3)	35.8	2.4	(14.2)	**251.4**	**5.9**
Aspen (22)	1.5	0.3	(12.7)	0.0	0.0	(0.0)	0.0	0.0	(0.0)	1.4	0.2	(12.1)	8.8	0.6	(75.2)	**11.7**	**0.3**
Ponderosa Pine (23)	270.1	58.1	(17.9)	267.9	28.1	(17.8)	157.1	31.0	(10.4)	328.3	39.4	(21.8)	484.9	32.5	(32.2)	**1508.4**	**35.5**
Pinyon-Juniper (24)	18.0	3.9	(1.6)	237.3	24.9	(21.1)	145.2	28.7	(12.9)	186.6	22.4	(16.6)	538.2	36.1	(47.8)	**1125.4**	**26.5**
Savanna 25	0.0	0.0	(0.0)	1.9	0.2	(3.9)	0.0	0.0	(0.0)	0.0	0.0	(0.0)	47.5	3.2	(96.1)	**49.4**	**1.2**
Grassland (30)	19.6	4.2	(11.1)	6.7	0.7	(3.8)	23.4	4.6	(13.2)	18.6	2.2	(10.5)	109.0	7.3	(61.4)	**177.5**	**4.2**
TOTAL	**465.1**	**100.0**	**(10.9)**	**951.9**	**100.0**	**(22.4)**	**506.6**	**100.0**	**(11.9)**	**832.3**	**100.0**	**(19.6)**	**1492.3**	**100.0**	**(35.1)**	**4248.1**	**100.0**

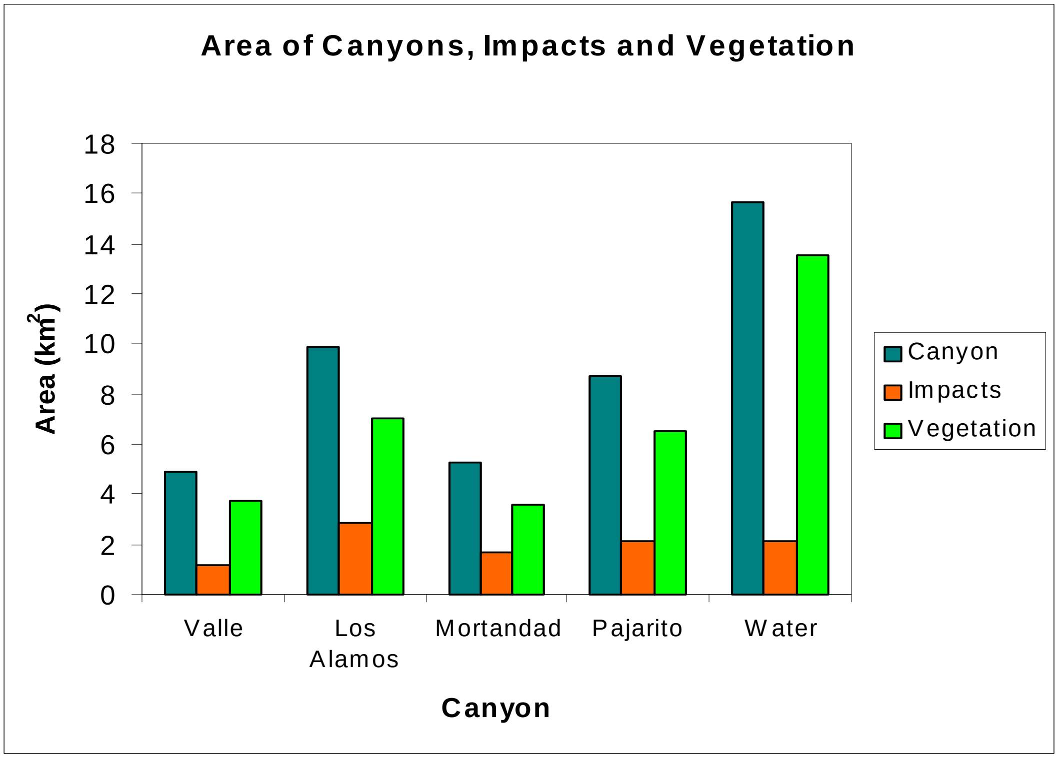

Figure 5. Total area of each LANL canyon and corresponding areas of impacts and vegetation (based on All Impacts layer).

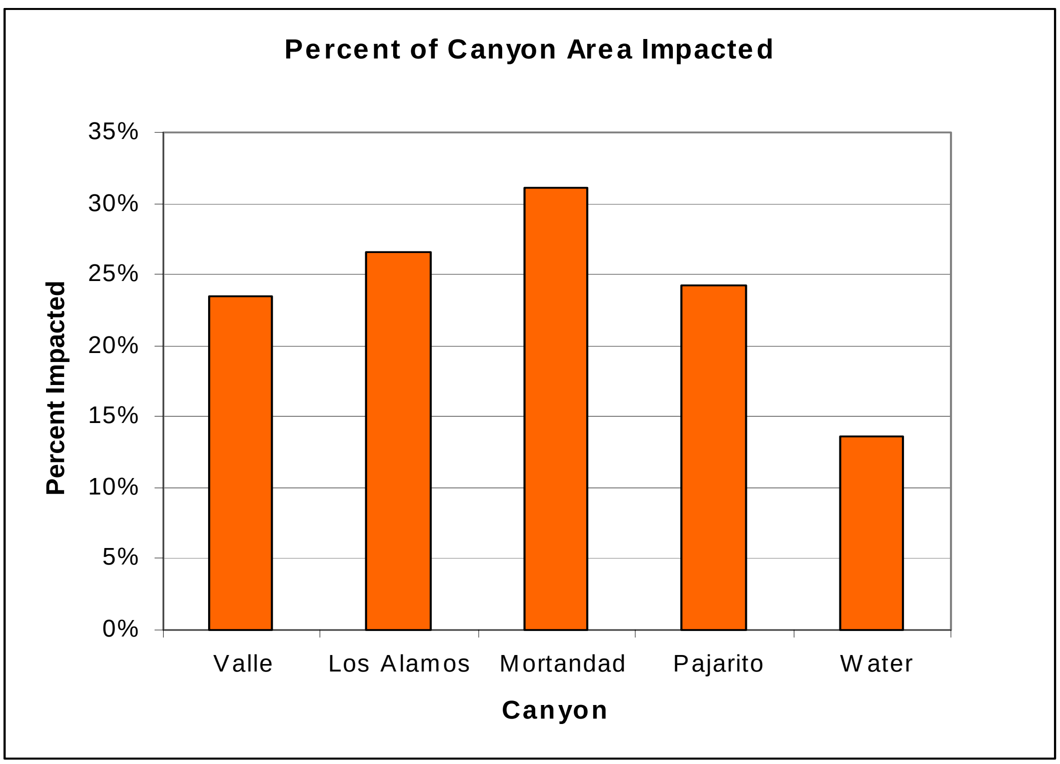

Figure 6. Percent of each LANL canyon impacted (based on All Impacts layer)

similar to Pajarito). Valle has the least amount of impact, but is also the smallest canyon. On a percentage basis; Water, the largest canyon, is the least impacted (Figure 6). Valle is next least impacted, but its size is small. In contrast, Mortandad canyon, which is also (moderately) small, has the greatest percent impact, followed by Los Alamos, reflecting the historical high concentration of LANL activities in these canyons. Pajarito is intermediate in impacts and size.

Differences in the spatial distribution of impacts are apparent when the canyons are stratified by landform (Figure 7). For Water and Valle, the least impacted canyons, most of the impacts are concentrated on the summit mesa tops, whereas Los Alamos, Mortandad and Pajarito have a more even distribution on summits and canyon slopes (canyon slopes are defined as greater than 5 degrees slope). There is also a striking difference with respect to impacts in the canyon bottoms. Pajarito and Los Alamos, both of which have paved roads in the canyon bottom, reflect a corresponding higher percentage of impacts. Mortandad and Water also show canyon bottom impacts, but these are due to dirt roads, which receive considerably less use. Valle has no roads through the bottom and, hence, has the least canyon bottom impacts.

The canyons have different vegetation compositions, based on the LANL land cover map, both on a relative and absolute basis (Figures 8-12). Forest cover dominates all of the sites, and the Ponderosa Pine type is predominant over Mixed Conifer and Pinyon-Juniper in all canyons except Water, which is dominated by Pinyon-Juniper. Because of its size, Water contains significant amounts of all vegetation types, and contains areas of Pinyon-Juniper, Grassland and Ponderosa Pine(Table 3). Pajarito and Los Alamos have moderate impacts, but the highest area of Mixed Conifer. The least amount of Ponderosa and of Mixed Conifer occur in Mortandad, which is a moderately small canyon and has the most impacts. Pinyon-Juniper is not a significant element in Valle, probably because of its higher overall elevation. In contrast, the field studies suggest that the Mixed Conifer type is underrepresented in the land cover map by as much as 25-50%, particularly on north-facing slopes (this may be the case for Water as well). Such error rates are to be expected when applying a Thematic Mapper satellite image based map meant to be used at 1:100,000 scale to high-resolution analysis such as this, at 1:24,000.

However, the land cover map remains the best estimate of general vegetation distribution, and the detected patch structure, regardless of vegetation type assignment, is probably highly accurate. When the area of the major cover types is compared against average and maximum patch sizes in each canyon, distinctive patterns are evident that reflect a combination of canyon size and degree of impact (Figure 13). For example, maximum patch size for Ponderosa Pine is found in Valle, despite the equal or greater amounts found in the other canyons, excepting Mortandad (Figure 14). This is probably a reflection of low relative impact amounts in Valle. Water Canyon has low maximum patch size, perhaps a consequence of past wild fires, but because of its size it still has a high mean patch size for Ponderosa Pine.

Pajarito and Los Alamos are again similar with respect to Mixed Conifer and have the largest maximum size patches and the highest mean patch sizes (Figure 15). Valle is

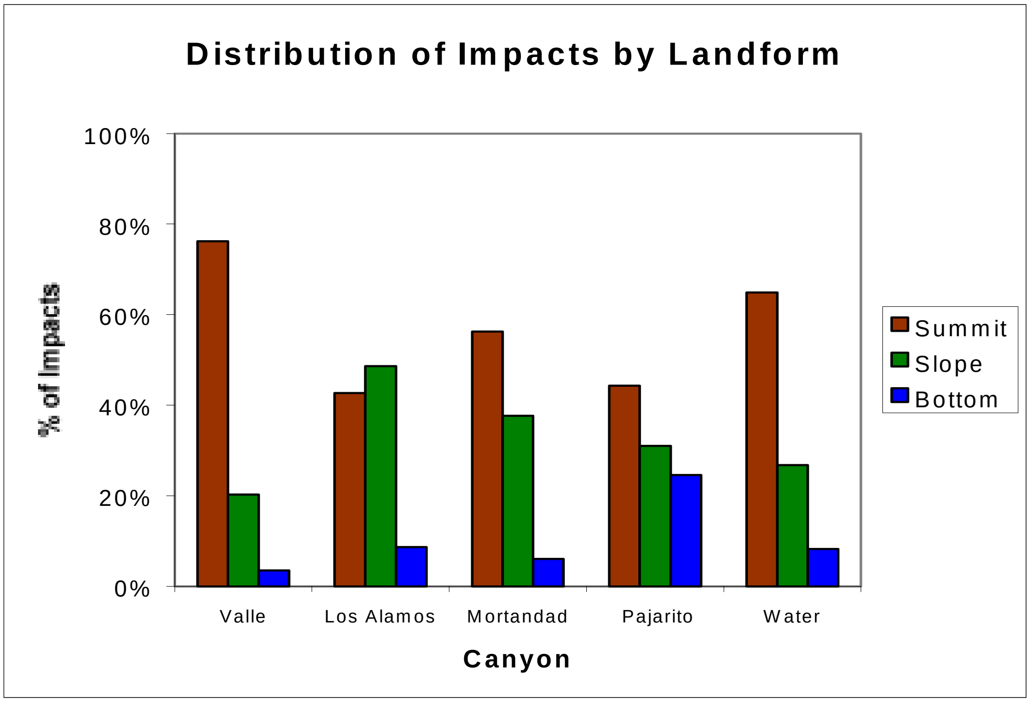

Figure 7. Distribution of impacts within each LANL canyon by landform (from All Impacts layer). Slopes greater than five degrees are in the Slope class. The "mesa tops" form most Summits, and the alluvial flats of the canyon bottoms are the Bottoms.

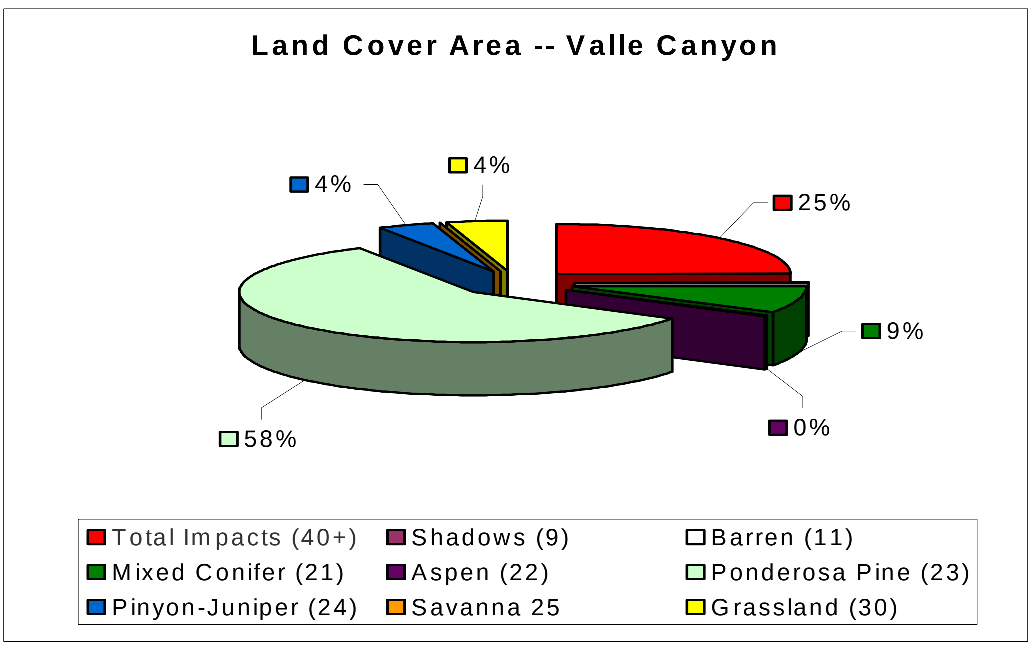

Figure 8. Distribution of land cover types in Valle Canyon on a percentage basis.

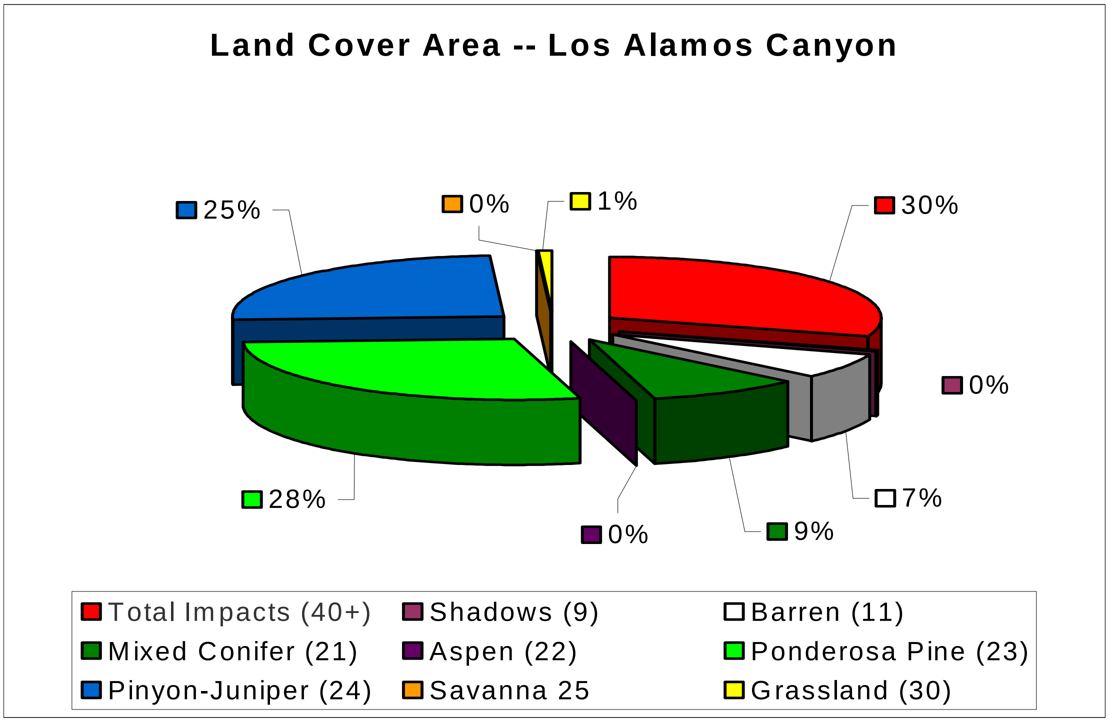

Figure 9. Distribution of land cover types in Los Alamos Canyon on a percentage basis.

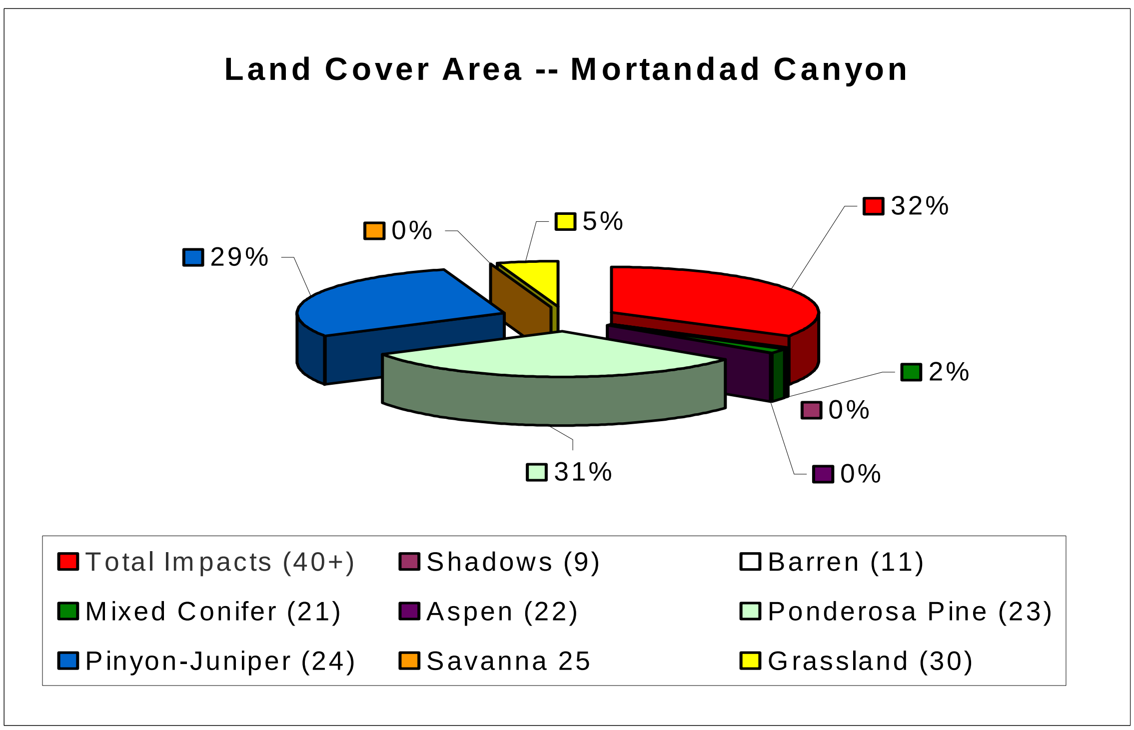

Figure 10. Distribution of land cover types in Mortandad Canyon on a percentage basis.

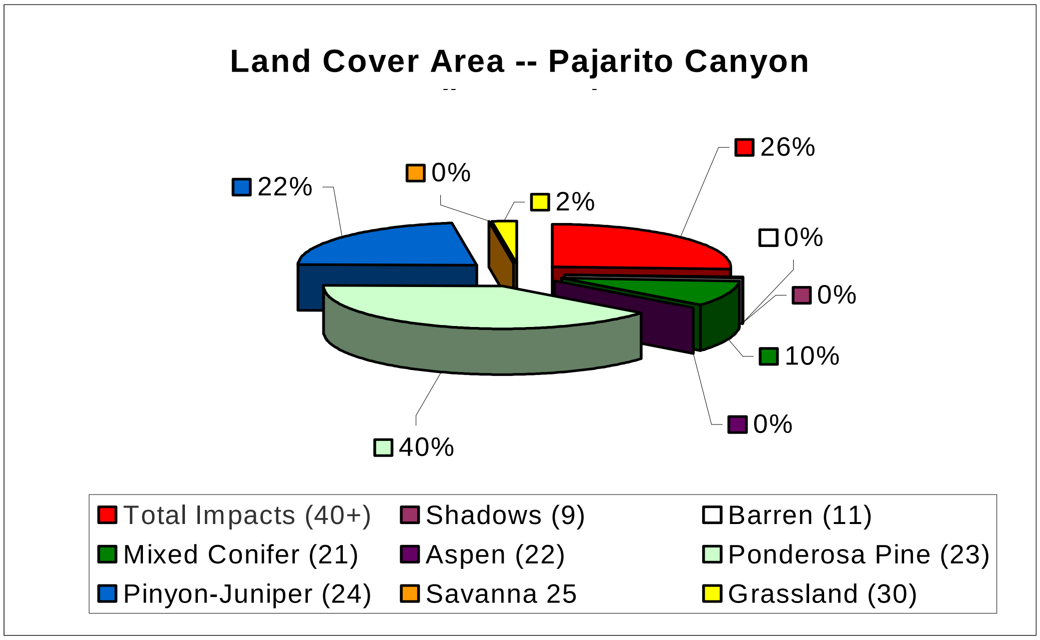

Figure 11. Distribution of land cover types in Pajarito Canyon on a percentage basis.

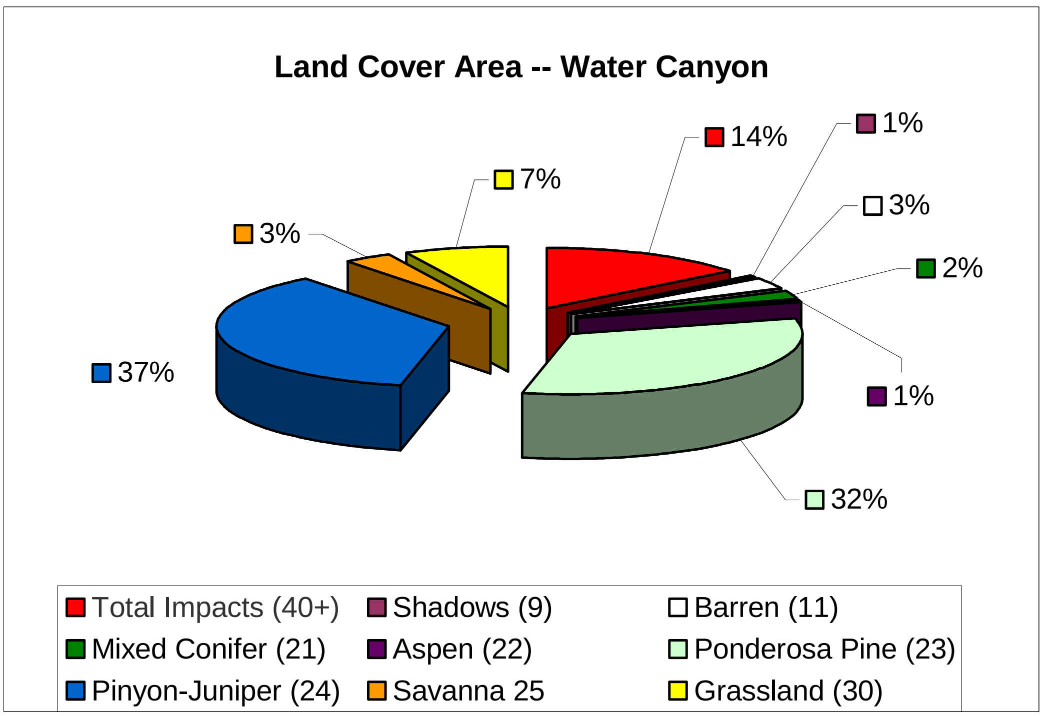

Figure 12. Distribution of land cover types in Water Canyon on a percentage basis.

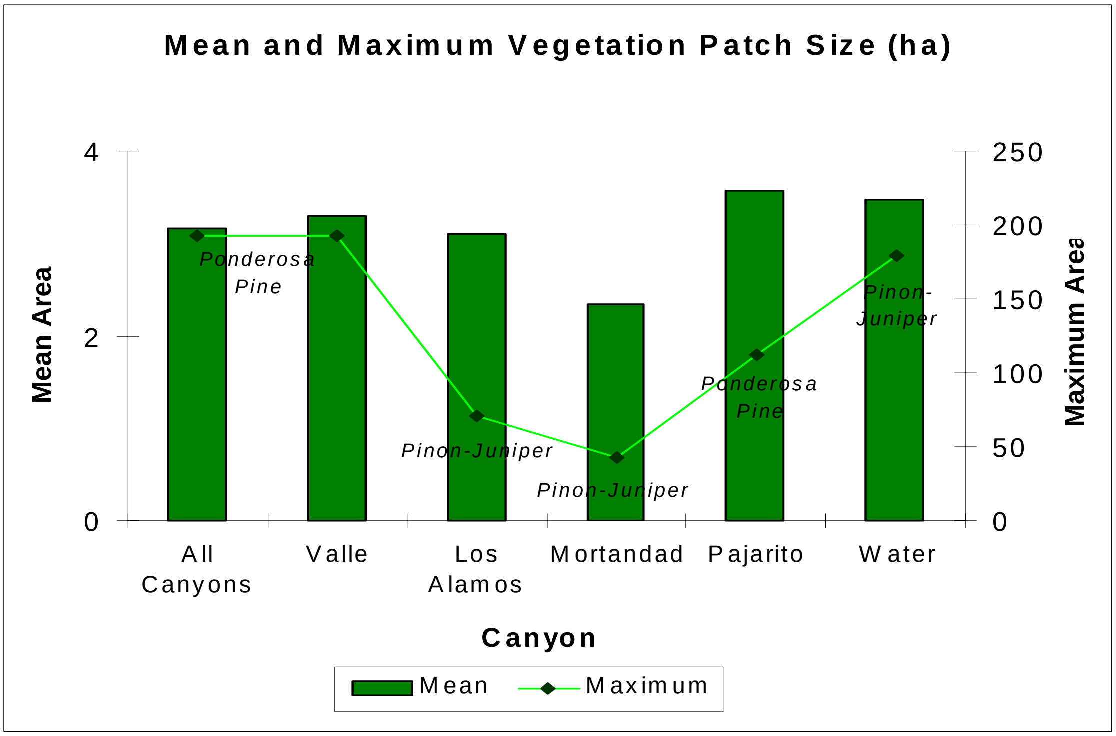

Figure 13. Mean and maximum vegetation patch size by canyon based on vegetation patches stratified by landform. Only patches >= 0.25 hectares included.

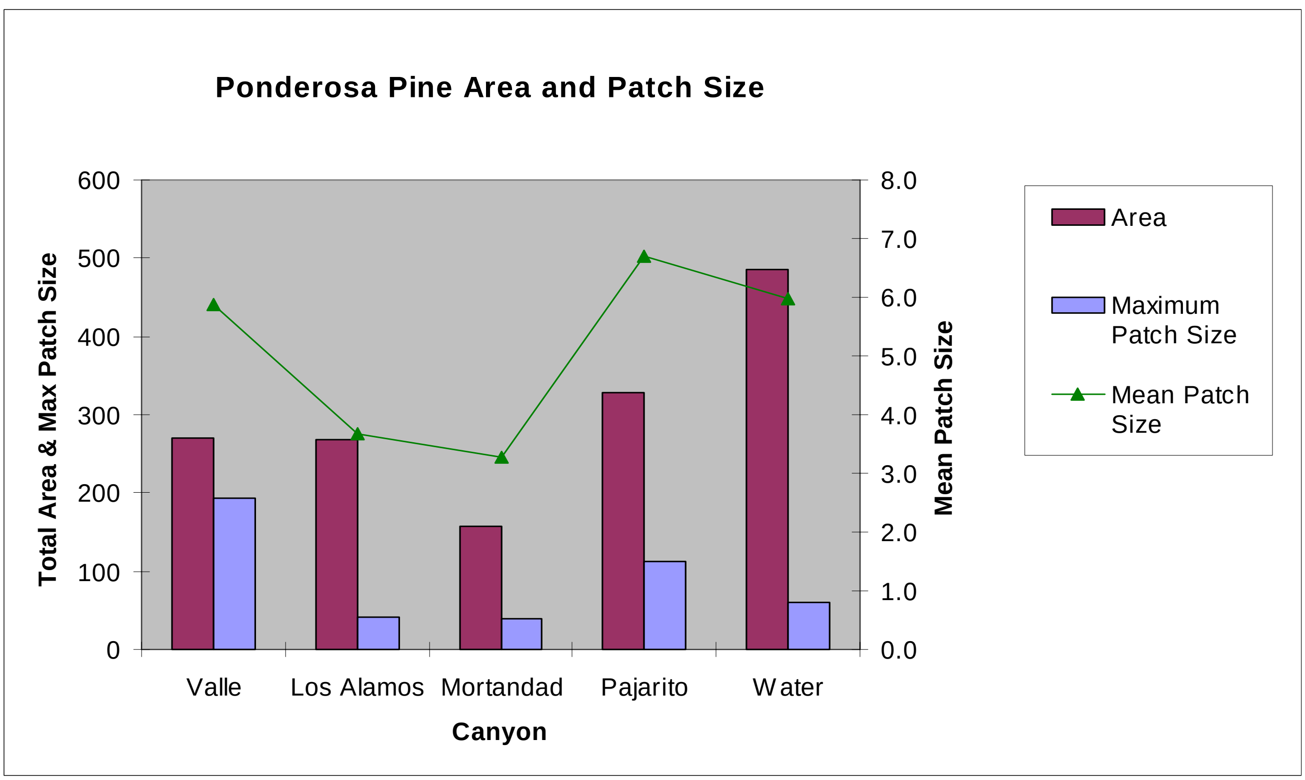

Figure 14. Ponderosa Pine mean and maximum patch sizes in relation to total LANL canyon area. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

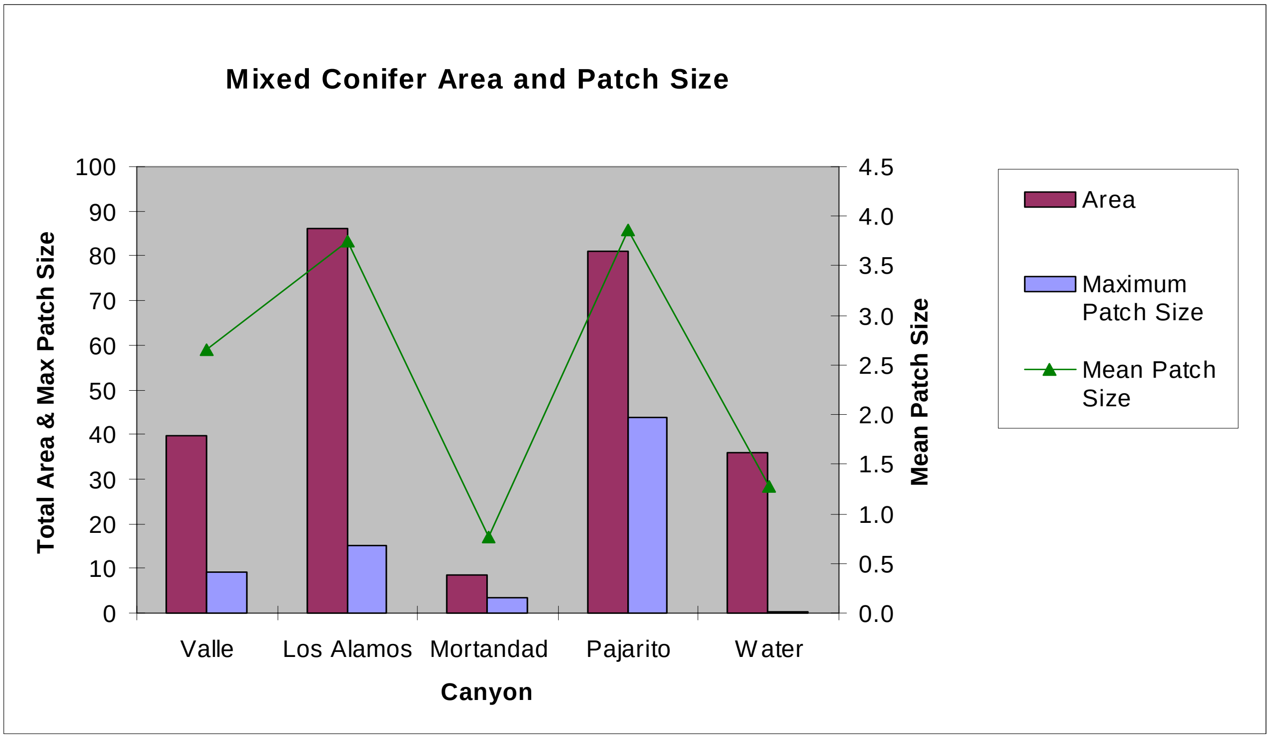

Figure 15. Mixed Conifer mean and maximum patch sizes in relation to total LANL canyon area. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

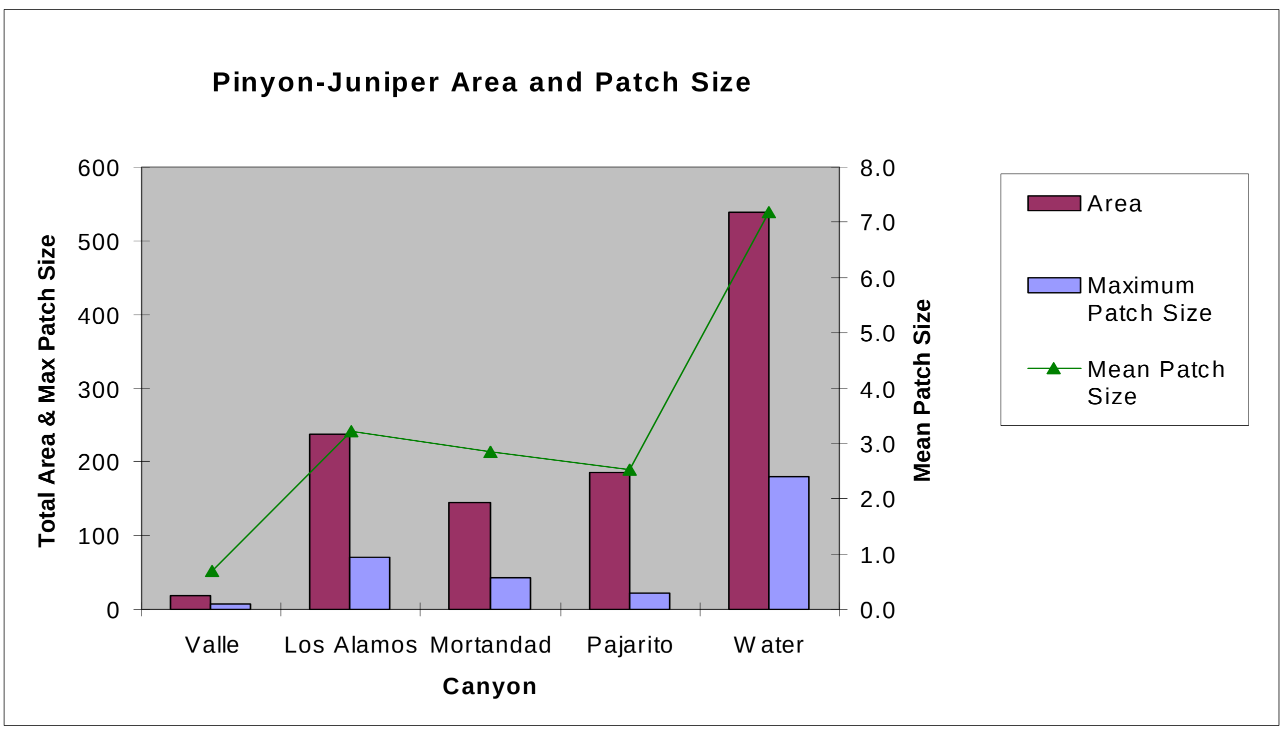

Figure 16. Pinyon-Juniper maximum and mean patch sizes in relation to total LANL canyon area. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

intermediate in Mixed Conifer mean patch size. Mortandad has significantly lower patch sizes, which may reflect the intensive impacts in the upper watershed where the Mixed Conifer may have once been more prevalent. Pinyon Juniper and Grassland patch sizes are greatest in Water Canyon, once again reflecting its larger size and higher overall diversity and accompanying lower impact amounts (Figures 16 and 17).

Overall, there is some suggestion of a relationship between mean and maximum vegetation patch size and impact area, although it may not be linear (Figures 18 and 19). Mortandad has significantly smaller mean and maximum patch sizes, which appears to reflect the degree of impact. Valle and Water have the least amount of impacts and the largest maximum patch sizes. The relationship between patch size and disturbance in Pajarito is perhaps more complex. Both Pajarito and Valle have similar amounts of impact and mean patch sizes, but in Pajarito the maximum patch size is significantly lower despite its large size. This may be due to a major paved road that occurs in the canyon bottom of Pajarito which effectively splits the potentially large patches of the canyon bottom, yet, because of its large size, the overall mean patch is maintained. A similar pattern may also hold true for Los Alamos.

When vegetation cover types are merged together into a single class of natural vegetation representing overall natural area patch pattern on LANL, the same patterns of patch structure are more or less maintained (Figure 20). Maximum natural area patch size is more or less correlated to degree of impact (Figure 21), but mean patch size seems more related to canyon size (Figure 22). The differential spatial distribution of large natural area patches is also apparent among canyons (Figure 23) with both Valle and Water showing the majority of their areas in patches greater than 100 hectares. The other three, the more impacted canyons, have the majority of their area in patches between 10 and 100 hectares.

Distance to impacts is another spatial measure of the possible effects of disturbance on canyon biological habitat. The mean distance of any point in a canyon from an impact is lowest in Mortandad, the canyon with most impacts (Figure 24). Maximum distance from impact may be correlated to canyon size as well as impacts. The mapping of distances from impacts in Figure 25 reflects a difference in spatial pattern among canyons. The areas that are furthest from impacts in Los Alamos, Pajarito and Mortandad tend to be located along canyon rims, whereas they extend into the interior of Valle and Water canyons. In fact, a multi-site analysis of adjacent canyons might further enhance these differences because peripheral areas might be located directly adjacent to previously unmeasured impact areas on the canyon rims (a likely scenario, since most impacts are on the mesa tops).

Another effect of impact on biological elements may be reflected in distance from urban centers, in this case the city of Los Alamos and Whiterock (Figures 26 and 27). For Los Alamos, Los Alamos Canyon obviously has the smallest minimum distance, but because of its long length it also has one of the longest maximum distances. Water and Valle are the furthest from the city of Los Alamos, but Valle, because of it small size, has the smallest maximum distance. The differences are not as strong for White Rock. Pajarito, because of it long length, has points that are both closest and farthest from White Rock. Similarly, the lower portion of Water is near White Rock, while the upper is not.

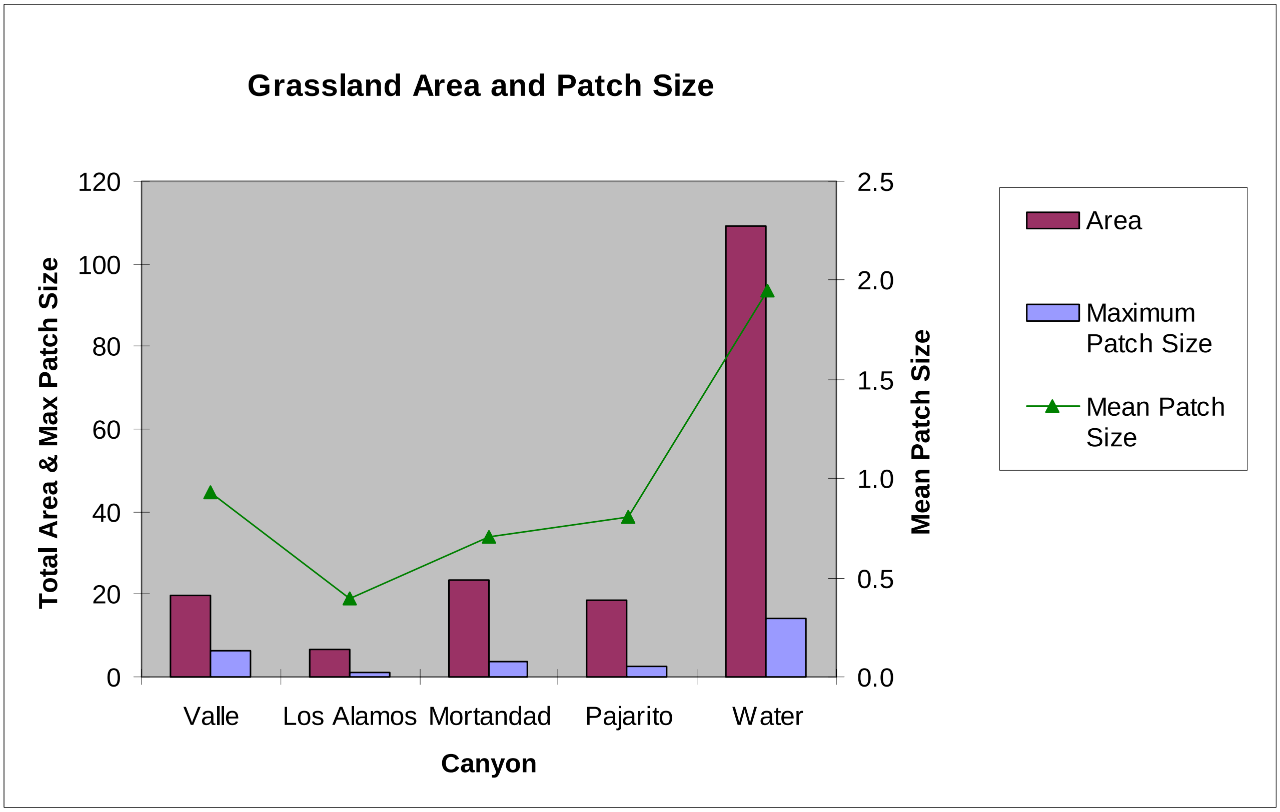

Figure 17. Grassland maximum and mean patch sizes in relation to total LANL canyon area. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

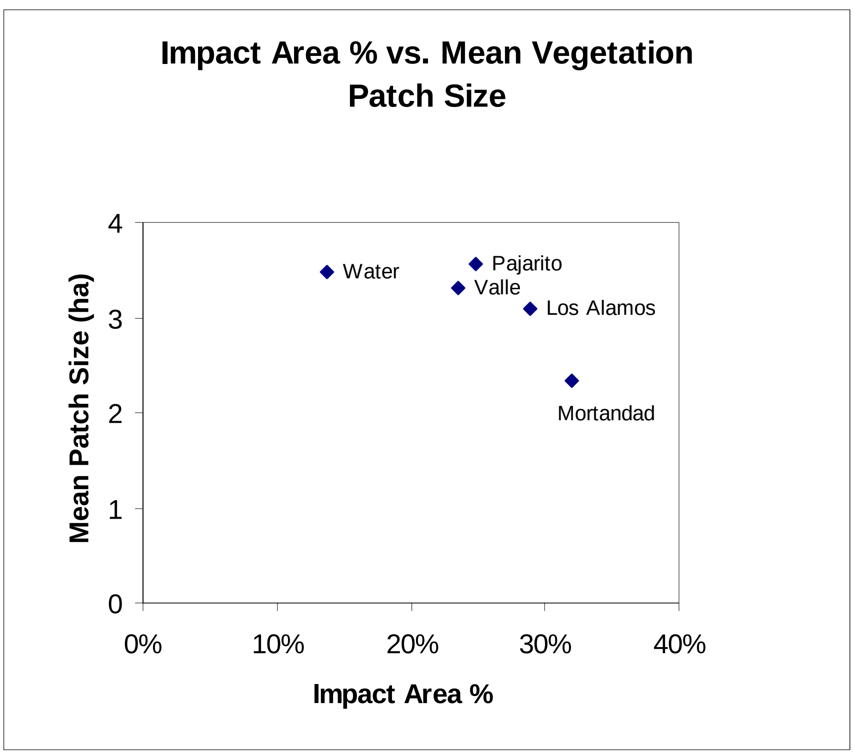

Figure 18. Impact area percentage versus mean vegetation patch size. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

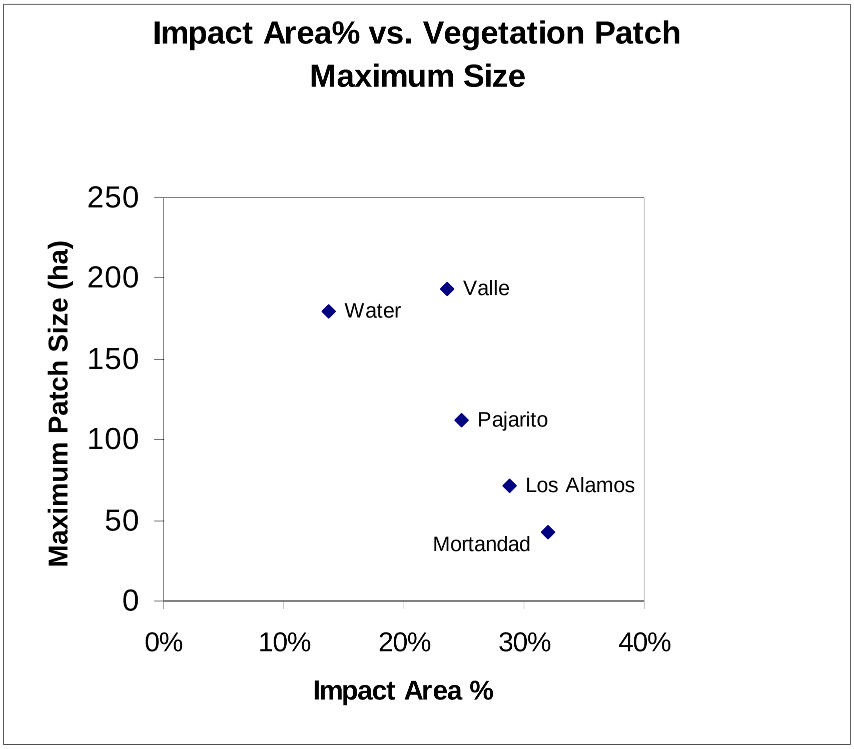

Figure 19. Impact area percentage versus vegetation patch maximum size showing the general trend of declining patch size with increasing impact. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

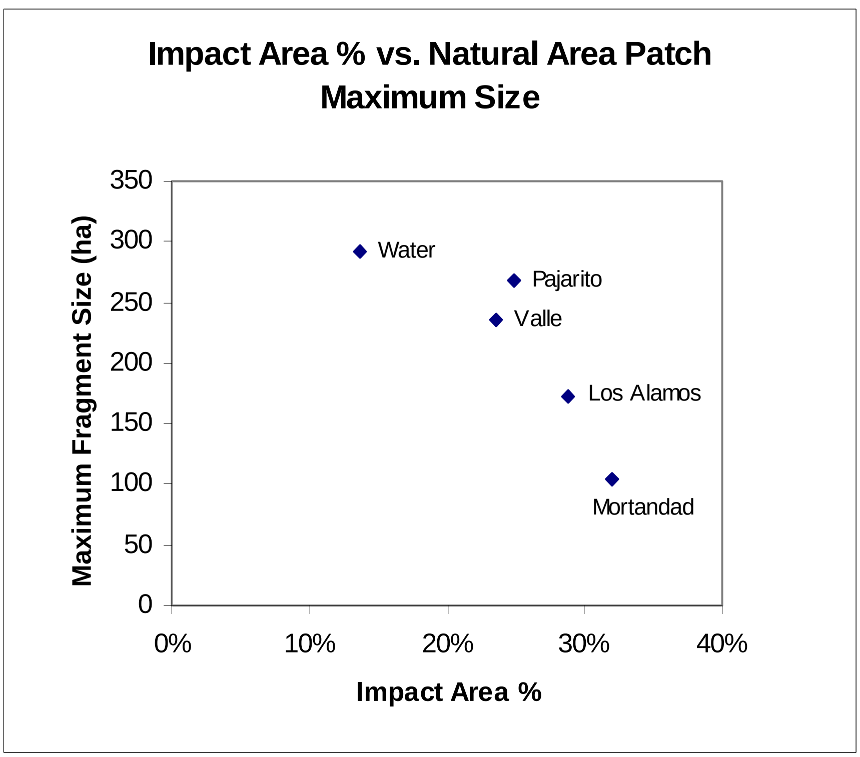

Figure 20. Mean and maximum natural area patch size by canyon. Based on vegetation patches stratified by landform and patches >= 0.25 hectares.

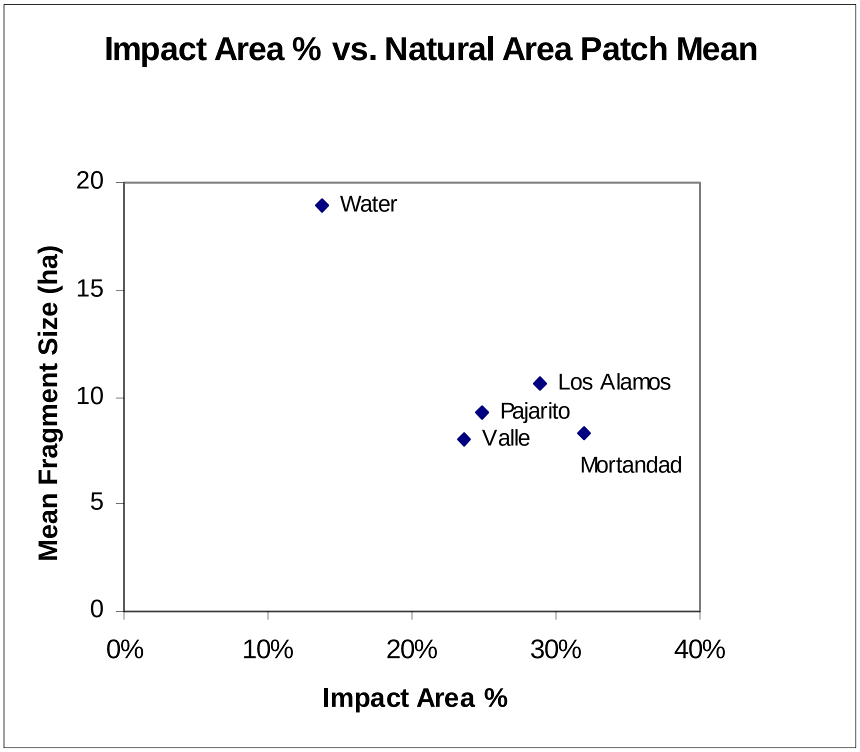

Figure 21. Impact area percentage versus natural area patch maximum size.

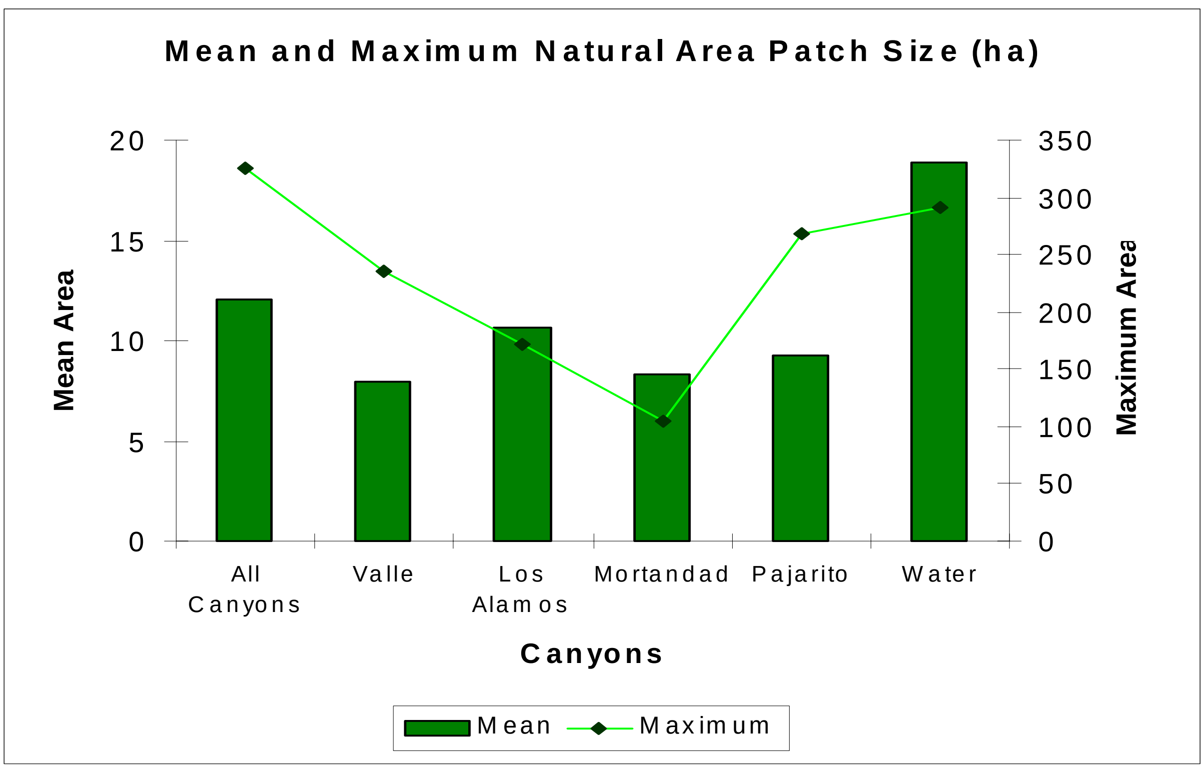

Figure 22. Impact area percentage versus natural area patch mean.

Distribution of Natural Area Patches

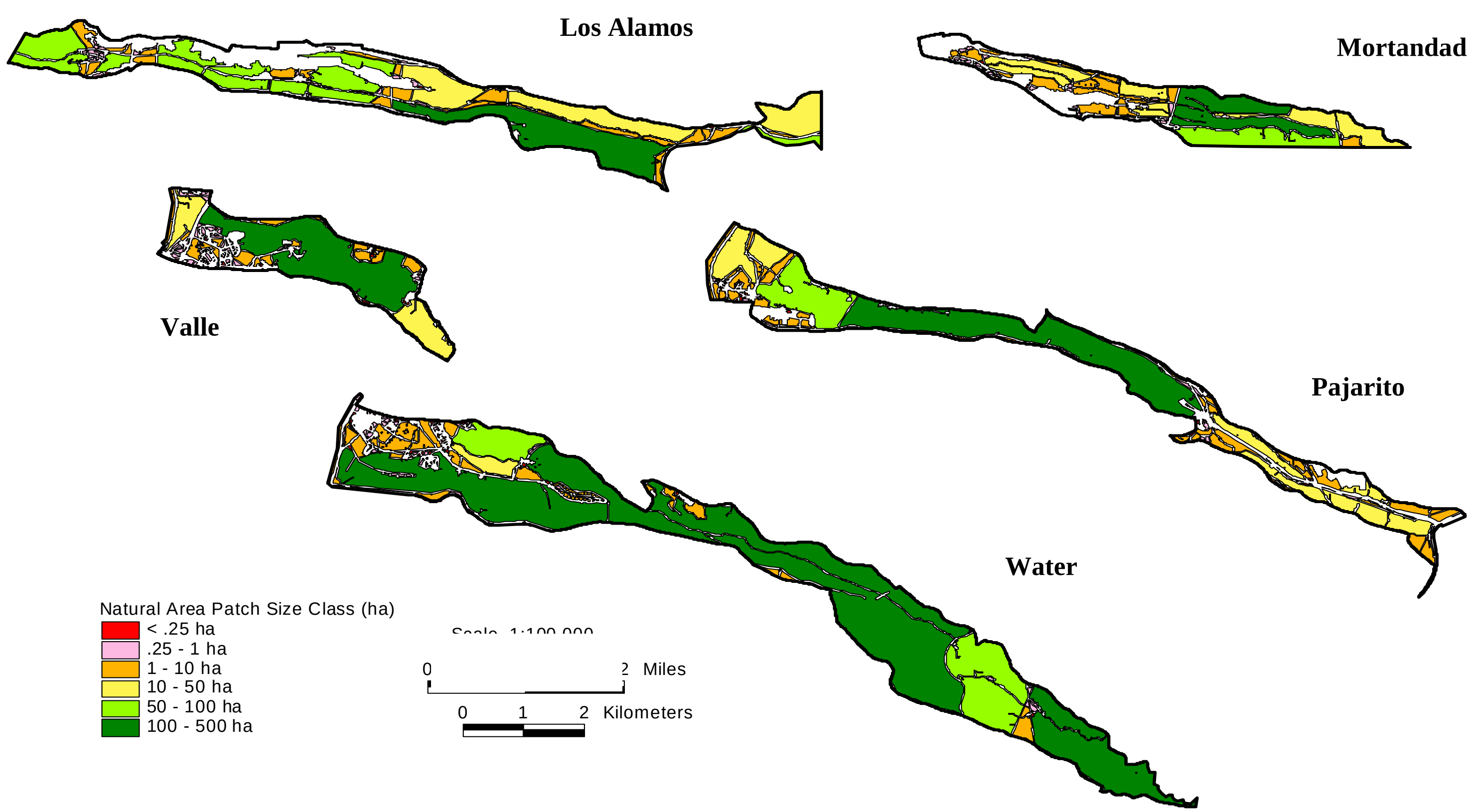

Figure 23. Distribution of natural area patches by size class in five LANL canyons. Derived from the merged land cover Natural Area layer.

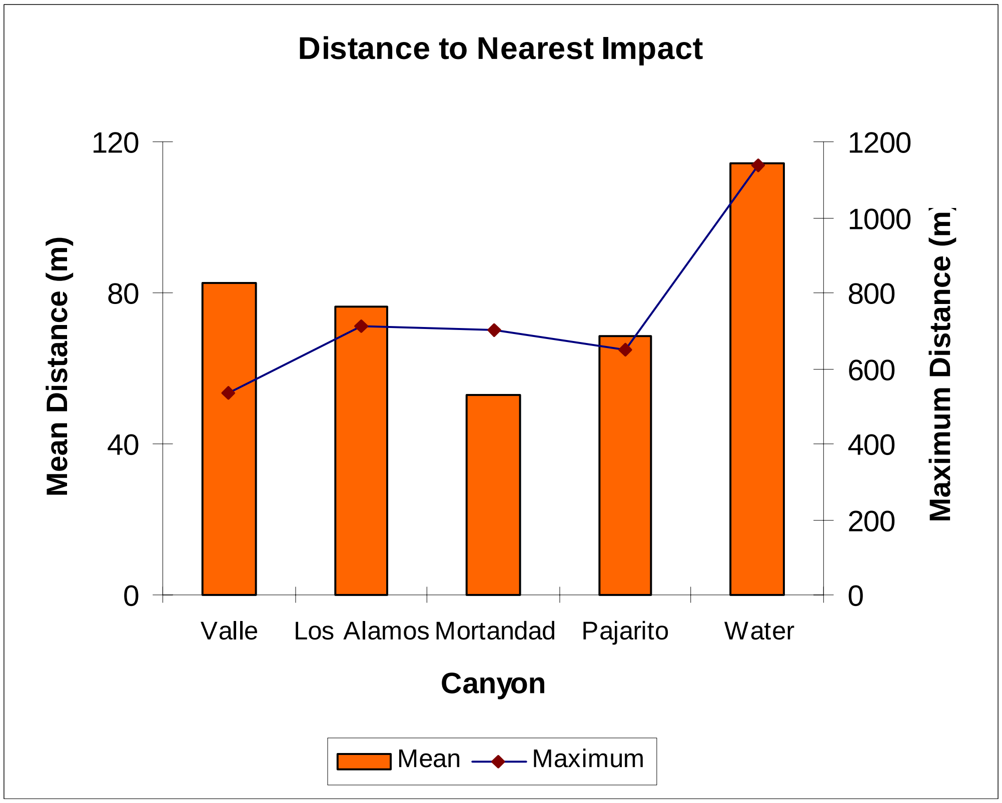

Figure 24. Distances to nearest in-canyon impact. Distances were calculated from all locations within each canyon.

Distance to Impacts

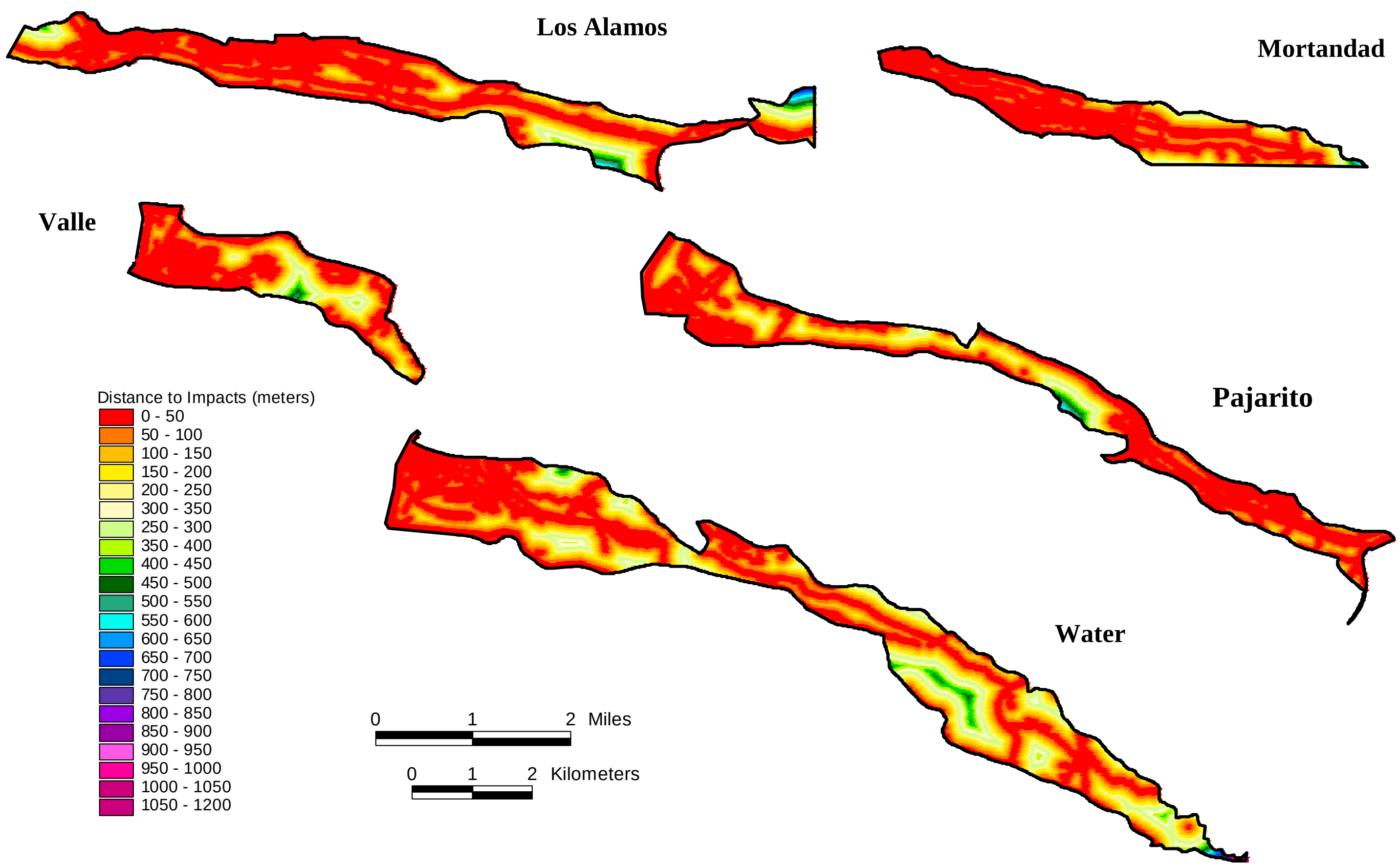

Figure 25. Distance to nearest impact by 50 meter distance classes. Based on the All Impacts layer.

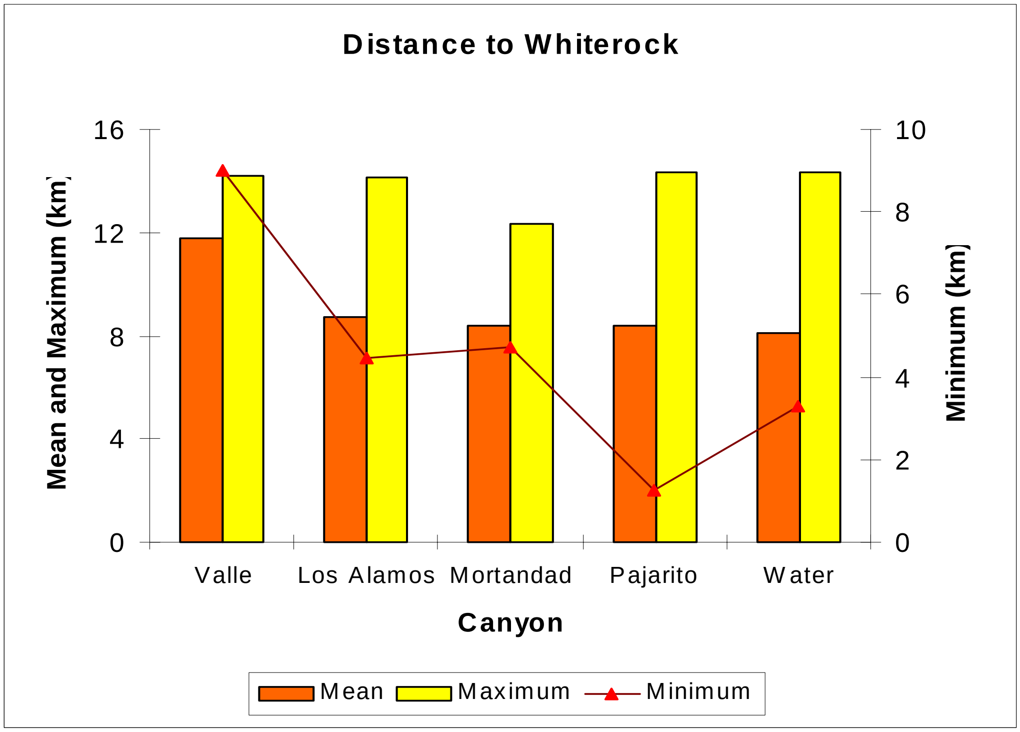

Figure 26. Distances to Whiterock. Distances were calculated from all locations within each canyon.

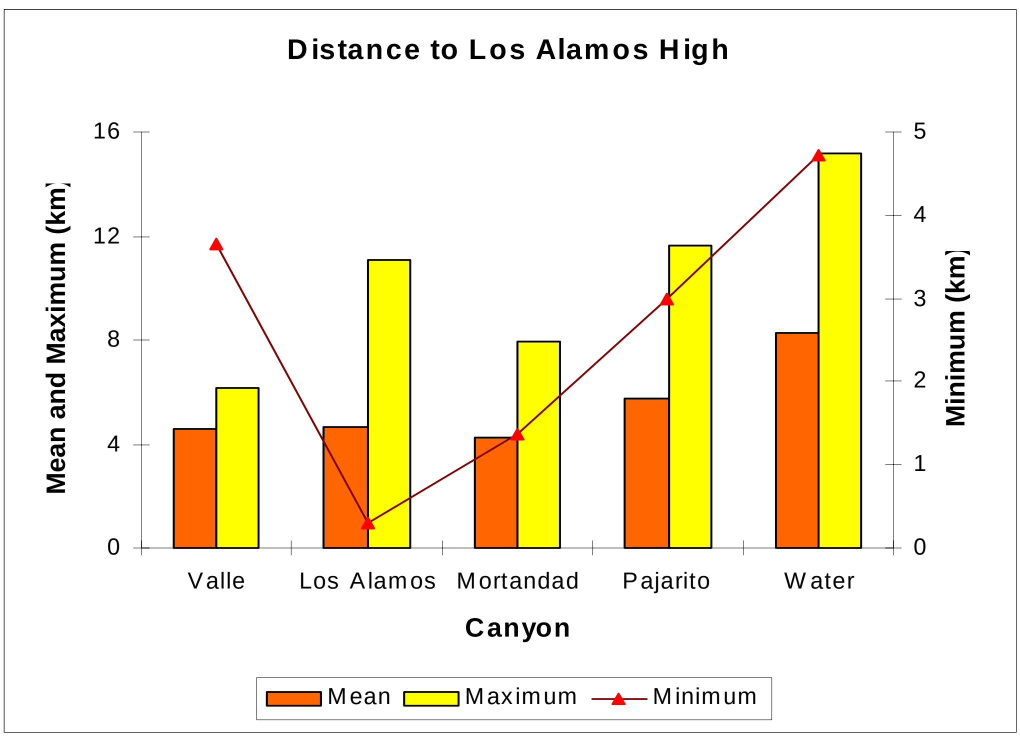

Figure 27. Distances to Los Alamos High. Distances were calculated from all locations within each canyon.

Element Occurrence and Site Quality Ranks for Valle and Mortandad Canyons

Based on the field studies data and landscape spatial analysis, Valle and Mortandad scored quite differently from one another, both with respect to individual plant community elements and overall site quality (Table 4). Detailed individual element ranking tables are provided in Appendix C. Valle has an overall Site Rank of 3.3, or "B", i.e., a site that has some impacts, but with minimal management intervention potentially restorable to an "A". Elements scored high on stand condition because of the long-term lack of human utilization such as grazing and logging. But infestations of mistletoe suggest some degree of poor forest health, perhaps due to long-term fire suppression. Landscape scores were moderate because of the small size of the canyon and overall low mean patch size, but the Ponderosa Pine types (*Pinus ponderosa/Schizarchyrium scoparium* and *Pinus ponderosa/Quercus qambelii/Muhlenbergia montana*) scored higher on size because of the large maximum patch size for this land cover type in the canyon.

Mortandad was scored a whole rank lower (2.6 or "C+") primarily because of landscape-level impacts. The overall greater disturbance in the upper watershed has had negative impacts downstream on the riparian/wetland communities (*Acer negundo/Prunus virens* and *Salix exigua/Juncus balticus*). The channel is entrenched and stream banks are eroding, perhaps due to higher surface runoff caused by development. Greater impact area also leads to lower element stand sizes where the high density of roads and other structures fragments the landscape. There is also a decrease in the buffer between natural areas and disturbance. There are more weedy species and exotics in incursions into the stands, lowering the overall condition of the elements. The upper reaches of Mortandad are also closer to the urban center, and people use the canyon recreationally to a greater degree, potentially impacting vegetation significantly and disrupting wildlife.

Multi-Site Analysis and an Example of Biodiversity Conservation Area Delineation

The importance of landscape-level impacts suggest that analyzing single watersheds in isolation from one another may be prone to error and constraining on the delineation of areas of biodiversity significance. For example, when Water, Valle, and Pajarito are considered together without watershed boundaries, the maximum and overall natural area patch size increases (Figure 28). These larger, cross-watershed natural areas now become candidate Biodiversity Conservation Areas (BCA). In our example, two immediate alternatives are possible: a smaller BCA based on the largest patch that is generated from the multi-site analysis (Figure 28a), and a larger one that merges four adjacent patches that are each over 225 hectares (Figure 28b). In the latter case the merger is a function of overriding the effect of impacts that separate the patches (a dirt road and powerline corridors) to create a larger unit where the beneficial effects of size would far outweigh the consequences of the impacts.

Table 4. Summary of plant community element occurrence and site ranking on condition, landscape, and size factor sets.

a) Canon de Valle

Canon de Valle

Plant Community Element RANKS	Condition	Landscape	Size	EO Rank	
PINPON/SCHSCO	3.6	3.0	3.5	**3.4**	**B+**
PINPON/QUEGAM/MUHMON	3.6	3.0	3.5	**3.2**	**B**
PSEMEN/QUEGAM	3.3	3.0	3.0	**3.1**	**B**
ABICON/SPARSE	3.4	3.0	3.0	**3.1**	**B**
ABICON/JAMAME	3.4	3.3	3.0	**3.2**	**B**
SITE RANK	**3.5**	**3.0**	**3.2**	**3.3**	**B**

b) Mortandad Canyon.

Mortandad Canyon

Plant Community Element RANKS	Condition	Landscape	Size	EO Rank	
PINPON/SCHSCO	3.2	2.7	2.5	**2.7**	**C+**
PSEMEN/QUEGAM	3.5	2.7	2.3	**2.7**	**C+**
PSEMEN/ACEGLA	3.2	2.7	2.5	**2.7**	**C+**
JUNMON/QUEPAU	2.7	2.6	3.0	**3.0**	**B**
PINPON/MUHMON	3.4	2.7	2.5	**2.7**	**C+**
ACENEG/PRUVIR	3.0	2.4	2.5	**2.6**	**C**
SALEXI/JUNBAL	2.0	2.4	2.0	**2.1**	**C**
STICOM/SPOFLE	2.4	2.4	2.0	**2.3**	**C**
SITE RANK	**2.9**	**2.6**	**2.4**	**2.6**	**C+**

Potential Biodiversity Conservation Areas

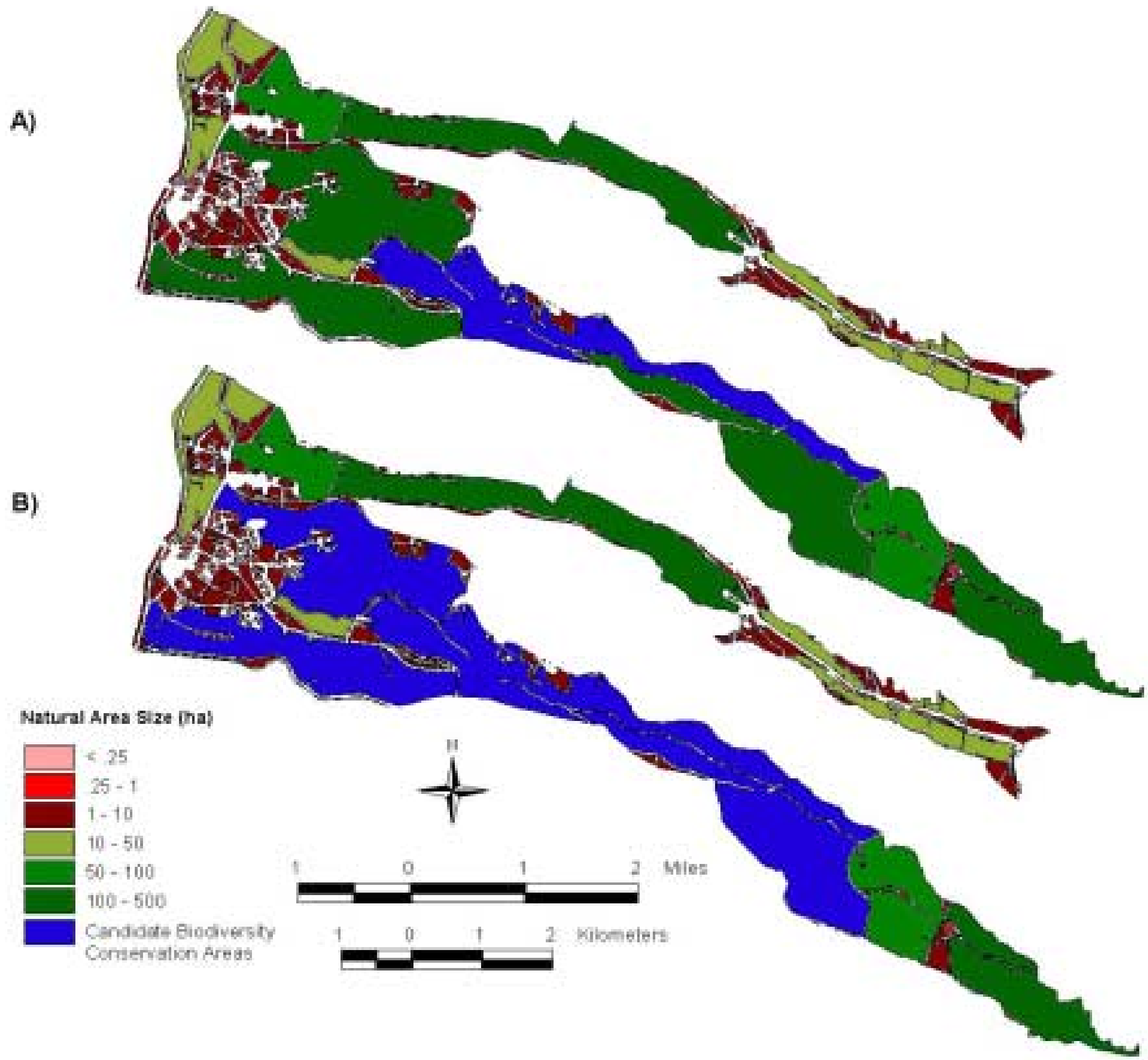

Figure 28. The identification of the largest patches of natural vegetation is the first step in the multi-site design of Biodiversity Conservation Areas. In the top map (A) the single largest patch is identified creating the starting point. Three adjacent patches over 200 ha are then added to create one large area for consideration in further design (B). Patches may be added, deleted, or modified to match biodiversity needs. Other considerations, such as distance from impacts, may enrich BCA delineations.

Cross-site analysis does not necessarily result in larger areas and, even then, larger areas are not necessarily more biologically significant. A candidate BCA must be further evaluated in the same way as the original watershed sites, using the element occurrences ranks of its constituents. In addition, BCAs are also evaluated on the basis of rarity and imperilment of all biological elements, resulting in an overall Biodiversity Rank. These ranks not only take into account plant community quality and rarity, but also animals and plants that have been left out of the process until now. For example, a Federally Threatened species with a TNC Global Rank of G3 (Vulnerable) is known to occur in our example candidate BCA. This could potentially increase its Biodiversity Rank beyond that afforded by plant community elements alone. The delineation of the BCA boundaries can be modified based on the rare element distributions and on the careful examination of impinging impacts (this can lead to either area reduction or increase). In our example, because Pajarito and Water have not yet been field surveyed, this type of detailed evaluation is not currently possible, but would be a necessary requirement of an overall biodiversity site evaluation protocol.

Discussion

Meeting goals for protection and stewardship of the natural systems and the biota that depend on them in the context of the LANL mission is an exciting challenge. To help meet this challenge we have presented a detailed protocol for evaluating the overall biodiversity value of sites to support the design of effective biological management units. The site ranking and design process that is outlined here relies on sound ecological information derived from field studies and state-of-the-art GIS-based spatial analysis, made possible by the long-term commitment of LANL to biological and spatial databases. We have attempted to make the evaluation process as straightforward and unambiguous as possible, but there are always quantitative and qualitative judgements that need to be made when evaluating scientific data. The protocols provide a mechanism for tracking both the data and the decision making process, and hence allow an open forum for discussion of the results. This is particularly important for the complex process of developing an optimal biological resources management plan that incorporates both biodiversity values and lab mission obligations.

This pilot study examined two canyons with both field studies and GIS-based spatial analysis, and three additional canyons with spatial analysis only. There are an estimated ten other canyons within LANL still to be evaluated. Our preliminary comparison among canyons suggests that multi-site analysis is necessary to arrive at a comprehensive understanding and delineation of areas of high biodiversity value. Canyons studied in isolation from one another tend to ignore landscape-level processes that affect biodiversity sustainability, and possibly result in ineffective biological management units. Furthermore, the canyons within LANL boundaries are only part of an even larger landscape of the Pajarito Plateau with its many canyons and accompanying jurisdictions. Setting true priorities for management will require putting the LANL canyons in this more regional context. The protocol presented here effectively allows for this in such a way that when one arrives at a final delineation and Biodiversity Rank for a site, all biological and spatial information that is necessary and available has been incorporated in the process.

There are some data gaps that need to be addressed. A full understanding of what constitutes a natural fire regime for LANL is needed to support an accurate landscape-level assessment of fire affects on its ecosystems. Excellent studies have been conducted at Bandelier National Monument and elsewhere in the Jemez Mountains that can be used as a backdrop for future work on the history of fire at LANL, its spatial pattern, and its role in ecological processes and biodiversity sustainability (Touchan, Allen and Swetnam 1996). Higher resolution vegetation maps of the LANL canyons would also enhance the spatial analysis. The pilot studies relied solely on a land cover map derived from Thematic Mapper satellite imagery, which has inherent limits with respect to accuracy and precision when used at the operational scale we applied here (1:24,000 and finer). High-resolution digital ortho-photography is currently available for LANL, and could be utilized to make a more detailed vegetation map in a cost-effective manner.

Finally, our preliminary analysis suggests that the biodiversity values of LANL may have regional and global significance. The long-term withdrawal of LANL from typical land uses of the region has created a situation in which natural processes have been allowed to operate in certain undeveloped areas more or less unimpeded, except for fire. Hence, there are a wide variety of ecological communities that have had a chance to recover from historical impacts, such as overgrazing and logging, to become excellent examples of the region's diversity. Through a well-thought-out design, the protection of these excellent examples can be achieved within the arena of LANL's mission, and at the same time make a contribution to the goals of the DOE and the nation for preservation of natural systems and biodiversity values.

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Appendix A

VEGETATION SURVEY HANDBOOK

Draft

NEW MEXICO NATURAL HERITAGE PROGRAM

DEPARTMENT OF BIOLOGY

UNIVERSITY OF NEW MEXICO

1999

Appendix A

New Mexico Natural Heritage Program Vegetation Survey Protocols

Field Form and Instructions – 1999

<u>General Plot Description</u> (Form 2)

PLOT ID (seven-character alphanumeric code)**.** [Required]
This is the master NMNHP record identification number for all sampling at the site. All subsequent sampling or other independent data at the site will be tied to this number. It must be unique and is formatted as follows:

Record in order the year (2-digits), the first and second initial of lead surveyor as designated under the Surveyors field (2-characters), and the plot ascension number (3-digits).

> Example: The 33rd plot sampled in 1991 by Hank Gleason
> would be entered as 91HG033.

Monitoring data are assigned sub-record monitoring numbers under the PLOT ID, as are any quadrat sample numbers.

PROJECT. Project code – for example: LANL98. If no code is available, enter temporary project designation. [Required]

SURVEY TYPE. Method of locating plot. Enter one of the following:

> A - Reconnaisance Inventory and Assessment. Plot subjectively located to represent vegetation in occurrence (typically used in inventory and mapping).
>
> B - Monitoring. Plot subjectively located to represent stand, and will be used to monitor vegetation change through time with or without treatment.
>
> C - Analytic Inventory, Assessment and Monitoring. Plot is part of series of replicated plots systematically or randomly located within occurrence to describe the occurrence
>
> E - Experimental. Plot is part of series of replicated plots systematically or randomly located in treatment or control area to measure vegetation change with treatment over time.
>
> F - Validation. Plot is part of predetermined stratified sampling design (e.g., gradsect or map validation).

MO DATE YEAR. Two digit month, day and year numbers. [Required]

SURVEYORS. Last names of sampling personnel, led by the person responsible for botanical determinations.

PLOT TYPE:

S = Standard plot where all species within the plot are recorded and their abundance estimated, and the quality of occurrence is ranked using the ranking form.

V = Voucher or Validation plot; only the dominant and most common species recorded with their abundance to ensure proper identification of the type, and enough site information to provisionally rank the quality of the occurrence.

R = Releve or Reconnaissance plot. Full species list of both plot and stand, with element quality ranking using the ranking form.

A = Analytical plot. Full species list of both plot and stand with subsampling of abundance (usually quadrat based). Element quality ranking using the ranking form.

O = Observation point with most qualitative data on an occurrence.

PLTDIM. Plot size and shape.

L/R: Plot Radius or Length - enter plot radius (for circular plots) or length (for rectangular plots). Indicate units of measurement. Note: a 400 m squared plot has a radius of 11.3 m (37.1 ft); a 100 m squared plot has a radius of 5.6 m (18.5 ft)

PLOT W. Enter width if a rectangular plot shape is used. Enter 0 (numeric) if a circular plot shape is used. Indicate units of measurement.

CT. Community type or plant association to which vegetation data refers to. Use six (seven) letter species acronyms. For example: PINPON/QUEGAM. Who ever makes the CT determination must date and initial the designation. Refer to the NMNHP vegetation classification for current types and acronyms. If the type does not appear to match any on the list, assign a temporary name and indicate your reasoning behind the assignment in the CT COMMENT field. If you are uncertain about what to call it, enter UNCLASS.

CT KEY. Was a dichotomous key used to arrive at the community designation (Y/N)?

CT MAP. Was the boundary of the community mapped: N= no, T= on a field topographic map, S= filed sketch or chart.

CT COMMENT. If you assigned a new acronym, indicate your reasons for the designation and any specific decision rules you have developed. If CT is questionable, make notes concerning the problem.

SURVEY SITE. Name assigned to the plot site at the time it is sampled, or the name of the site on a Survey Site form if it had been previously surveyed.

Naming guidelines:
1. Do not use element names in the site name
2. Use local place names when available or features on topographic maps.
3. Avoid names that are too generalized such as “Spring Site” or “Flat Top Mountain.”
   Good examples: “Lower Big Gyp Mountain East”, “Animas Canyon Main Spring”

COUNTRY, STATE and COUNTY. Abbreviations. (NMNHP code for the county assigned when entered into Biological Conservation Database − BCD).

DIRECTIONS. Directions to plot ─ enter precise directions to the plot using a readily locatable landmark (e.g., a city, a major highway, etc.) as the starting point on a state or local roadmap. Use clear complete sentences that will be understandable to someone who is unfamiliar with the area, needs to get to the plot, and has only your directions to follow. Cite distances as closely as possible to the 1/10 of a mile, use compass directions (N, S, E, and W), and be sure to specify the best access to the plot, such as where to park or which trail to use.

MAPNAME. Map used to locate and mark plot, usually the USGS 7.5' topographic quadrangle map name.

QUADCODE. NMNHP USGS quadrangle code.

MARGNUM. Margin number on the field map associated with the mapped plot position. Each plot position within the map is marked with a dot and associated margin number. The margin number for the plot is also placed along the margin of the topographic map. Associated with each margin number is a margin note indicating the Plotid, CT acronym and, in parentheses, the 10,10 (described below).

10,10. The 10,10 is an imaginary grid over the map, 10 ten cells across and ten cells down to facilitate locating the dot at a later time on the map. For example, (5,6) indicates 5 cells across from left to right and 6 cells down from top to bottom. This would be almost half way across the map, and more than half way down.

T R S 4/s. Township, Range Section and quarter section indicating location of occurrence, if UTMs not available.
LAT, LONG. Latitude and longitude, if UTMs not available.
UTM. Enter Northing and Easting UTM coordinates and Zone. If not available fill in Lat/Long or TRS.

ACCURACY. One letter code for accuracy of plot location:

H = High accuracy within 30 meters. Usually determined by *differential* GPS.
S = Second - mappable within a three-second radius or 100 m.
M = Minute - mappable within a one-minute radius (approximately two km or one mile)
G = General - mappable to quad or place name precision only (precision within about 8 km or 5 miles)

GPS. (Y/N) Was a GPS used to determine location and a GPS file generated?

SITE PHOTOS. Indicate each photo taken of, or from the plot, with indication of direction and subject. e.g., "looking N across entire plot" or "looking to the western horizon towards the Tularosa Basin." Photos should have plot numbers on a chalk board, flip pad or something similar, and a reference to show scale, but preferably not people (at least not in the center of the picture).

PHOTO PT. Was a permanent photo point established and tagged (Y/N)?
PT COMMENT. Information on photo point location, monument, and orientation.
AERIAL PHOTO NO. If the plot has been located on aerial photos indicate the flight line and photo number and year. Locate plots on the backside of aerial photo, or with a transparent stick-on dot, and indicate plot number on the backside of photo.

ELEV. Elevation *in feet* unless otherwise noted
ASPECT. Enter the *azimuth (0-360 degrees)* of the slope aspect on which the plot occurs.
SLOPE %. Enter the angle of the slope on which the plot occurs in *percent slope.*

EROSION TYPE. Enter one of the following codes to indicate the dominant type of erosion or deposition occurring on the plot:

NO - type not evident or not evaluated
SE - sheet erosion
RE - rill erosion
GE - gully erosion
WE - wind erosion
SC - soil creep
SL - slump (earth flow)
SL - landslide
UE - undifferentiated erosion

WD- wind (Aeolian) deposited sediments
TD - fluvial terrace or fan deposits
UD - undifferentiated deposition

OT - Other and specify in GEN COMMENT section

SLOPE SHAPE. Enter one of the following codes to indicate the vertical shape of the slope on which the plot lies.

S - straight or even
R - rounded or convex
D - depression or concave
P - patterned (micro-relief of hummocks and swales)
U - undulating pattern or low ridges or knolls and draws
X - other

LANDFORM (six number code)**.** Enter the landform followed by the code as classified in the NMNHP landform classification.

SURFACE ROCK TYPE. Enter the code for the dominant surface rock type:

Sedimentary
SETU - type unknown
LIME - limestone
DOLO - dolomite
SAND - sandstone
CASA - calcareous sandstone
SILT - siltstone
CASI - calcareous siltstone
SHAL - shale
RESH - red shale
CASH - calcareous shale
CONG - conglomerate
CACO - calcareous conglomerate

Metamorphic
METU - type unknown
ARGI - argilliate
CAAR - calcareous argillite
SILI - siltite
QUAR - quartzite
SLAT - slate
PHYL - phyllite
SCHI - schist
BISC - biotite schist
MISC - mica schist
GNBG - gneiss and biotite gneiss

Igneous
IGTU - type unknown
BASA - basalt (including obsidian)
ANDE - andesite
DIGA - diorite to gabbro
LATI - latite
QUMO - quartz monzonite
TRSY - trachyte and syenite
RHYO - rhyolite
GRBG - granite and biotite granite

WETU - welded tuf (tufa)
SCOR - scoria (porcelanite), clinker

Miscellaneous
GRAL - gravelly alluvium
SAAL - sandy alluvium
SIAL - silty alluvium
CLAL - clayey alluvium
MIAL - mixed alluvium
GLTI - glacial till, mixed origin
ASHT - ash (of any origin)
MISE - mixed sedimentary
MIME - mixed metamorphic
MIIG - mixed igneous
LOES - loess
MIRT - mix of tow or more rock types
DUNE - sand dunes

SOIL SURFACE TEXTURE. Indicate the soil texture by feel using standard SCS techniques and the soil triangle.

SUR SOIL COLOR. Indicate the Munsel Soil Color and code ─ indicate if it is dry, moist, ped or crushed and rubbed.

SOIL TAXON/MAP UNIT. Enter the taxonomic soil name to the family, if possible, or the soil map unit the site falls within on a soil survey map.

VEGETATION/SITE SUMMARY. Description (a "word picture") of the site and community sampled. Indicate stand dominants, the structure and physiognomy of the community along with a landscape position and site features narrative (including geomorphology, soils and geology).
Adjacent Communities. Indicate surrounding plant associations and the spatial relationships (e.g. Is the occurrence a matrix or patch community). Indicate the width of ecotones and evident successional relationships.
Disturbance and Fragementation. Disturbances both natural and otherwise, their extent, intensity and time frame: livestock grazing utilization and impacts; roads number and distance from; logging and fuelwood cutting; building and obstructions. Estimate frequency and degree of disturbance (light, moderate, heavy, etc.). Indicate degree of element fragmentation, i.e., reduced patch size and corridors.
Disease. Dwarf mistletoe damage (give a rating of average % extent spread of within and among trees); insect damage, fungal rot and rusts.
Animal use evidence. Wildlife browse damage, sightings and sign (bird calls, tracks, scat and animal disturbances such as beaver dens, gopher holes etc., and remember the insects).

OTHER COMMENTS. Miscellaneous comments from all sections.

MANAGEMENT/CONSERVATION. Comment on any stewardship (new or additional) needed to ensure continued existence of the community occurrence, and chances (and means) of bringing it about. Any other pertinent comments go here as well, e.g., "... clearing of competing vegetation has been tried in the past but without success". Comments on the conservation attributes of the occurrence, long-term viability and threats.

OCC TYPE. Is the occurrence a “matrix” or large or small “patch” community.

OCC SIZE (hectares/acres). Occurrence or total stand size surrounding the plot.

OCC CONDITION, LANDSCAPE CONTEXT, SIZE, FINAL EO QUALITY RANKS

Element Occurrence Ranks from ranking form.

A - excellent; B - good; C - fair; D - poor

FORMS. Forms filled out for the plot.

S - Survey Site Designation and Description Form [Form1]
G - General Plot Description Form [Form2]
R - Floristic Inventory Data Form [Form3]
M - Microplot Vegetation Data Form [Form 3b]
T - Tree Measurement Form
E - Soil Characterization Form
L - Litter/debris
P - Photo point
E - Element Occurrence ranking form
O - Other specify

DATA ENTRY. Entry date to PLOT database or other database, and by whom.

FILE/TABLE. Data file or database table that data was entered into.

QC1 and QC2. Quality Control checks, date and initials.

EOR Date. Entry date of Element Occurrence Record data to BCD (Biological Conservation Database) and by whom.

ELCODE (14-character alphanumeric code)**.** Element Occurrence Code − enter this code in the field only if it is known. Record in order the NMNHP element code (10-characters), a period, and occurrence ascension number (3-digits).

Example: The 23rd occurrence of the Douglas-fir/little
bluestem plant association would be entered as C2ABBABF0.023.

Floristic Inventory (Form 3)

DATE. Date of vegetation inventory. Two-digit month, day and year numbers.

PLOT ID (seven-character alphanumeric code)**.** NMNHP standard record tracking number (see general description – Form2).

PLOT TYPE:

S = Standard plot where all species within the plot are recorded and their abundance estimated, and the quality of occurrence is ranked using the ranking form.

V = Voucher or Validation plot; only the dominant and most common species recorded with their abundance to ensure proper identification of the type, and enough site information to provisionally rank the quality of the occurrence.

R = Releve or Reconnaissance plot. Full species list of both plot and stand, with element quality ranking using the ranking form.

A = Analytical plot. Full species list of both plot and stand with subsampling of abundance (usually quadrat based). Element quality ranking using the ranking form.

CT. Community type or plant association to which vegetation data refers to. Should be the same as entered on Form2. Use six (seven) letter species acronyms. For example: PINPON/QUEGAM. Who ever makes the CT determination must date and initial the designation. Refer to the NMNHP vegetation classification for current types and acronyms. If the type does not appear to match any on the list, assign a temporary name and indicate your reasoning behind the assignment in the CT COMMENT field. If you are uncertain about what to call it, enter UNCLASS the plant association to which vegetation data refers to. Use six letter species acronyms (you can write it out if you wish). For example: PINPON/QUEGAM. Who ever makes the CT determination must date and initial the designation.

GROUND SURFACE. Enter % cover fraction for each of the following types of cover as they occur over the surface of the plot (must add up to 100%).

S - exposed soil (particles < 1/16 in. or 2 mm dia.)
G - gravel (particles 1/16 to 3 in. dia.; 2 mm to 7.5 cm dia.)
R - rock as composed of cobbles, stones and bed rock (particles > 3 in. or >7.5 cm dia.)
L - litter and duff. Litter includes freshly-fallen leaves, needles, twigs < 1/4 in. (.0.5cm), bark, fruits, seeds; duff is decomposed litter (fermentation layer and humus layer).
BV - basal area occupied by the cross-section of root crowns and stems (not leaf canopy cover). Values rarely exceed 30%, and are usually very low.
W - woody (downed debris > 1/4 in. or 0.5 cm dia.)
M - microphytic (cryptogams) crust cover; mosses, lichens and algae (includes cover found on logs, but not tree bases)

SPECIES LIST

Conventions:

All species within the plot and in the stand are listed by Strata/lifeform categories (See the NMNHP species list for lifeform classification of individual species).

Use the accepted acronyms from the current NMNHP species list or spell out the species scientific name (do not use common names). If the species is not on the list, spell it out.

Tree species can occur in several height strata and should be listed separately under different acronyms representing different operating taxonomic units (OTU's). A number is attached to the end of the six-letter acronym to indicate which strata the OTU is from. For example: PINPON1 represents *Pinus ponderosa* seedlings, PINPON2 are saplings of the shrub layer, PINPON3 are mature trees of the tree layer.

If you do not know the name of a species indicate this with the code UNID1, UNID2, UNID3 etc., for each different unknown species.

TREES: usually single bole with lateral branches, and with the potential to grow over 5 meters tall (some may be less than 5m such as various *Juniperus* spp., see NMNHP species list for lifeform classification if in doubt).

SHRUBS: usually multi-stemmed woody species, spiny rosettes or succulents (cacti, yuccas and agave etc.) less than 5m and greater than 0.5m.

DWARF SHRUBS: usually multi-stemmed woody species, spiny rosettes and succulents (cacti, yuccas and agave etc.) less than 0.5m. Small suffrutescent species that are only woody at or near the base or at the root-crown are usually considered forbs, e.g., *Eriogonum*. See the NMNHP species list for lifeform classification.

GRAMINOIDS: grasses and grass-like plants such as sedges and rushes, but not showy flowering monocots such as iris, lily or commelina (Iridaceae, Liliaceae or Commelineceae).

FORBS: Non-woody perennial and annual species that are not grass-like (includes monocots of the Iridaceae, Liliaceae, Commelineceae)

Species id number. Each species that is listed has a line number associated with it by strata/lifeform (T1, S3, G10, F20, etc.). Blank species number lines are available on the forb side of the form for additions grasses, shrubs, and trees. *Circle* the species number when a voucher has been taken for that species.

Total Cov (by strata). Percent aerial cover for tree, shrub, dwarf shrub, graminoid and forb layers. This the total canopy cover of a strata as projected over the surface, regardless of species, and does not include overlapping cover where canopies interlock within a strata (e.g., cover cannot exceed 100%).

Cov. The percent cover for each species within the plot estimated directly using the precision guidelines below, *or* the Modified Domin-Krajina scale in Table 1 (and at the bottom of Form 3).

Percent Cover Estimation Precision Guidelines:
+0 ─ species outside the plot, but within the stand
"r" ─ for less than .05% (trace $<0.25m^2/400m^2$ or $<.01m^2/100m^2$)
"+"─ for less than 1% ($>0.25m^2/400m^2$)
1-10% to the nearest 1% (each % equals $4m^2/400m^2$)
10-30% to the nearest 5%
30-100% to nearest 10%

Ht Modal height of each species to the nearest *meter* for trees, nearest *decimeter* for shrubs, grasses and forbs.

P Phenology. Use "*" for flowering or "@" for fruiting, "X" if it is a dead annual, and leave blank if vegetative).

Vouchers. When a voucher specimen is taken for species, the species number MUST be circled on the plot sheet, and the plot number and species number put on the plant tag or collection sheet of the voucher.

Table 1. Modified Domin-Krajina cover-abundance scale.

NMNHP 1999 scale	Concept	% Cover	$meters^2$ / 400 $meters^2$
+0	outside plot	.001	
r	solitary-accidental	.05	
+ [<1%]	scarce	.5	trace
1 [1-4%]	common	2.5	20 cm^2
5	well-represented	5	>0.2m^2 and <4m^2
10		10	4-19m^2
15		15	20-39m^2
20		20	40-59m^2
25	abundant	25	60-79m^2
30		30	80-99m^2
40	lLuxuriant	40	100m^2
50		50	
60		60	
70		70	
80		80	
90		90	
100		100	

NMNHP VEGETATION SURVEY -- FORM 2-- GENERAL PLOT DESCRIPTION (JULY 1999)

PLOT ID__________________**PROJECT**______________SURVEY TYPE_________________ **MO**___**DAY**___**YEAR**___
SURVEYORS____**PLOT TYPE**___PLOTDIM(M)L/R ____W ____
CT____**CT KEY**____ **CT MAP**___
CT Comment____
____
SURVEY SITE____ COUNTRY___ STATE___COUNTY_____________
DIRECTIONS____
____
____
MAPNAME___________________________________ QUADCODE _ _ _ _ _ _ _ **MARGNUM** ___ **10,10** ________
T _ _ _ R_ _ _ S _ _ 4/S _ _ 4/S _ _ 4/S _ _ LAT__________________ LONG___________________
UTM: NORTHING__________________ **EASTING**__________________ **Zone**____ **ACCURACY**_____ **GPS**________
SITE PHOTOS:____ ____
____ ____
PHOTO POINT____ PT COMMENT ____
____AERIAL PHOTO NO.___________________
ELEV ________ ft ASPECT______ SLOPE _____% EROSION TYPE________/___SLOPE SHAPE_________/___
LANDFORM: ____/ __ __ __ __ __ __
SURFACE ROCK TYPE ____/________
SUR SOIL TEXTURE__________________________ COLOR______________________________/____________
SOIL TAXON/Comment____
VEGETATION/SITE SUMMARY____
____
____
____
____
____
____
____
____
Adjacent Communities:____
____
____
Disturbance/Fragmentation:____
____
____
____
Disease____
____
Animal Use Evidence____
____
OTHER COMMENTS:____
____
MANAGEMENT/CONSERVATION COMMENTS:____
____
____
____
OCC TYPE____________ Comment:____
OCC SIZE ____________ Comment:____
OCC CONDITION ______ Comment:____
OCC LANDSCAPE ______ Comment:____
EO QUALITY RANK_____ Comment:____
FORMS: S___ G_x_ R___ M___ T___ E___ L___ P___ E___Other__________________________________
DATA ENTRY Date _______By: ____ FILE/TABLE________________________QC1____ ____ QC2____ ___
EOR Date __ __ __ By:___ EOCODE_ _ _ _ _ _ _ _ _ _ _ *_ _ _

NMNHP VEGETATION SURVEY -- FORM3 -- Vegetation

MO____ **DAY** ___ **YEAR** ___ **Surveyor**__________________________________ **PLOT ID**______________________

SUBPLOT ID______________________

CT.____**PLOT TYPE**______________________

CIRCLE VOUCHER NUMBERS

Ground Surface Cover S______ G______ R______ L_____ BV______ W______ M_____=100%

TREES Total Cov____%	**P**	**ACRONYM**	**Cov**	**Ht**	**FORBS Total Cover____%**	**P**	**ACRONYM**	**Cov**	**HT**
T1					F1				
T2					F2				
T3					F3				
T4					F4				
T5					F5				
T6					F6				
T7					F7				
T8					F8				
T9					F9				
T10					F10				
T11					F11				
T12					F12				
SHRUBS Total Cov____ %	**P**	**ACRONYM**	**Cov**	**Ht**	F13				
S1					F14				
S2					F15				
S3					F16				
S4					F17				
S5					F18				
S6					F19				
S7					F20				
S8					F21				
DWARF SHRUBS Tot.Cov___	**P**	**ACRONYM**	**Cov**	**Ht**	F22				
DS1					F23				
DS2					F24				
DS3					F25				
DS4					F26				
DS5					F27				
DS6					F28				
DS7					F29				
DS8					F30				
GRAMINOIDS Tot Cov____%	**P**	**ACRONYM**	**Cov**	**Ht**	___				
G1					___				
G2					___				
G3					___				
G4					___				
G5					___				
G6					___				
G7					___				
G8					___				
G9					___				
G10					___				
G11					___				
G12					___				
G13					___				
G14					___				
G15					___				
G16					# of Spp. T___ S___ DS___ G___ F___ Tot______				

Tot.Cov.=total % cover by strata **Phenology:** *=Flowering @=fruiting X=dead annual

Ht= species modal height (trees nearest m, shrubs,grasses & forbs nearest dm)

Cov= % canopy cover **+0**=outside plot,in stand

1=<0.05% (<0.25m^2/400m^2)

2=^{3}0.05 and <1% (^{3}0.25m^2/400m^2)

3=1-4% (^{3}4m^2/400m^2)

4=5-10%(^{3}20m^2/400m^2)

5=10-25%(^{3}40m^2/400m^2)

6=25-33%(^{3}100m^2/400m^2)

7=33-50%

8=50-75%

9=75-95%

10=95-100%

JULY 1999

Community Element Occurrence (EO) Ranking Form. **New Mexico Natural Heritage Program 1999**

EO Number/PLOT ID____ Plant Association_________________________________

Evaluator________________________________ Date_______________ Site Name____

	Condition Factors	Rank (1-4 pt)	Wt.	Score	Comments
C1	*Exotics versus Natives Canopy*				
C2	*Undergrowth Exotics*				
C3	*Structural Diversity and Cover*				
C4	*Species Richness*				
C4	*Fire Fuel loads*				
C6	*Erosion*				
C7	*Streambank Conditions*				
C8	*Parasites and Disease*				
	Condition Final Rank				

	Landscape Context Factors	Rank (1-4 pt)	Wt.	Score	
L1	*Hydrological Regime -- Stream Flow*				
L2	*Hydrological Regime -- Lateral Stream Movement*				
L3	*Hydrological Regime-- Channel Conditions*				
L4	*Fire Regime -- Size*				
L5	*Fire Regime -- Frequency*				
L6	*Landscape/ Fragmentation*				
L7	*Landscape Community Diversity and Function*				
	Landscape Context Final Rank				

	Size Factor	Rank (1-4 pt)	Wt.	Score	
S1	*Size*				
	FINAL ELEMENT OCCURENCE RANK			______	

Appendix B

Vegetation plot data for biodiversity evaluation

at Los Alamos National Laboratory

Appendix B. Vegetation plot data for biodiversity evaluation at Los Alamos National Laboratory (see Appendix A for definition of terms).

Vegetation 97SY001

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S. Muldavin, E.
SITE: Upper Canon de Valle (TA15)

PA: PINPON / QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
304	65	0	5	1	40	50	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	ROBNEO	RONE	.5	Robinia neomexicana	New Mexico locust
1	QUEGAM	QUGA	29	Quercus gambelii	Gambel's oak
1	PSEMEN2	PSME	2.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	PINPON3	PIPO	17.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON1	PIPO	.05	Pinus ponderosa - yng regen	ponderosa pine
1	PINFLE3	PIFL2	2.5	Pinus flexilis - mature	limber pine
1	PINFLE	PIFL2	.05	Pinus flexilis	limber pine
1	ABICON2	ABCO	2.5	Abies concolor - adv regen	white fir
2	PRUNUS	PRUNU	.001	Prunus spp.	chokecherry
2	JAMAME	JAAM	.05	Jamesia americana	cliffbush
2	BRIFEN	BRFE	.5	Brickellia fendleri	Fendler's brickellbush
3	MUHMON	MUMO	2.5	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.05	Koeleria macrantha	prairie junegrass
3	CAREX	CAREX	.5	Carex spp.	sedge
3	BROMUS	BROMU	.05	Bromus spp.	brome
4	GALIUM	GALIU	.05	Galium spp.	bedstraw
4	FRAVESA	FRVEA2	.05	Fragaria vesca ssp. americana	woodland strawberry
4	ERIGER	ERIGE2	.001	Erigeron spp.	fleabane
4	ARTLUD	ARLU	.05	Artemisia ludoviciana	Louisiana sagewort

Vegetation 97SY002

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Lower Canon de Valle

PA: ABICON / JAMAME

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
166	5	0	0	0	1	90.9	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	2.5	Quercus gambelii	Gambel's oak
1	PSEMEN	PSME	41.5	Pseudotsuga menziesii	Douglas fir
1	PINPON	PIPO	.001	Pinus ponderosa	ponderosa pine
1	ACENEG	ACNE2	2.5	Acer negundo	box elder
1	ABICON2	ABCO	2.5	Abies concolor - adv regen	white fir
1	ABICON	ABCO	41.5	Abies concolor	white fir

2	JAMAME	JAAM	7.5	Jamesia americana	cliffbush
3	ORYMIC	ORMI2	7.5	Oryzopsis micrantha	littleseed ricegrass
3	CARROS	CARO6	7.5	Carex rostrata	beaked sedge
4	FRAVESA	FRVEA2	2.5	Fragaria vesca ssp. americana	woodland strawberry

Vegetation 97SY003

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Lower Canon de Valle (SE - facing slope)

PA: PSEMEN / QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
232	45	0	0	6	16	69	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	ROBNEO	RONE	.5	Robinia neomexicana	New Mexico locust
1	QUEGAM3	QUGA	2.5	Quercus gambelii - mature	Gambel's oak
1	QUEGAM	QUGA	41.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	41.5	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	17.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	PINPON3	PIPO	7.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	.001	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.05	Pinus ponderosa - yng regen	ponderosa pine
2	YUCBAC	YUBA	.001	Yucca baccata	banana yucca
2	TOXRAD	TORA2	.05	Toxicodendron radicans	poison ivy
2	QUEUND	QUUN	.001	Quercus undulata	wavyleaf oak
2	PHIMIC	PHMI4	.05	Philadelphus microphyllus	littleleaf mockorange
2	PAXMYR	PAMY	.5	Paxistima myrsinites	myrtle boxleaf
2	PARQUIQ	PAQUQ	.001	Parthenocissus quinquefolia var. quinquefolia	Virginia creeper
2	BRICAL	BRCA3	.05	Brickellia californica	California brickellbush
2	BRIBRA	BRBR2	2.5	Brickellia brachyphylla	plumed brickellbush
3	SCHSCO	SCSC	.5	Schizachyrium scoparium	little bluestem
3	ORYMIC	ORMI2	.5	Oryzopsis micrantha	littleseed ricegrass
3	MUHMON	MUMO	2.5	Muhlenbergia montana	mountain muhly
3	MELPOR	MEPO	.5	Melica porteri	Porter's melicgrass
3	KOEMAC	KOMA	2.5	Koeleria macrantha	prairie junegrass
3	CARROS	CARO6	2.5	Carex rostrata	beaked sedge
3	ANDGER	ANGE	.001	Andropogon gerardii	big bluestem
4	VERTHA	VETH	.5	Verbascum thapsus	common mullein
4	THAFEN	THFE	.05	Thalictrum fendleri	Fendler's meadowrue
4	FUNGUS		.05	Fungus	
4	FRAVESA	FRVEA2	.01	Fragaria vesca ssp. americana	woodland strawberry
4	ARTLUD	ARLU	.5	Artemisia ludoviciana	Louisiana sagewort
4	ANTPAR	ANPA4	.05	Antennaria parvifolia	smallleaf pussytoes

Appendix B. Vegetation plot data for biodiversity evaluation at Los Alamos National Laboratory (see Appendix A for definition of terms).

Vegetation 97SY004

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Lower Canon de Valle (NE - facing slope)

PA: PSEMEN / QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
82	30	7,000	0	1	3	90	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	17.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	65	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	PINEDU1	PIED	.05	Pinus edulis - yng regen	pinyon pine
1	ACENEG	ACNE2	.5	Acer negundo	box elder
1	ABICON1	ABCO	.5	Abies concolor - yng regen	white fir
2	TOXRAD	TORA2	.05	Toxicodendron radicans	poison ivy
2	SOLIDA	SOLID	.05	Solidago sp.	goldenrod
2	RIBES	RIBES	.05	Ribes spp.	currant; gooseberry
2	PRUVIRM	PRVIM	2.5	Prunus virginiana var. melanocarpa	western black chokecherry
2	PHIMIC	PHMI4	.5	Philadelphus microphyllus	littleleaf mockorange
2	PAXMYR	PAMY	.05	Paxistima myrsinites	myrtle boxleaf
2	PARINC	PAIN2	.01	Parthenium incanum	mariola
2	JAMAME	JAAM	.001	Jamesia americana	cliffbush
2	BRICAL	BRCA3	.05	Brickellia californica	California brickellbush
3	ORYMIC	ORMI2	17.5	Oryzopsis micrantha	littleseed ricegrass
4	WOODSI	WOODS	.05	Woodsia spp.	cliff fern
4	VERTHA	VETH	.001	Verbascum thapsus	common mullein
4	THAFEN	THFE	.05	Thalictrum fendleri	Fendler's meadowrue
4	SEDUM	SEDUM	.01	Sedum spp.	stonecrop
4	OXALIS	OXALI	.05	Oxalis spp.	woodsorrel
4	GERRIC	GERI	.01	Geranium richardsonii	Richardson's geranium
4	GERCAE	GECA3	.01	Geranium caespitosum	pineywoods geranium
4	FRAVESA	FRVEA2	.5	Fragaria vesca ssp. americana	woodland strawberry
4	CYSFRA	CYFR2	.01	Cystopteris fragilis	brittle bladderfern
4	CLEMAT	CLEMA	.05	Clematis spp.	clematis
4	CHEILA	CHEIL	.05	Cheilanthes spp.	lipfern
4	ARTLUD	ARLU	2.5	Artemisia ludoviciana	Louisiana sagewort

Appendix B. Vegetation plot data for biodiversity evaluation at Los Alamos National Laboratory (see Appendix A for definition of terms).

Vegetation 97SY005

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Upper Canon de Valle (NE - facing Slope)

PA: PSEMEN / QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
50	30	7,400	8	1	1	57	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	2.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	17.5	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	29	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	.05	Pseudotsuga menziesii - yng regen	Douglas fir
1	PINPON3	PIPO	2.5	Pinus ponderosa - mature	ponderosa pine
1	ABICON3	ABCO	7.5	Abies concolor - mature	white fir
1	ABICON2	ABCO	17.5	Abies concolor - adv regen	white fir
1	ABICON1	ABCO	2.5	Abies concolor - yng regen	white fir
2	JAMAME	JAAM	.05	Jamesia americana	cliffbush
3	KOEMAC	KOMA	.01	Koeleria macrantha	prairie junegrass
3	DANSPI	DASP	.5	Danthonia spicata	Poverty oat grass
3	CARROS	CARO6	.05	Carex rostrata	beaked sedge
3	AGRSCA	AGSC5	.5	Agrostis scabra	rough bentgrass
4	VERTHA	VETH	.05	Verbascum thapsus	common mullein
4	THAFEN	THFE	.05	Thalictrum fendleri	Fendler's meadowrue
4	FRAVESA	FRVEA2	.5	Fragaria vesca ssp. americana	woodland strawberry
4	ANTPAR	ANPA4	.5	Antennaria parvifolia	smallleaf pussytoes

Vegetation 97SY007

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Lower Mortandad (bottom)

PA: STICOM / SPOCRY , ARTDRA

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
170	2	6,680	25	1	0	61	

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	PINPON3	PIPO	.001	Pinus ponderosa - mature	ponderosa pine
1	PINEDU3	PIED	.001	Pinus edulis - mature	pinyon pine
1	JUNMON3	JUMO	2.5	Juniperus monosperma - mature	oneseed juniper
1	JUNMON1	JUMO	.001	Juniperus monosperma - yng regen	oneseed juniper
2	RHUTRI	RHTR	2.5	Rhus trilobata	skunkbush sumac
2	CHRNAU	CHNA2	.5	Chrysothamnus nauseosus	rubber rabbitbrush
3	STICOM	STCO4	7.5	Stipa comata	needle and thread
3	SPOCRY	SPCR	7.5	Sporobolus cryptandrus	sand dropseed
3	ORYHYM	ORHY	.5	Oryzopsis hymenoides	Indian ricegrass

3	ELYELY	ELEL5	.5	Elymus elymoides	bottlebrush squirreltail
3	BROTEC	BRTE	.5	Bromus tectorum	cheatgrass
3	BROCIL	BRCI2	.5	Bromus ciliatus	fringed brome
3	BOUGRA	BOGR2	.5	Bouteloua gracilis	blue grama
4	SENECI	SENEC	.05	Senecio spp.	groundsel
4	MACHAE	MACHA	.5	Machaeranthera spp.	tansyaster
4	IPOLON	IPLO2	.05	Ipomopsis longiflora	flaxflowered gilia
4	HELPET	HEPE	.05	Helianthus petiolaris	prairie sunflower
4	GAIPUL	GAPU	.05	Gaillardia pulchella	firewheel
4	FUNGUS		.001	Fungus	
4	ERIFLA	ERFL	.001	Erigeron flagellaris	trailing fleabane
4	ARTDRA	ARDR4	17.5	Artemisia dracunculus	wormwood
4	ARTCAR	ARCA14	.001	Artemisia carruthii	Carruth's sagewort

Vegetation 97SY008

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Lower Mortandad (NE - facing toeslope)

PA: PINPON / SCHSCO , MUHMON

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
38	10	6,760	1	0	0	96.5	

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	PINPON3	PIPO	7.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	2.5	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.5	Pinus ponderosa - yng regen	ponderosa pine
1	PINEDU1	PIED	.5	Pinus edulis - yng regen	pinyon pine
1	JUNMON3	JUMO	.001	Juniperus monosperma - mature	oneseed juniper
1	JUNMON1	JUMO	.05	Juniperus monosperma - yng regen	oneseed juniper
2	RHUTRI	RHTR	.5	Rhus trilobata	skunkbush sumac
3	STICOM	STCO4	.5	Stipa comata	needle and thread
3	SCHSCO	SCSC	29	Schizachyrium scoparium	little bluestem
3	PASSMI	PASM	.05	Pascopyrum smithii	western wheatgrass
3	MUHMON	MUMO	2.5	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	2.5	Koeleria macrantha	prairie junegrass
3	ELYELY	ELEL5	.5	Elymus elymoides	bottlebrush squirreltail
3	BOUGRA	BOGR2	2.5	Bouteloua gracilis	blue grama
4	VICAME	VIAM	.5	Vicia americana	american vetch
4	VERTHA	VETH	.5	Verbascum thapsus	common mullein
4	ORTPUR	ORPU2	.001	Orthocarpus purpureoalbus	purplewhite owlclover
4	IPOAGG	IPAG	.05	Ipomopsis aggregata	skyrocket gilia
4	HETFUL	HEFU3	2.5	Heterotheca fulcrata	rockyscree falsegoldenaster
4	BAHPED	BAPE	.05	Bahia pedata	bluntscale bahia
4	ARTLUD	ARLU	.5	Artemisia ludoviciana	Louisiana sagewort
4	ARTDRA	ARDR4	.05	Artemisia dracunculus	wormwood
4	ARTCAR	ARCA14	2.5	Artemisia carruthii	Carruth's sagewort

Vegetation 97SY009

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Lower Mortandad (SW - facing Slope)

PA: JUNMON / QUEUND

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
192	42	6,840	5	5	75	7	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	PINPON3	PIPO	.001	Pinus ponderosa - mature	ponderosa pine
1	PINEDU2	PIED	.5	Pinus edulis - adv regen	pinyon pine
1	PINEDU1	PIED	.05	Pinus edulis - yng regen	pinyon pine
1	JUNMON2	JUMO	17.5	Juniperus monosperma - adv regen	oneseed juniper
2	RIBCER	RICE	.05	Ribes cereum	wax currant
2	RHUTRI	RHTR	.5	Rhus trilobata	skunkbush sumac
2	QUEUND	QUUN	17.5	Quercus undulata	wavyleaf oak
2	OPUPOL	OPPO	.05	Opuntia polyacantha	plains pricklypear
2	FORPUBP	FOPUP	.001	Forestiera pubescens var. pubescens	New Mexico olive
2	FALPAR	FAPA	.001	Fallugia paradoxa	Apacheplume
2	CHRNAU	CHNA2	.05	Chrysothamnus nauseosus	rubber rabbitbrush
2	BRICAL	BRCA3	.5	Brickellia californica	California brickellbush
2	ATRCAN	ATCA2	.001	Atriplex canescens	fourwing saltbush
3	POAFEN	POFE	.001	Poa fendleriana	muttongrass
3	ORYHYM	ORHY	.001	Oryzopsis hymenoides	Indian ricegrass
3	LYCPHL	LYPH	.5	Lycurus phleoides	common wolfstail
3	KOEMAC	KOMA	.001	Koeleria macrantha	prairie junegrass
3	BROTEC	BRTE	.001	Bromus tectorum	cheatgrass
3	BOUGRA	BOGR2	.05	Bouteloua gracilis	blue grama
3	ARIPUR	ARPU9	.01	Aristida purpurea	purple threeawn
3	ARIHAV	ARHA3		Aristida havardii	Havard's threeawn
4	THEWRI	THWR	.001	Thelypodium wrightii	Wright's thelypody
4	SALVIA	SALVI	.001	Salvia spp.	sage
4	MIRMUL	MIMU	.01	Mirabilis multiflora	Colorado four o'clock
4	MACBIG	MABI	.001	Machaeranthera biglovii	Bigelow's tansyaster
4	HETFUL	HEFU3	.5	Heterotheca fulcrata	rockyscree falsegoldenaster
4	ERIJAM	ERJA	.5	Eriogonum jamesii	James' buckwheat
4	ECHTRI	ECTR	.001	Echinocereus triglochidiatus	kingcup cactus
4	CHENOP	CHENO	.001	Chenopodium spp.	goosefoot
4	ARTLUD	ARLU	.5	Artemisia ludoviciana	Louisiana sagewort
4	ARTFRI	ARFR4	.5	Artemisia frigida	fringed sagewort

Vegetation 97SY010

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Middle Mortandad (Bottom)

PA: ACENEG / FORPUB , QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
85	3	6,940	2	1	0.5	92.5	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM3	QUGA	.05	Quercus gambelii - mature	Gambel's oak
1	QUEGAM1	QUGA	7.5	Quercus gambelii - yng regen	Gambel's oak
1	PINPON3	PIPO	.05	Pinus ponderosa - mature	ponderosa pine
1	ACENEG1	ACNE2	7.5	Acer negundo - yng regen	boxelder
1	ACENEG	ACNE2	.05	Acer negundo	box elder
2	RUBIDAS	RUIDS2	.5	Rubus idaeus ssp. strigosus	grayleaf red raspberry
2	PARINC	PAIN2	2.5	Parthenium incanum	mariola
2	FORPUBP	FOPUP	29	Forestiera pubescens var. pubescens	New Mexico olive
3	SETVIR	SEVI4	.5	Setaria viridis	green bristlegrass
3	ORYMIC	ORMI2	.05	Oryzopsis micrantha	littleseed ricegrass
3	MELPOR	MEPO	.05	Melica porteri	Porter's melicgrass
3	BROTEC	BRTE	.05	Bromus tectorum	cheatgrass
3	AGRGIG	AGGI2	.01	Agrostis gigantea	redtop
4	THAFEN	THFE	2.5	Thalictrum fendleri	Fendler's meadowrue
4	TAROFF	TAOF	.05	Taraxacum officinale	common dandelion
4	SALKAL	SAKA	.05	Salsola kali	prickly Russian thistle
4	POLCON		.05	Polygonum convolvulus	black bindweed
4	OENELAH	OEELH	.05	Oenothera elata ssp. hirsutissima	Hooker's eveningprimrose
4	LACTARP	LATAP2	.05	Lactuca tartarica var. pulchella	blue lettuce
4	HACFLO	HAFL2	.05	Hackelia floribunda	manyflowered stickseed
4	GERCAE	GECA3	2.5	Geranium caespitosum	pineywoods geranium
4	FRAVESA	FRVEA2	.5	Fragaria vesca ssp. americana	woodland strawberry
4	CONCAN	COCA5	.05	Conyza canadensis	Canadian horseweed
4	CHEFRE	CHFR3	.05	Chenopodium fremontii	Fremont's goosefoot
4	AMARET	AMRE	.05	Amaranthus retroflexus	redroot pigweed

Vegetation 97SY012

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Middle Mortandad

PA: PSEMEN / QUEGAM , ORYMIC

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
82	16		0	0	1	94	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	17.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	7.5	Pseudotsuga menziesii - mature	Douglas fir

1	PSEMEN2	PSME	29	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	2.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	ACENEG	ACNE2	2.5	Acer negundo	box elder
1	ACEGLA	ACGL	2.5	Acer glabrum	Rocky Mountain maple
2	JAMAME	JAAM	.5	Jamesia americana	cliffbush
2	BRICAL	BRCA3	.05	Brickellia californica	California brickellbush
3	ORYMIC	ORMI2	17.5	Oryzopsis micrantha	littleseed ricegrass
3	ELYELY	ELEL5	.05	Elymus elymoides	bottlebrush squirreltail
3	BROANO	BRAN	.5	Bromus anomalus	nodding brome
4	MAISTE	MAST4	.05	Maianthemum stellatum	starry false Solomon's seal
4	HEUPAR	HEPA11	.05	Heuchera parvifolia	littleleaf alumroot
4	GALBOR	GABO2	.5	Galium boreale	Northern bedstraw
4	GALAPA	GAAP2	.5	Galium aparine	stickywilly
4	CYSFRA	CYFR2	.05	Cystopteris fragilis	brittle bladderfern
4	BERFEN	BEFE	.05	Berberis fendleri	Colorado barberry

Vegetation 97SY013

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Middle Mortandad (TA-35)

PA: PINPON / SCHSCO

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
358	17	7,100	6	1	3	85	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	.001	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	2.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	.05	Pseudotsuga menziesii - yng regen	Douglas fir
1	POPTRE1	POTR5	.001	Populus tremuloides - yng regen	quaking aspen
1	PINPON3	PIPO	7.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	7.5	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.05	Pinus ponderosa - yng regen	ponderosa pine
1	PINFLE	PIFL2	.001	Pinus flexilis	limber pine
1	ACEGLA	ACGL	.05	Acer glabrum	Rocky Mountain maple
2	SOLIDA	SOLID	.5	Solidago sp.	goldenrod
2	RHUTRI	RHTR	.05	Rhus trilobata	skunkbush sumac
2	PRUVIRM	PRVIM	.05	Prunus virginiana var. melanocarpa	western black chokecherry
2	CERMON	CEMO2	2.5	Cercocarpus montanus	mountain mahogany
3	SCHSCO	SCSC	2.5	Schizachyrium scoparium	little bluestem
3	MUHMON	MUMO	.5	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.05	Koeleria macrantha	prairie junegrass
3	ELYCAN	ELCA4	.01	Elymus canadensis	Canada wildrye
3	CAREX	CAREX	.05	Carex spp.	sedge
3	BLETRI	BLTR	.01	Blepharoneuron tricholepis	pine dropseed
4	SENWOO	SEWO	.05	Senecio wootonii	Wooton's ragwort
4	PENBAR	PEBA2	.01	Penstemon barbatus	beardlip penstemon

4	LINNEO	LINE	.5	Linum neomexicanum	New Mexico yellow flax
4	LIAPUN	LIPU	.05	Liatris punctata	dotted grayfeather
4	HETVIL	HEVI4	.5	Heterotheca villosa	hairy goldenaster
4	GILPIN	GIPI	.01	Gilia pinnatifida	sticky gilia
4	BERFEN	BEFE	.05	Berberis fendleri	Colorado barberry
4	ARTLUD	ARLU	.001	Artemisia ludoviciana	Louisiana sagewort
4	ARTCAR	ARCA14	.01	Artemisia carruthii	Carruth's sagewort
4	ANTPAR	ANPA4	.05	Antennaria parvifolia	smallleaf pussytoes

Vegetation 97SY014

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Middle Mortandad (north-facing cliff)

PA: PSEMEN / ACEGLA

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
84	32	7,060	1	0	15	72	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	2.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	17.5	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	17.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	7.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	POPFRE	POFR2	.05	Populus fremontii	Fremont's cottonwood
1	PINFLE3	PIFL2	2.5	Pinus flexilis - mature	limber pine
1	ACEGLA	ACGL	29	Acer glabrum	Rocky Mountain maple
1	ABICON3	ABCO	.001	Abies concolor - mature	white fir
1	ABICON2	ABCO	.001	Abies concolor - adv regen	white fir
2	RUBIDAS	RUIDS2	.001	Rubus idaeus ssp. strigosus	grayleaf red raspberry
2	PRUVIRM	PRVIM	7.5	Prunus virginiana var. melanocarpa	western black chokecherry
2	PHYMON	PHMO4	.001	Physocarpus monogynus	mountain ninebark
2	FRAJAM	FRJA	7.5	Frankenia jamesii	James' seaheath
4	VALERI	VALER	.05	Valeriana spp.	valerian
4	MAISTE	MAST4	.01	Maianthemum stellatum	starry false Solomon's seal

Vegetation 97SY015

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Middle Mortandad (south-facing bench)

PA: PINPON / SCHSCO

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
170	20	7,120	0	1	4	92	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	.001	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	.001	Pseudotsuga menziesii	Douglas fir - adv regen
1	PINPON3	PIPO	17.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	2.5	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.5	Pinus ponderosa - yng regen	ponderosa pine
1	PINEDU3	PIED	.001	Pinus edulis - mature	pinyon pine
1	PINEDU2	PIED	.001	Pinus edulis - adv regen	pinyon pine
1	JUNMON1	JUMO	.5	Juniperus monosperma - yng regen	oneseed juniper
1	JUNMON	JUMO	.001	Juniperus monosperma	oneseed juniper
2	YUCGLA	YUGL	.05	Yucca glauca	soaptree yucca
2	YUCBAC	YUBA	.001	Yucca baccata	banana yucca
2	RIBCER	RICE	.5	Ribes cereum	wax currant
2	RHUTRI	RHTR	.001	Rhus trilobata	skunkbush sumac
2	QUEUND	QUUN	.5	Quercus undulata	wavyleaf oak
2	OPUPOL	OPPO	.5	Opuntia polyacantha	plains pricklypear
2	CERMON	CEMO2	2.5	Cercocarpus montanus	mountain mahogany
3	SCHSCO	SCSC	20	Schizachyrium scoparium	little bluestem
3	MUHMON	MUMO	.5	Muhlenbergia montana	mountain muhly
3	ANDGER	ANGE	.05	Andropogon gerardii	big bluestem
4	LIAPUN	LIPU	.01	Liatris punctata	dotted grayfeather
4	HETVIL	HEVI4	.5	Heterotheca villosa	hairy goldenaster
4	ERIALA	ERAL4	.01	Eriogonum alatum	winged buckwheat

egetation 97SY016

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Upper Mortandad (south-facing bench)

PA: PINPON / SCHSCO

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
190	26	7,220	2	0	2	92.5	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	.001	Quercus gambelii	Gambel's oak
1	PINPON3	PIPO	17.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	2.5	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.05	Pinus ponderosa - yng regen	ponderosa pine
1	JUNMON2	JUMO	.001	Juniperus monosperma - adv regen	oneseed juniper
1	JUNMON1	JUMO	.001	Juniperus monosperma - yng regen	oneseed juniper
2	YUCBAC	YUBA	.001	Yucca baccata	banana yucca
2	TOXRAD	TORA2	.001	Toxicodendron radicans	poison ivy
2	RIBCER	RICE	.001	Ribes cereum	wax currant
2	QUEUND	QUUN	.001	Quercus undulata	wavyleaf oak
2	CERMON	CEMO2	2.5	Cercocarpus montanus	mountain mahogany
3	SCHSCO	SCSC	17.5	Schizachyrium scoparium	little bluestem
3	MUHMON	MUMO	.5	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.05	Koeleria macrantha	prairie junegrass
3	BLETRI	BLTR	.05	Blepharoneuron tricholepis	pine dropseed
3	ANDGER	ANGE	.001	Andropogon gerardii	big bluestem
3	AGRGIG	AGGI2	.001	Agrostis gigantea	redtop
4	VERTHA	VETH	.001	Verbascum thapsus	common mullein
4	PENBAR	PEBA2	.001	Penstemon barbatus	beardlip penstemon
4	HETVIL	HEVI4	.05	Heterotheca villosa	hairy goldenaster
4	ARTLUD	ARLU	.05	Artemisia ludoviciana	Louisiana sagewort
4	ANTPAR	ANPA4	.001	Antennaria parvifolia	smallleaf pussytoes

Vegetation 97SY017

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Upper Mortandad (North-facing)

PA: PINPON / MUHMON , CERMON

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
28	13	7,240	14	0	0	80	

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	7.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	.001	Pseudotsuga menziesii - mature	Douglas fir
1	PINPON3	PIPO	7.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	17.5	Pinus ponderosa - adv regen	ponderosa pine

1	PINPON1	PIPO	.05	Pinus ponderosa - yng regen	ponderosa pine
1	PINEDU2	PIED	3	Pinus edulis - adv regen	pinyon pine
1	JUNMON2	JUMO	.5	Juniperus monosperma - adv regen	oneseed juniper
2	GUTSAR	GUSA2	.5	Gutierrezia sarothrae	broom snakeweed
2	CERMON	CEMO2	41.5	Cercocarpus montanus	mountain mahogany
3	SCHSCO	SCSC	.5	Schizachyrium scoparium	little bluestem
3	MUHMON	MUMO	17.5	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.05	Koeleria macrantha	prairie junegrass
3	ELYELY	ELEL5	.05	Elymus elymoides	bottlebrush squirreltail
3	BROCIL	BRCI2	.05	Bromus ciliatus	fringed brome
3	BOUGRA	BOGR2	.05	Bouteloua gracilis	blue grama
3	BLETRI	BLTR	.5	Blepharoneuron tricholepis	pine dropseed
3	ANDGER	ANGE	.5	Andropogon gerardii	big bluestem
4	TOWEXI	TOEX	.05	Townsendia eximia	tall townsendia
4	MELALB	MEAL2	.05	Melilotus albus	white sweetclover
4	HYMENO	HYMEN7	.5	Hymenoxys spp.	rubberweed
4	HETVIL	HEVI4	.05	Heterotheca villosa	hairy goldenaster
4	GERCAE	GECA3	.05	Geranium caespitosum	pineywoods geranium
4	FRAVESA	FRVEA2	.05	Fragaria vesca ssp. americana	woodland strawberry
4	ERIGER	ERIGE2	.5	Erigeron spp.	fleabane
4	BAHDIS	BADI	.05	Bahia dissecta	ragleaf bahia
4	ARTLUD	ARLU	.05	Artemisia ludoviciana	Louisiana sagewort
4	ARTDRA	ARDR4	.05	Artemisia dracunculus	wormwood
4	ARTCAR	ARCA14	.05	Artemisia carruthii	Carruth's sagewort
4	ANTPAR	ANPA4	.05	Antennaria parvifolia	smallleaf pussytoes
4	ALLCER	ALCE2	.05	Allium cernuum	nodding onion

Vegetation 97SY018

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Upper Mortandad (wetland)

PA: SALIX / AGRALB

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
999	999	7,200	0	0	0	97	

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	.001	Quercus gambelii	Gambel's oak
1	PINPON3	PIPO	.001	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	.001	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.001	Pinus ponderosa - yng regen	ponderosa pine
2	SALEXI	SAEX	41.5	Salix exigua	coyote willow
2	ROSWOO	ROWO	.05	Rosa woodsii	Woods' rose
3	POAPRA	POPR	17.5	Poa pratensis	Kentucky bluegrass
3	ORYHYM	ORHY	.5	Oryzopsis hymenoides	Indian ricegrass
3	MUHMON	MUMO	.001	Muhlenbergia montana	mountain muhly
3	JUNCUS	JUNCU	41.5	Juncus spp.	Rush
3	FESTUC	FESTU	41.5	Festuca spp.	fescue

3	FESARU	FEAR3	.05	Festuca arundinaceae	tall fescue or K-31
3	ELYMUS	ELYMU	.5	Elymus spp.	wildrye
3	ELYELY	ELEL5	.001	Elymus elymoides	bottlebrush squirreltail
3	BROCIL	BRCI2	.001	Bromus ciliatus	fringed brome
3	ANDGER	ANGE	.001	Andropogon gerardii	big bluestem
3	AGRGIG	AGGI2	41.5	Agrostis gigantea	redtop
4	VERTHA	VETH	.001	Verbascum thapsus	common mullein
4	TRADUB	TRDU	.05	Tragopogon dubius	yellow salsify
4	RUMEX	RUMEX	.05	Rumex spp.	dock
4	MELALB	MEAL2	.001	Melilotus albus	white sweetclover
4	HETVIL	HEVI4	.001	Heterotheca villosa	hairy goldenaster
4	GERCAE	GECA3	.05	Geranium caespitosum	pineywoods geranium
4	CIRPAL	CIPA5	.5	Cirsium pallidium	pale thistle
4	ARGANS	ARAN7	2.5	Argentina anserina	silverweed cinquefoil

Vegetation 97SY019

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.
SITE: Upper Canon de Valle (Floodplain)

PA: AGRALB /

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
132	4	7,460	2	0.5	0.5	95.9	WETU

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	2.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	7.5	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PINPON3	PIPO	17.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	2.5	Pinus ponderosa - adv regen	ponderosa pine
1	PINPON1	PIPO	.5	Pinus ponderosa - yng regen	ponderosa pine
1	ABICON1	ABCO	.5	Abies concolor - yng regen	white fir
2	ROSWOO	ROWO	.05	Rosa woodsii	Woods' rose
2	RIBINE	RIIN2	.5	Ribes inerme	whitestem gooseberry
3	POAPRA	POPR	.01	Poa pratensis	Kentucky bluegrass
3	MUHMON	MUMO	.001	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.001	Koeleria macrantha	prairie junegrass
3	JUNCUS	JUNCU	.05	Juncus spp.	Rush
3	FESARU	FEAR3	2.5	Festuca arundinaceae	tall fescue or K-31
3	FESARI	FEAR2	29	Festuca arizonica	Arizona fescue
3	ELYMUS	ELYMU	.5	Elymus spp.	wildrye
3	ELYELY	ELEL5	2.5	Elymus elymoides	bottlebrush squirreltail
3	DANSPI	DASP	.05	Danthonia spicata	Poverty oat grass
3	CAREX	CAREX	.5	Carex spp.	sedge
3	BROINE	BRIN2	.5	Bromus inermis	smooth brome
3	BROCAR	BRCA5	.05	Bromus carinatus	California brome
3	BOUGRA	BOGR2	.001	Bouteloua gracilis	blue grama
3	AGRGIG	AGGI2	29	Agrostis gigantea	redtop

4	THAFEN	THFE	.05	Thalictrum fendleri	Fendler's meadowrue
4	MELALB	MEAL2	.05	Melilotus albus	white sweetclover
4	GERCAE	GECA3	.05	Geranium caespitosum	pineywoods geranium
4	FRAVESA	FRVEA2	.05	Fragaria vesca ssp. americana	woodland strawberry
4	EPICIL	EPCI	.05	Epilobium ciliatum	hairy willowherb
4	CONCAN	COCA5	.01	Conyza canadensis	Canadian horseweed
4	CIRVUL	CIVU	2.5	Cirsium vulgare	bull thistle
4	CAMROT	CARO2	.5	Campanula rotundifolia	bluebell bellflower
4	BERFEN	BEFE	.5	Berberis fendleri	Colorado barberry
4	ARTLUD	ARLU	.05	Artemisia ludoviciana	Louisiana sagewort
4	ACHMIL	ACMI2	.05	Achillea millefolium	common yarrow

Vegetation 97SY020

PROJECT: LANL Ecology

SURVEYORS: Yanoff, S.

SITE: Middle Canon de Valle (NE-facing footslope)

PA: PINPON / QUEGAM

Azimuth	Slope %	Elevation	Soil	Gravel	Rock	Litter/BV	Surface Rock
36	10	7,260	0	0	0	99	

Life Form	NMNHP Acronym	Kartez Symbol	Abundance	Species Name	Common Name
1	QUEGAM	QUGA	62.5	Quercus gambelii	Gambel's oak
1	PSEMEN3	PSME	17.5	Pseudotsuga menziesii - mature	Douglas fir
1	PSEMEN2	PSME	2.5	Pseudotsuga menziesii	Douglas fir - adv regen
1	PSEMEN1	PSME	2.5	Pseudotsuga menziesii - yng regen	Douglas fir
1	PINPON3	PIPO	17.5	Pinus ponderosa - mature	ponderosa pine
1	PINPON2	PIPO	.01	Pinus ponderosa - adv regen	ponderosa pine
1	JUNMON1	JUMO	.001	Juniperus monosperma - yng regen	oneseed juniper
3	STISPA	STSP2	2.5	Stipa spartea	porcupine grass
3	SCHSCO	SCSC	.5	Schizachyrium scoparium	little bluestem
3	MUHMON	MUMO	.05	Muhlenbergia montana	mountain muhly
3	KOEMAC	KOMA	.5	Koeleria macrantha	prairie junegrass
3	ELYTRAS	ELTRS	.5	Elymus trachycaulus ssp. subsecundus	bearded wheatgrass
3	DANSPI	DASP	62.5	Danthonia spicata	Poverty oat grass
3	CARROS	CARO6	.5	Carex rostrata	beaked sedge
4	VICAME	VIAM	.05	Vicia americana	american vetch
4	VERCAL	VECA2	.5	Veratrum californicum	Calif. false hellebore
4	THAFEN	THFE	.5	Thalictrum fendleri	Fendler's meadowrue
4	IPOAGG	IPAG	.01	Ipomopsis aggregata	skyrocket gilia
4	GENAFF	GEAF	.05	Gentiana affinis	pleated gentian
4	ERIGER	ERIGE2	.05	Erigeron spp.	fleabane
4	BERFEN	BEFE	.05	Berberis fendleri	Colorado barberry
4	ARTLUD	ARLU	.5	Artemisia ludoviciana	Louisiana sagewort
4	ANTPAR	ANPA4	.05	Antennaria parvifolia	smallleaf pussytoes
4	ANEMON	ANEMO	.05	Anemone spp.	anemone
4	ACHMIL	ACMI2 .	05	Achillea millefolium common	yarrow

Appendix C

Element Occurrence Ranking Sheets

For

Mortandad and Canon De Valle Biodiversity Evaluation

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking

Site **Canon de Valle**

EO **PINPON/MUHMON**

Plots

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	4.0	20.0	
C3	Structural Diversity and Cover	10	4.0	40.0	not recent tree removals
C4	Species Richness	10	3.5	35.0	moderate diversity (29sp.), no ruderals
C6	Fire Fuel loads	5	2.5	12.5	Fuel loads light to moderate mostly needles
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		114.5	
C	**Condition Rank**		**3.6**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow				
L2	Hydrological Regime -- Lateral Stream Movement				
L3	Hydrological Regime-- Channel Conditions				
L4	Fire Regime -- Size				
L5	Fire Regime -- Frequency				
L6	Landscape/ Fragmentation	10	3.0	30.0	<25% of site disturbed but near impacts
L7	Landscape Community Diversity and Function	8	3	24	Successional types present, but reduced in area; moderate community diversity
	Sum	18		54	
L	**Landscape Rank**		**3.0**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**3**	3	Mostly large patch community

FINAL EO RANK (C+L+S)/3) **3.2 B**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking

Site **Canon de Valle**
EO **PSEMEN/QUEGAM**
Plots **97SY003,97SY004, 97SY05**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	3.5	17.5	virginia creeper mullen
C3	Structural Diversity and Cover	10	3.5	35.0	not recent tree removals, misteltoe infestation, good undergrowth cover
C4	Species Richness	10	3.5	35.0	high diversity (35 sp), some ruderals
C6	Fire Fuel loads	5	2.5	12.5	Fuel loads are moderate coarse woody debris
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		107.0	
C	**Condition Rank**		**3.3**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow				
L2	Hydrological Regime -- Lateral Stream Movement				
L3	Hydrological Regime-- Channel Conditions				
L4	Fire Regime -- Size				
L5	Fire Regime -- Frequency				
L6	Landscape/ Fragmentation	10	3.0	30.0	<25% of site disturbed
L7	Landscape Community Diversity and Function	8	3	24	Successional types present, but reduced in area; moderate community diversity
	Sum	18		54	
L	**Landscape Rank**		**3.0**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**3**	3	patch size reduced by upper watershed disturbace, Matrix community

FINAL EO RANK (C+L+S)/3) **3.1 B**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking

Site **Canon de Valle**
EO **PINPON/QUEGAM**
Plots **97SY001,97SY021, 97SY020**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	4.0	20.0	
C3	Structural Diversity and Cover	10	4.0	40.0	not recent tree removals
C4	Species Richness	10	3.5	35.0	moderate diversity (29sp.), no ruderals
C6	Fire Fuel loads	5	2.5	12.5	Fuel loads light to moderate mostly needles
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		114.5	
C	**Condition Rank**		**3.6**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow				
L2	Hydrological Regime -- Lateral Stream Movement				
L3	Hydrological Regime-- Channel Conditions				
L4	Fire Regime -- Size				
L5	Fire Regime -- Frequency				
L6	Landscape/ Fragmentation	10	3.0	30.0	<25% of site disturbed but near impacts
L7	Landscape Community Diversity and Function	8	3	24	Successional types present, but reduced in area; moderate community diversity
	Sum	18		54	
L	**Landscape Rank**		**3.0**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**3.5**	3.5	Mostly intact matrix community

FINAL EO RANK (C+L+S)/3) **3.4 B+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO)
Ecological Ranking
Site **Mortandad**
EO **PINPON/MUHMON**
Plots **97SY017**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	3.8	18.8	clover, mullen
C3	Structural Diversity and Cover	10	4.0	40.0	Some lower than expected cover on some sites perhaps a function of intense fire;some misteltoeand widthrow; no grazing; some browse; no logging or fuelwood removals
C4	Species Richness	10	3.0	30.0	high diversity (33 sp.); moderate ruderal abundance
C6	Fire Fuel loads	5	3.0	15.0	Fuel loads are moderate, mostly grass litter; some coarse woody debris
C7	Erosion	1	3.0		light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		107.8	
C	**Condition Rank**		**3.4**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	na			
L2	Hydrological Regime -- Lateral Stream Movement	na			
L3	Hydrological Regime-- Channel Conditions	na			
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			Indications of fire in the last 30 years
L6	Landscape/ Fragmentation	10	2	20.0	
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		48	
L	**Landscape Rank**		**2.7**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**2.5**	2.5	Matrix community reduced by disturbace.

FINAL EO RANK (C+L+S)/3) **2.8 C+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO)
Ecological Ranking
Site **Mortandad**
EO **PINPON/SCHSCO**
Plots **97SY008, 97SY013, 97SY015,97SY016**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	3.8	19.0	clover, mullen
C3	Structural Diversity and Cover	10	3.3	33.0	Some lower than expected cover on some sites perhaps a function of intense fire;some misteltoeand widthrow; no grazing; some browse; no logging or fuelwood removals
C4	Species Richness	10	2.8	28.0	moderatediversity (25 sp.); moderate ruderal abundance
C6	Fire Fuel loads	5	3.0	15.0	Fuel loads are moderate, mostly grass litter; some coarse woody debris
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		102.0	
C	**Condition Rank**		**3.2**		

	Landscape Factors	**Weight**	**Points**	**Score**	**Comments**
L1	Hydrological Regime -- Stream Flow	na			
L2	Hydrological Regime -- Lateral Stream Movement	na			
L3	Hydrological Regime-- Channel Conditions	na			
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			Indications of fire in the last 30 years
L6	Landscape/ Fragmentation	10	2	20.0	
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		48	
L	**Landscape Rank**		**2.7**		

	Size Factor	**Weight**	**Points**	**Score**	**Comments**
S	Occurenece Size	1	**2.5**	2.5	Matrix community reduced by disturbace.

FINAL EO RANK (C+L+S)/3) **2.8 C+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO)
Ecological Ranking
Site Mortandad
EO ACENEG/PRUVIR
Plots 97SY010

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	10	4.0	40.0	
C2	Undergrowth Exotics	5	2.0	10.0	virginia creeper, redtop, clover, russina thistle
C3	Structural Diversity and Cover	10	3.5	35.0	canopy cover lower tha expected, but acer is reproducing
C4	Species Richness	10	2.5	25.0	diversity high (35 sp) but ruderals common
C6	Fire Fuel loads	unkn	2.0		Fuel loads are moderate, mostly grass litter; some coarse woody debris
C7	Erosion	na			
C8	Streambank Conditions	5	2.0	10.0	channel partally vegetated
	Sum	40		120.0	
C	**Condition Rank**		**3.0**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	7	2.5	17.5	excessive outfall inputs
L2	Hydrological Regime -- Lateral Stream Movement	5	2	10	entrenched and banks unstable
L3	Hydrological Regime-- Channel Conditions	5	1.75	8.75	degrading stream
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			
L6	Landscape/ Fragmentation	10	2	20.0	
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	35		84.25	
L	**Landscape Rank**		**2.4**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**2.5**	2.5	moderate size but road directly through the occurrence

	FINAL EO RANK (C+L+S)/3)		**2.6**	**C+**	

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking
Site **Mortandad**
EO **SALEXI/JUNBAL**
Plots **97SY018**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	10	4.0	40.0	
C2	Undergrowth Exotics	5	2.0	10.0	kentucky bluegrass, redtop, clover
C3	Structural Diversity and Cover	10	3.5	35.0	willoow cover may be reduced
C4	Species Richness	10	2.0	20.0	Narrowleaf cottonwood expected; diversity moderate (24 sp) ruderals common
C6	Fire Fuel loads	unkn			Fuel loads are moderate, mostly grass litter; some coarse woody debris
C7	Erosion	na			
C8	Streambank Conditions	5	4.0	20.0	channel well-vegetated
	Sum	40		125.0	
C	**Condition Rank**		**3.1**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	7	3	21	excessive outfall inputs
L2	Hydrological Regime -- Lateral Stream Movement	5	4	20	
L3	Hydrological Regime-- Channel Conditions	5	4	20	
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			Indications of fire in the last 30 years
L6	Landscape/ Fragmentation	10	2	20.0	
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	35		109	
L	**Landscape Rank**		**3.1**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**2**	2	small
	FINAL EO RANK (C+L+S)/3)		**2.7**	**C+**	

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking

Site **Mortandad**
EO **PSEMEN/QUEGAM**
Plots **97SY012**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	4.0	20.0	
C3	Structural Diversity and Cover	10	4.0	40.0	diverse structure no grazing ; some browse; no logging or fuelwood removals
C4	Species Richness	10	3.5	35.0	moderate diversity (21 sp.); few ruderals
C6	Fire Fuel loads	5	2.0	10.0	Fuel loads are moderate, both grass litter and coarse woody debris
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		112.0	
C	**Condition Rank**		**3.5**		

	Landscape Factors	**Weight**	**Points**	**Score**	**Comments**
L1	Hydrological Regime -- Stream Flow	na			
L2	Hydrological Regime -- Lateral Stream Movement	na			
L3	Hydrological Regime-- Channel Conditions	na			
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			Indications of fire in the last 30 years
L6	Landscape/ Fragmentation	10	2	20.0	
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		48	
L	**Landscape Rank**		**2.7**		

	Size Factor	**Weight**	**Points**	**Score**	**Comments**
S	Occurenece Size	1	**2.3**	2.3	patch size reduced by disturbace, major community type in the canyon

FINAL EO RANK (C+L+S)/3) **2.8 C+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking
Site Mortandad
EO STICOM/SPOFLE
Plots 97SY007

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	2.5	12.5	Cheat grass
C3	Structural Diversity and Cover	10	2.8	27.5	some shrub invasion; no grazing ;low cover
C4	Species Richness	10	2.0	20.0	diversity lower than expected, several rudersls common and grazing increasers
C5	Fire Fuel loads	5	2.0	10.0	Fuel loads are moderatecoarse woody debris
C6	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C7	Streambank Conditions	na			
	Sum	32		77.0	
C	**Condition Rank**		**2.4**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	na			
L2	Hydrological Regime -- Lateral Stream Movement	na			
L3	Hydrological Regime-- Channel Conditions	na			
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			
L6	Landscape/ Fragmentation	10	1.5	15.0	>30% of site disturbed; old homestead
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		43	
L	**Landscape Rank**		**2.4**		

	Size Factor	**Weight**	**Points**	**Score**	
S	**Size**	1	**2**	2	patch size reduced by disturbace, major community type in the canyon

FINAL EO RANK (C+L+S)/3) **2.3 C+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO)
Ecological Ranking
Site Mortandad
EO PSEMEN/ACEGLA
Plots 97SY014

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	4.0	20.0	
C3	Structural Diversity and Cover	10	3.5	35.0	no grazing ; some browse; no logging or fuelwood removals; low undergrowth cover
C4	Species Richness	10	3.0	30.0	moderately high shrub diversity; some ruderals, snakeweed low grass diversity
C6	Fire Fuel loads	5	2.0	10.0	Fuel loads are moderatecoarse woody debris
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		102.0	
C	**Condition Rank**		**3.2**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow				
L2	Hydrological Regime -- Lateral Stream Movement				
L3	Hydrological Regime-- Channel Conditions				
L4	Fire Regime -- Size				
L5	Fire Regime -- Frequency				
L6	Landscape/ Fragmentation	10	2.0	20.0	>30% of site disturbed
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		48	
L	**Landscape Rank**		**2.7**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**2.5**	2.5	patch size reduced by upper watershed disturbace, Matrix community

FINAL EO RANK (C+L+S)/3) 2.8 C+

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO) Ecological Ranking

Site **Mortandad**
EO **JUNMON/QUEPAU**
Plots **97SY009**

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	1	4.0	4.0	
C2	Undergrowth Exotics	5	4.0	20.0	
C3	Structural Diversity and Cover	10	3.0	30.0	no grazing ; some browse; historical and prehidtoric fuelwood removals; low undergrowth cover
C4	Species Richness	10	2.5	25.0	moderately high shrub diversity, but some ruderals, snakeweed low grass diversity
C6	Fire Fuel loads	5	2.0	10.0	Fuel loads are moderate, both grass litter and coarse woody debris
C7	Erosion	1	3.0	3.0	light mostly in keeping with naturally steep slopes
C8	Streambank Conditions	na			
	Sum	32		92.0	
C	**Condition Rank**		**2.9**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	na			
L2	Hydrological Regime -- Lateral Stream Movement	na			
L3	Hydrological Regime-- Channel Conditions	na			
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			
L6	Landscape/ Fragmentation	10	1.9	19.0	>30% of site disturbed; power lines and roadds neaby
L7	Landscape Community Diversity and Function	8	3.5	28	Successional types present, but reduced in area; moderate community diversity
	Sum	18		47	
L	**Landscape Rank**		**2.6**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**3**	3	patch size reduced by disturbace, major community type in the canyon

FINAL EO RANK (C+L+S)/3) **2.8 C+**

LANL Ecological Studies -- Vegetation Community Element Occurrence (EO)
Ecological Ranking
Site Canon de Valle
EO ABICON/JAMAME
Plots 97SY002

	Condition Factors	**Weight**	**Points**	**Score**	**Comments**
C1	Exotics versus Natives Canopy	10	4.0	40.0	
C2	Undergrowth Exotics	5	3.5	17.5	virginia creeper, redtop, clover, russina thistle
C3	Structural Diversity and Cover	10	3.8	37.5	canopy cover lower tha expected, but acer is reproducing
C4	Species Richness	10	3.0	30.0	diversity high (35 sp) but ruderals common
C6	Fire Fuel loads	unkn			Fuel loads are moderate, mostly grass litter; some coarse woody debris
C7	Erosion	na			
C8	Streambank Conditions	5	2.0	10.0	channel partally vegetated
	Sum	40		135.0	
C	**Condition Rank**		**3.4**		

	Landscape Factors	**Weight**	**Points**	**Score**	
L1	Hydrological Regime -- Stream Flow	7	3	21	some additions due to outfalls
L2	Hydrological Regime -- Lateral Stream Movement	5	4	20	appears normal; confined only by slopes of canyon
L3	Hydrological Regime-- Channel Conditions	5	3.75	18.75	at equilibrium; possible excess flow may be altering cahnnel
L4	Fire Regime -- Size	unkn			
L5	Fire Regime -- Frequency	unkn			
L6	Landscape/ Fragmentation	10	3.0	30.0	
L7	Landscape Community Diversity and Function	8	3	24	Successional types present, but reduced in area; moderate community diversity
	Sum	35		113.75	
L	**Landscape Rank**		**3.3**		

	Size Factor	**Weight**	**Points**	**Score**	
S	Occurenece Size	1	**3**	3	small patch community with moderate size relative to the canyon

FINAL EO RANK (C+L+S)/3) 3.2 B